



Drivers and Barriers Toward Healthy and Environmentally Sustainable Eating in Switzerland: Linking Impacts to Intentions and Practices

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Food consumption is among the activities with the most significant environmental impacts, and furthermore contributes to rising health costs. We explored the factors that foster or hinder healthy and sustainable eating in Switzerland. Based on an online household survey with 620 respondents, we first determined the disability adjusted life years and greenhouse gas impacts associated with individuals' dietary habits to measure healthy and environmentally sustainable eating. We then relate the nutritional health and environmental impacts to individual's intentions, and explore what interpersonal and societal factors foster or hinder healthy and sustainable eating. Results suggest that intentions for healthy eating are stronger than intentions to eat environmentally sustainable and that intentions for healthy eating transmit better into behavior than intentions for environmentally sustainable eating. Males and females had similar intentions but males showed substantially higher dietary related health impacts with 12 min of healthy life lost per day and 14% higher carbon footprint than females. Furthermore, vegan and vegetarian diets yielded very high nutritional health benefits of >23 min of healthy life gained per person and day, mostly realized through the reduced intake in processed and red meat and increased consumption of nuts, wholegrain, and to a lesser extent in fruits and vegetables. Meatless diets show concurrent high reductions in the carbon footprint of -42% for vegetarians and -67% for vegan. A key obstacle to healthier and more environmentally sustainable eating is that people do not recognize the high nutritional and environmental co benefits of vegetarian and vegan diets. This suggests that policies promoting healthy eating can target factors affecting intentions, while measures targeting environmentally sustainable eating should aim at overcoming the intention behavior gap, by informing on e.g. the importance of reducing meat consumption toward environmental sustainability.

Keywords: dietary choices, environmental impact, nutritional health impacts, motivation, sustainable diets

INTRODUCTION

Food production and consumption are essential to societal wellbeing because they crucially affect human health and the environment (Stylianou, 2018). Imbalanced diets significantly contribute to early mortality and reduce the health status of individuals and health risk in high-income countries increasingly relate to over-consumption and obesity (Swinburn et al., 2019). Globally, 11 million lives and 255 million healthy years of life are lost annually due to dietary risk factors. The influential contributors were low intake of whole grains and fruits, and high consumption of sodium (Afshin et al., 2019). In the European context fast paced dietary shifts that increasingly deviate from dietary recommendations are major causes for non-transmittable diseases (McCarthy et al., 2013). For example, in Switzerland, over-consumption of unhealthy foods in combination with a lack of essential micronutrients causes serious health risks, which account for roughly one-third of the health costs, or 28 billion Swiss francs annually (Wieser et al., 2014).

The production of the foods furthermore has significant environmental consequences. Research suggest that agriculture and food processing accounts for 15–30% of global greenhouse gas emissions (GHG) (Popp et al., 2010; Blanco et al., 2014; Tilman and Clark, 2014; Willett et al., 2019). For Europe, estimates are more conservative ranging between 10% and 15% (Dace and Blumberg, 2016). In addition to GHG emission, agricultural production is associated with other environmental impacts such as; land and water use, ammonia contributing to fine particulate matter creation, nitrates and phosphate losses contributing to eutrophication, and lastly, pesticide emission contributing to ecotoxicological impacts (Aleksandrowicz et al., 2016). In a holistic life cycle approach taking into account various emissions into the air, surface- and groundwater, soil intake, resource extractions, waste production, and noise emissions, it was calculated that food production in Switzerland has the largest environmental impact, followed by housing and mobility (Frischknecht and Büsser Knöpfel, 2013). On the European level, the food sector contributes ~17% to EU household emissions with considerable variation from 11–32% across regions according to a study by Ivanova et al. (2017).

To reduce health and environmental burdens, the literature concordantly focuses on animal, and particularly meat products (Graça et al., 2015; Apostolidis and McLeay, 2016; de Boer et al., 2017). On the production side, climate-smart livestock systems offer chances to reduce GHG and other environmental emissions (Campbell et al., 2014; Havlík et al., 2014). On the consumption side, consumer studies point to the benefits of reducing meat consumption (Westhoek et al., 2014; Macdiarmid et al., 2016). For example, if the consumption of animal products is halved in the EU, premature mortality and disease morbidity [disability adjusted life years (DALY)] would decrease by 10%, and sectoral GHG emissions by 42% (Westhoek et al., 2014). However, reducing or abandoning animal production can also have drawbacks, such as the undersupply of protein for human consumption, excess of humanly inedible foods, the abandonment of non-arable lands, and a shortage of natural N fertilization (White and Hall, 2017). When considering

food-related health and environmental impacts, many factors such as overall dietary composition, product origins and standards, packaging and the degree of food processing may equally determine impacts. So far, studies focusing on healthy and sustainable dietary choices have been investigating the willingness to buy organic, local or regional products, low packaged products, or reducing meat consumption and sugar intake (Niva et al., 2014; Woythal, 2015; Zakowska-Biemans et al., 2019; Battle-Bayer et al., 2020). Although informative, these studies primarily investigate pro-environmentally friendly behaviors with few studies focusing on food-related practices that influence both human health and environmental impacts.

In this study, we aim to overcome this gap by linking the health and climate impacts of individuals' dietary habits to their motivations and broader societal factors. More specifically, our analysis aims at giving a better understanding of the drivers and barriers of healthy and sustainable eating in Switzerland. To do so, we address the following research questions:

1. What are the health and climate impacts of dietary habits in Switzerland?
2. What are the intentions of consumers regarding healthy and sustainable eating, and how do intentions relate to the actual health and climate impacts of individual diets?
3. Which interpersonal and societal factors drive or hinder healthy and sustainable eating?

We proceed as follows: the next section introduces the conceptual framework, followed by the method section, where we describe the data sources and statistical analyses. The results section provides estimates for dietary impacts, relates these to the respective intentions, and determines drivers and barriers for healthy and sustainable eating. Finally, in the discussion section, we deliberate on methodological choices, key findings and draw some policy implications, followed by a short conclusion.

CONCEPTUAL FRAMEWORK

To study healthy and sustainable eating in Switzerland, we use a conceptual framework that links reported dietary habits to nutritional health and environmental impacts and associates impacts with individuals' intentions and societal factors (**Figure 1**). This is implemented in three main steps. First, we calculate the life cycle environmental and nutritional health impacts of individuals' dietary habits. Second, we build on theory of planned behavior (TPB) to measure the individuals' intentions (Ajzen, 1985, 1991) regarding healthy and environmentally sustainable food consumption in order to allow for a comparison of intentions with behavioral outcomes. Thirdly, we test a set of broader sociocultural factors that were identified to play a major role in shaping eating habits for Switzerland based on a practice theory research approach (Godin and Sahakian, 2018; Sahakian et al., 2020) to test whether they drive or hinder healthy and sustainable eating. This study accordingly aims to link psychological and societal factors to environmental and health impacts associated with dietary habits taking a novel interdisciplinary approach (**Figure 1**).

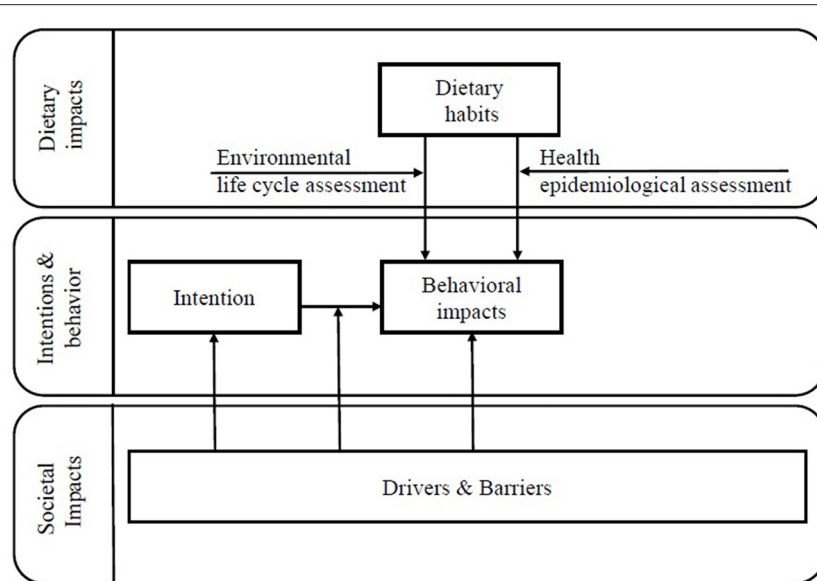


FIGURE 1 | Conceptual framework.

Dietary Impact Assessments

To determine the eating habits of Swiss consumers, we used a food frequency questionnaire developed by Willett et al. (1985) as one part of the household survey, which we conducted. Despite their different limitations, food frequency surveys allow collecting the information effectively for a given set of individuals, while dietary recall methods are more resource-intensive and not very suitable for capturing individuals' habits, and instead provide more accurate information at the aggregate level.

Different approaches exist to measure the nutritional performance and quality of eating habits. These approaches are typically classified in three main categories, namely:

- nutrient profiling indices such as Nutrient Rich Food (NRF) Index (Fulgoni et al., 2009) and Weighted Nutrient Density Score (WNDS) (Drewnowski et al., 2019);
- indices that measure adherence to dietary recommendations such as the Healthy Eating Index (HEI) and the Alternate Healthy Eating Index (AHEI) (Gil et al., 2015; Schwingshackl et al., 2018), and more recently;
- hybrid profiling approaches that take into account both nutrients and food groups (Drewnowski et al., 2019).

Although these approaches have been relatively good health indicators (Chiuve et al., 2012; Schwingshackl and Hoffmann, 2015; Wang et al., 2015; Onvani et al., 2017), they fail to adequately capture the healthiness and contribution of individual foods (Arvaniti and Panagiotakos, 2008), as well as to quantify health burdens. Epidemiology-based nutritional assessments can address these limitations and enable the systematic quantification of health burdens attributable to specific dietary risks. The Global Burden of Disease study series use this approach to estimate premature mortality and disease morbidity at population level

associated with 14 dietary risks that cover both, nutrients and food groups for which either high intake (e.g., sodium) or low intake (e.g., fruits) pose a health risk (Forouzanfar et al., 2016; Gakidou et al., 2017). Stylianou et al. (2016, 2021) introduced an approach using the epidemiologically based risk ratios of the global burden of disease to characterize the human health impacts of individual food items and consistently combined it with environmental Life Cycle Assessment (LCA). This approach was selected for the present study to calculate all human health impacts from diet or air pollution in terms of Disability-Adjusted Life-Years (DALYs), accounting for Swiss specific background mortality rates (Ernststoff et al., 2020).

We applied the LCA approach for assessing the environmental aspects associated with LCA inventory of environmentally relevant emissions and resource extractions to determine multiple environmental impacts (Guinée et al., 2001; Jolliet et al., 2003). In this part, we focused on global warming impacts, by calculating CO₂-equivalents associated with food production since data available broadly shows that most environmental impacts of foods are highly correlated with global warming impacts (Stylianou et al., 2021) and because carbon footprint is likely to be the ecological impact that consumers first think of when considering the environmental sustainability of their food choices.

Available studies focusing on consumers' behavior predominantly investigate proxies for sustainable eating rather than actual behavioral outcomes. For example, Tobler et al. (2011) propose six environmentally significant/relevant food consumption patterns and let people estimate their relative environmental benefits and their willingness to apply their consumption behavior. A similar approach has been pursued by Verain et al. (2015), who focused on two aspects of sustainable eating, namely product choices such as buying

organic or regional, and curtailment such as reducing meat consumption. Further attempts used factor analysis to identify clusters of pro-environmental eating behaviors (Verain et al., 2015; Zakowska-Biemans et al., 2019). In contrast to these approaches, we quantified the actual carbon footprint associated with the dietary habits of each participant.

Measuring Intentions Toward Healthy and Sustainable Eating

TPB was used to measure the intentions to eat healthy as well as environmentally sustainable. According to TPB, the intention consists of three main components namely:

- **Attitude**, which refers to the subjective utility evaluation, based on expected benefits related to the costs or burdens of the action;
- **Subjective norm**, which refers to the perceived strength of peer pressure toward performing a behavior;
- **Perceived behavioral control (PBC)**, which refers to the perceived ease or difficulties associated with implementing the behavior (Ajzen, 1991).

TPB is one of the best-validated models in behavioral psychology and has been extensively applied to predict environmentally sustainable behaviors (Armitage and Conner, 2001). Besides, TPB has also been used to investigate health-related intentions and behavior (Godin and Kok, 1996) and consumer food choices such as purchase intentions of regional products (Lorenz et al., 2015), genetically modified food (Cook et al., 2002), and for organic products (Magnusson et al., 2001; Tarkiainen and Sundqvist, 2005; Chen, 2007; Arvola et al., 2008; Scalco et al., 2017; Hansmann et al., 2020).

Societal Impacts

The societal impacts cover a set of variables describing food practice-specific, values, social norms, beliefs, and wants (Hess et al., 2018) that we expect to impact eating practice beyond individual levels intentions. Accordingly, we focused on values operationalized through four items of the new environmental paradigm known to have high internal consistency, as proposed by Dunlap and Van Liere (1978). We further applied the lifestyle typology suggested by Otte (2008), which distinguishes two axes: modernity and endowment. We considered modernity as a value property that could impact eating habits, while endowment is regarded as a dispositional variable. With regard to beliefs, we investigated the role of four dietary norms and their contribution to healthy and sustainable diets.

Concerning the material dimensions, our focus was on constraints for healthy and sustainable eating, notably restaurant offers, shopping opportunities, time, and money. We investigated how strongly people feel obstructed by these factors. Furthermore, we also considered socioeconomic endowment as proposed by Otte (2008) along with household income to determine healthy and sustainable eating.

The disposition of competence elements included individual skills and the respective beliefs that enable particular eating practices. We inquired dispositions and competencies for healthy

and sustainable eating through perceived behavioral control, self-reported level of knowhow on healthy and sustainable diets, and educational attainment. As further dispositional variables, we asked where people predominantly eat their meals and whether they are vegetarian or vegan. Finally, socio-demographic variables were included to elucidate their role in eating choices and associated environmental and health impacts.

MATERIALS AND METHODS

Data Collection

We relied on three primary data sources for this study: (i) A household survey conducted by the authors; (ii) nutritional health impact estimates based on data from the Global Burden of Diseases [Institute for HealthMetrics and Evaluation (IHME), 2019], and (iii) environmental impacts estimates relying on data from the Ecoinvent database (Steubing et al., 2016). The data on dietary habits, intentions, drivers, and barriers were all derived from the household survey conducted among Swiss households. To quantify the impacts of the observed consumption patterns, we combined the consumed quantities of each food group with epidemiological data for the nutrition related health impacts, and with corresponding life cycle inventory (LCI) data to quantify the carbon footprint of dietary patterns.

Household Survey

The questionnaire consisted of five main blocks. The first section asked about respondents' current dietary habits. Accordingly, we first asked participants how frequently they consume 12 particular foods that we selected concerning the three criteria: representativeness of national dietary patterns, coverage of caloric intake, and coverage of foods known to have, substantial health and environmental impacts. Accordingly, the food categories selected were processed meats, red meat, fish, whole grains, refined grains, vegetables, fruits, nuts and seeds, dairy products, sugar sweetened beverages (SBB), alcohol, and sweets/desserts. To support the self assessment and increase response comparability between participants, we provided pictures of portion sizes with the three most frequently consumed foods in Switzerland, as observed in a nationwide study with more than 2000 participants [Swiss Federal Food Safety and Veterinary Office (FSVO), 2019]. For example, for processed meat, the picture contained a plate with portions of 100 g each of a typical sausage ("Bratwurst"), salami, and meatloaf.

In the second section, the questionnaire asked if participants recently changed diet, and if applicable, investigated the motivations for doing so. The third section aimed at exploring eating places and particular needs behind food choices. Specifically, this section included questions such as "Where do you predominantly eat lunch/dinner?"; "How important do you deem the criteria 1-6 during lunch/dinner meals?" The criteria were assessed on a 5 point Likert scale. They included time saving (fast), taste (tasty), low costs (cheap), nutritional quality/healthiness (health), atmosphere (atmos), and to eat environmentally friendly (env. friendly). The fourth section contained questions aiming to measure the intention to eat healthy and sustainable. In this section, we used the direct

measure for attitude, subjective norms, and perceived behavioral control, as discussed by Francis et al. (2004). This section also comprised questions on material dimensions. Asking how strongly the participant felt restricted on a 5 point Likert scale in their attempt to eat healthy and sustainable by knowledge (knowhow), restaurant offers (restaurants), shopping opportunities (shopping), time to cook (time), and budget restrictions (money).

Furthermore, this section asked whether people agreed that organic product based diets (natural), local product based diets (regio), vegetarian diets (veg), or fruits and vegetable (fruit&vegi) based diets are particularly healthy and sustainable using a 5 point Likert scale. To measure the pro environmental values of individuals, we included the four out of the 12 items that were shown to have the highest internal consistency in the new environmental paradigm proposed by Dunlap and Van Liere (1978). Further questions investigated the association and evaluation of food labels such as regional and organic, and the issues to operationalize the lifestyle typology according to Otte (2008). In the final section, we asked participants about their situation concerning socio economic status, education, household situation, and cultural and national background.

The household survey was conducted online between August 8th and September 16th of 2018. We invited 3,000 households drawn from the Federal Statistical Office (FSO) of Switzerland. We followed a stratified sampling approach, over representing people that have recently changed address, and families with newborns. We stratified the sample as for these criteria as they are known to affect food consumption (Cliff et al., 2019). Each of the two strata consisted of 900 households. Households were invited by postal mail to participate in the online survey. The invitation letter encouraged the person most responsible for food shopping and cooking in the family to complete the survey. The invitation letter contained a link to the online survey, a personalized identification code and a password. After four weeks, we sent a reminder, finally enabling us to collect 620 responses after six weeks duration.

Health Epidemiological Assessment

To evaluate the nutritional health impacts associated with dietary habits, we adapted the Health Nutritional Index (HENI) proposed by Stylianou (2018), Stylianou et al. (2021) to develop a Swiss-specific Nutritional Index (DANI). DANI quantifies the health burden from all-cause of premature mortality and disease morbidity associated with 16 dietary risks, that are expressed in disability adjusted life years (DALYs) per reference amount of food. The beneficial health risks considered in DANI are milk, nuts and seeds, vegetables, legumes, fruits, whole grains, calcium, fiber, omega-3 fatty acids from seafood, and polyunsaturated fatty acids (PUFA), that are presently under-consumed. The list of dietary risks with detrimental health effects includes processed meat, red meat, sugar-sweetened beverages (SSB), sodium, trans-fatty acids (TFA), saturated fatty acids (SFA), and alcohol, that are presently over-consumed. Dietary risks include 15 risks identified by the Global Burden of Disease (GBD) plus saturated fatty acids (mediated through estimated increase in blood cholesterol). The risks are characterized by a series of

dietary risk factors (DRFs) that expressed in DALYs/g quantify the damage or benefit associated with the consumption of 1 g of the considered risk component. Positive estimates indicate that the risk is generating health burden, while negative estimates indicate that the risk component is associated with avoided health burden (e.g., health benefit). Multiplying for each representative food its typical decomposition into the risk components (in. e.g., $g_{\text{processedmeat}} / 100 g_{\text{food}}$) by the corresponding DRFs (e.g. $0.40 \mu\text{DALYs}/g_{\text{processedmeat}}$) yields the quantified DANI scores per 100 g, expressed in $\mu\text{DALYs}/100 g_{\text{food}}$, for each of the representative food. For example, 100 g of salami contains $77 g_{\text{processedmeat}}$, which yields $77 \times 0.40 = 31 \mu\text{DALYs}$ (i.e., ~ 16 min) lost per $100 g_{\text{salami}}$ due to processed meat alone.

Additionally, DRFs do not apply to the considered dietary risk when outside of a dynamic range of intake, i.e., when the inputs of a given risk component are below (detrimental effect, e.g., no health damage for the first 2.9 g/d consumed of processed meat) or above (protective effect, e.g., no additional benefit for fruit consumption above 250 g/d) certain levels of consumption, known as theoretical minimum risk level (TMLRs, **Table 1**), obtained from the Global Burden of Disease studies (Gakidou et al., 2017). We have, therefore, tested each dietary patterns and restricted the application of the DRFs to the dynamic range of intake.

Environmental Lifecycle Assessment

The daily consumption of foods in the diet (in units of kg/d per food type) is used as the functional unit (FU) of the LCA based results. The system boundary of the LCA-based results considers the food production stage (i.e., at farm, and when relevant at slaughterhouse, or at production facility) and datasets were chosen to represent production on a generic, globally sourced market (however, cheese was assumed to be from European production). Without further detailed information on the location and supply chain of foods consumed in the diet, as a screening exercise, the impacts of other life cycle stages such as packaging, logistics, storage and preparation (e.g., from retail and at-home) were excluded and in some cases may be similar per kg across products. Food waste values (including in-home waste) were considered to adjust the amount of food production required to fulfill the FU, given evidence of relatively high and variable waste rates for various food types in Switzerland. CO₂ equivalents were used as the comparative metric to indicate environmental impact. To compute the environmental impacts of individuals' diets, we referred to CO₂-equivalent emissions available in the LCI from the Ecoinvent 3.6 database (Steubing et al., 2016) and the World Food Database (<https://quantis-intl.com/metrics/databases/wfdb-food/>). We accounted for food losses according to Beretta et al. (2017), excluding packaging (Zampori and Pant, 2019). We refer to Swiss data sets were available and to EU datasets for proxies. We used the inventory for the representative products shown during the survey, weighted by their respective consumption averages from menuCH-study dataset [Swiss Federal Food Safety and Veterinary Office (FSVO), 2019] to determine one representative inventory per surveyed food category. The climate change midpoint impacts scores expressed in kg CO₂-eq/kg-food were

TABLE 1 | Self-reported intake of twelve foods normalized for a 2,000 kcal diet and corresponding nutritional health and environmental impacts. Foods listed from most detrimental to most protective.

Product	Consumption 2,000 kcal		Health impacts					Environmental impacts	
	Mass (g/day) Mean (SD)	Calories (kcal/day) Mean (SD)	TMLR (g/day)	Per 100 g below TMLR (μ DALYs/100 g)	Per 100 g above TMLR (μ DALYs/ 100g)	For amount consumed impact (μ DALYs /person-d) Mean (SD)	Max. benefit at TMLR (μ DALYs /person-d)	Production impact (kg CO ₂ - eq/100 g)	Consumption Impact (kg CO ₂ -eq/ person-d) Mean (SD)
Processed meat	49.1 (45.7)	139.2 (129.7)	2.86	11.92	39.66	18.75 (18.05)		1.27	0.62 (0.58)
Sweets and desserts	74.5 (56.4)	261.4 (197.8)	.	7.76	7.76	5.78 (4.38)		0.23	0.17 (0.12)
Sugar sweetened beverage	178.8 (310.5)	68.0 (118.0)	2.61	0.00	2.89	5.17 (8.97)		0.02	0.04 (0.07)
Alcohol ^(a)	11.5 (13.9)	186.1 (226.1)	5.00	0.00	61.91	4.91 (8.00)		0.34	0.04 (0.04)
Red meat	58.6 (54.0)	71.9 (66.2)	24.64	4.71	8.74	4.34 (4.53)		2.03	1.19 (1.10)
Refined grains and starches	134.5 (90.5)	306.1 (206.0)	.	1.96	1.96	2.64 (1.78)		0.17	0.23 (0.15)
Dairy	327.6 (194)	346.7 (205.3)	818.87	0.77	1.36	2.52 (1.53)		0.45	1.46 (0.86)
Fish and seafood	33.5 (37.7)	45.6 (51.4)	36.94	-25.91	1.27	-5.23 (3.57)	-9.57	0.58	0.20 (0.22)
Whole grains	90.9 (80.4)	220.9 (195.2)	243.69	-7.45	2.37	-6.48 (5.31)	-18.15	0.28	0.25 (0.22)
Vegetables	249.1 (187.2)	60.5 (45.5)	364.35	-4.16	0.60	-8.67 (4.65)	-15.15	0.06	0.16 (0.12)
Nuts and seeds	23.8 (27.4)	125.7 (144.7)	20.51	-85.37	-6.24	-11.70 (7.57)	-17.51	0.15	0.03 (0.04)
Fruits	259.9 (167.1)	167.9 (107.9)	250.00	-11.21	-0.32	-21.91 (7.44)	-28.03	0.03	0.08 (0.05)
Total (n = 597)						-9.88 (36.99)	-88.42		4.47 (1.51)
Female (n = 315)						-20.80 (33.66)			4.20 (1.29)
Male (n = 282)						2.32 (36.78)			4.78 (1.51)
Vegan (n = 5)						-55.98 (21.26)			1.48 (0.20)
Vegetarian incl. pescetarian (n = 30)						-52.12 (23.42)			2.59 (0.66)

Positive μ DALY values refer to detrimental effects (increased number of years of life disabled and of years of life lost due to early mortality: 1 μ DALY = 0.526 minutes of healthy lifespan lost, considering that there are 0.526 million minutes in a year). In contrast, negative μ DALY values refer to avoided health burdens and prolonged lifespan.

then calculated using the latest IPCC 2013 GWP100 with carbon feedbacks to convert the various greenhouse gas emissions such as methane or carbon dioxide into a single impact measure (Joliet et al., 2018).

Statistical Analysis

Computing Dietary Impacts

The food items surveyed were expected to capture approximately 75% of total daily caloric intake assuming an average intake of 2,000 kcal/day per day. However, people underreported their consumption as their self-assessment suggested an average

daily caloric intake of about 1,200 kcal/day. Comparing the information from the survey against the observation made in the menuCH-study (Chatelan et al., 2017) showed that underreporting occurred systematically across all foods in the range of 15-30%. Therefore, we normalized the reported consumption for a 2,000 kcal/day diet before computing the impacts.

To estimate the health burden and protective effects of individuals' diets, we used the DRFs and the respective threshold displayed in **Table 1**. This allowed us to directly calculate health impacts associated with the consumption of fruits, nuts and

seeds, processed meats, red meat, sugar-sweetened beverages (SBB), and vegetables. For alcohol, dairy, desserts, fish, refined, and whole grains, we computed the health impacts for the three particular products presented in the survey. We then computed averages of DANI scores per 100 g based on Swiss consumption patterns [Swiss Federal Food Safety and Veterinary Office (FSVO), 2019]. This data allowed us to derive the consumption-related health impacts per 100 g considered food.

To compute the environmental impacts of individuals diets, we compiled the life cycle carbon footprint of each food group accounting for the detailed production process, expressing global warming impacts in CO₂-equivalents (kg CO₂-eq/kg). The consumption weighted impacts of the three most representative foods per category according to Swiss consumption patterns [Swiss Federal Food Safety and Veterinary Office (FSVO), 2019] are displayed in **Table 1**.

Computing Intentions and Behavior

We computed both healthy and sustainable eating intentions as principal components from the attitude, subjective norm, and perceived behavioral control. We thereafter proceeded with normalized values for the intentions. To investigate the relationship between intention and behavior, we computed the correlation coefficients between the intention and the health and environmental impacts. Furthermore, we performed a Wilcoxon rank-sum test to compare the intention components for healthy and environmentally sustainable eating.

Statistical Analyses of Drivers and Barriers

To better understand what motivates eating decisions, we performed non-parametric tests to compare the importance of the different wants, beliefs, material dimensions (constraints), and intentions. Accordingly, we performed a Friedman test, followed by Kruskal-Wallis and Paired Wilcoxon sign-rank sum test for *post hoc* estimation to investigate which wants, beliefs and constraints affect people's eating habits.

To analyze drivers and barriers toward healthy and sustainable eating, we performed regression analyses on intentions, behavior, and its gap with motivational predictors described above. For both healthy and sustainable eating we used the same set of predictors. In contrast, the gap between intention and behavior are the residuals from linearly regressing the computed intention on impacts. We also controlled the sociodemographic characteristics and regional differences in the regression models. The models were tested for multi-collinearity, omitted variable bias, and heteroscedasticity. In response to the latter, we performed robust regressions.

Household Sample Description

The sample for this study was relatively gender-equal, with 52% female respondents. The average age of the participants was 45 years (sd = 15 years). Most participants were either married (39%) or lived in stable relationships (27%), while a significant amount also identified as singles (22%). Other statuses, such as widowed, accounted for the rest (12%). The median annual household income category ranged from 60'001 – 88'000 CHF while the average household consisted of ~2.4 persons. The

regional distribution of the surveyed households consisted of 68% from the German-speaking part, 27% from the French-speaking, and 5% from the Italian-speaking part. In terms of rural-urban representation, we sampled 30% of individuals living in urban areas, 47% in suburban, and 27% living in rural areas. The socio-demographic characteristics of this sample appropriately represent the Swiss population with regards to variables such as age (mean = 42.2 years), marital status (married = 42%) (Federal Statistical Office (FSO), 2018a), household income (mean = 90'790 CH) (Federal Statistical Office (FSO), 2018b), and regional distribution (German 67%, French 24%, Italian 8%) (Federal Statistical Office (FSO), 2019).

RESULTS

Behavioral Impacts

Average Diet

Considering a normalized diet of 2,000 kcal per day diet, the most consumed products were dairy products with 327.6 grams per day (g/d), followed by fruits with 259.9 g/d, and vegetables, with 249.1 g/d. The least consumed food items were nuts and seeds with 23.8 g/d, followed by fish and seafood 33.5 g/d (see **Table 1**, left).

Nutritional impacts per 100 g are high for processed meat and alcohol (**Table 1**, middle), but cannot be directly compared across food groups since consumed amounts vary widely. When considering the amount of each food group consumed, the nutritional health burdens are by far the highest for processed meat, accounting on average for 19 μ DALYs /person-d, or almost half of the total detrimental dietary health burden. The other disadvantageous foods accounted for much lower health burdens ranging between 6 and 2.5 μ DALYs /person-d. The products providing the most health benefits per 100 g were nuts and seeds, fish seafood, and fruits when consumed below the TMLR threshold (**Table 1**). When combining these nutritional impacts per 100 g with the amount consumed, fruit consumption provided the highest health benefits due to high intake, followed by nuts and seeds and vegetables. When the average consumption for fruits is close to the threshold value as well as optimal consumption levels, individuals could realize more health benefits by tripling their intake of the whole-grain. Overall, the total of the detrimental effects in the average diet of 44 μ DALYs /person-d are more than compensated by the impact of beneficial foods of -54 μ DALYs /person-d to yield a net benefit of -10 μ DALYs /person-d (**Figure 2**).

Regarding production- and provision-related GHG emissions, red meat followed by processed meat is associated by far with the most significant carbon footprint per 100 g, with 2.03 and 1.27 kg CO₂-eq/100 g. The meats are followed by fish and dairy with 0.58 and 0.45 kg CO₂-eq/100 g respectively. In contrast, vegetables, fruits, and non-alcoholic beverages are produced with little carbon footprints (**Table 1**), produced in heated greenhouses or transported over long distances. Although meat, particularly red meat, had a much higher carbon footprint per 100 g than dairy, dairy accounted for the most significant overall carbon footprint because of the high intake of dairy products in the Swiss diet. Therefore, the red meat-related carbon footprint per

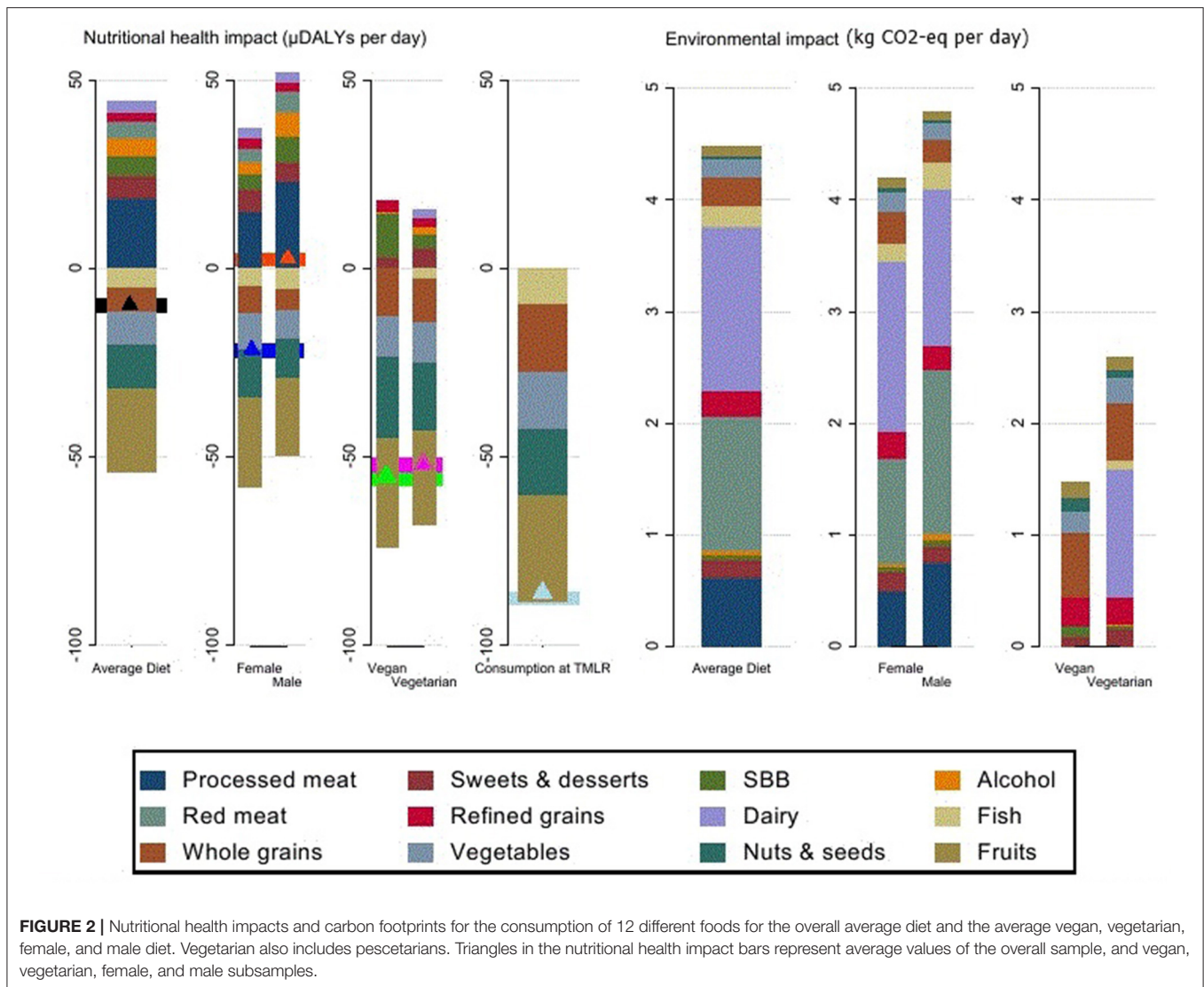


FIGURE 2 | Nutritional health impacts and carbon footprints for the consumption of 12 different foods for the overall average diet and the average vegan, vegetarian, female, and male diet. Vegetarian also includes pescetarians. Triangles in the nutritional health impact bars represent average values of the overall sample, and vegan, vegetarian, female, and male subsamples.

day was second with a slightly lower impact, while processed meat came third with half the effect of dairy. Overall, these three animal product categories cause almost three-quarters of the carbon footprint in an average Swiss diet, which amounts to 4.5 kg CO_{2-eq}/person-d.

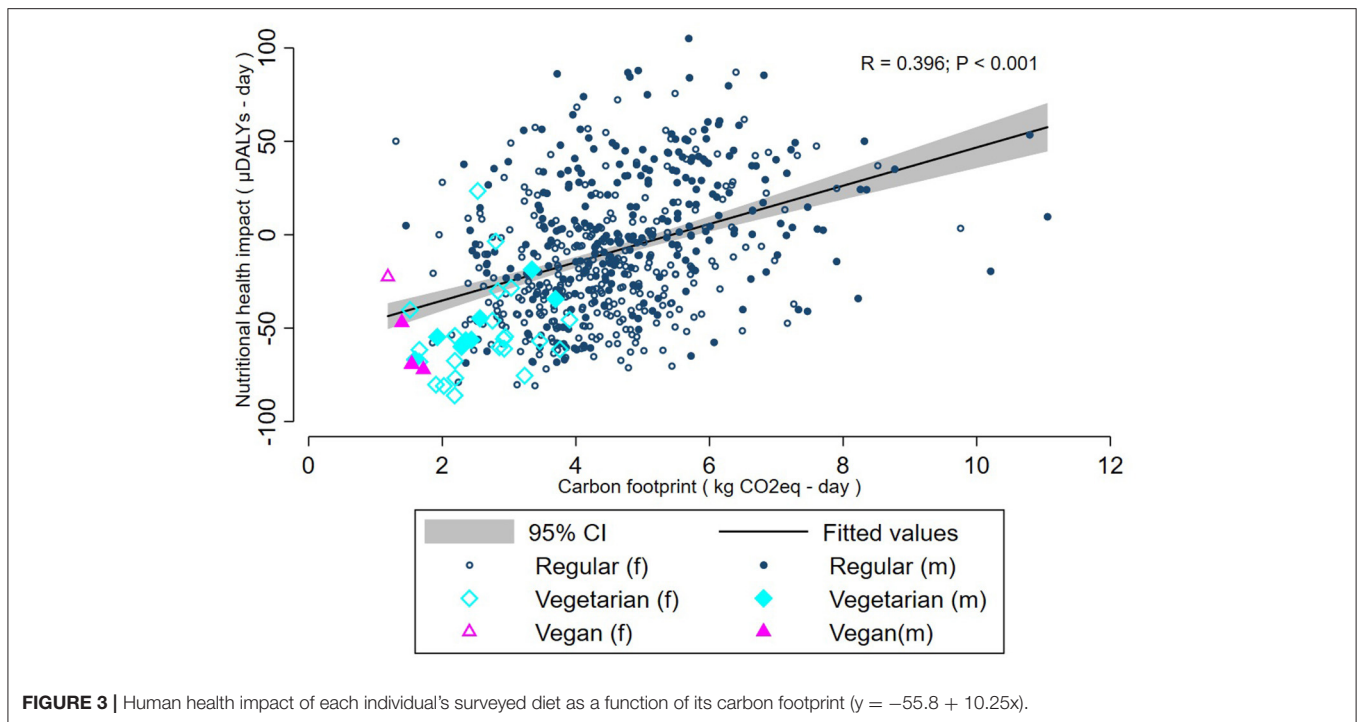
Gender Differences

Table 1 shows significant differences in nutrition between the genders. By comparison, females (-21 µDALYs/d) were found to eat substantially healthier than males that have a close to neutral but slightly detrimental health impacts of their diet (+2 µDALYs-d), thus a difference of 23 µDALYs-d between genders. Figure 2 shows that this is due to higher consumptions of processed meat, red meat, alcohol beverages and sodas by males and slightly lower intakes of whole grain, vegetable and fruits. For the environmental impacts, females (4.2 kg CO_{2-eq}/d) also have lower carbon footprints than males (4.78 CO_{2-eq}/d). Still, the difference of 12% is relatively restricted as it only captures the

relative composition of the diets and not the differences in the amounts consumed due to the normalization of the diets.

Vegetarian, Vegan, and Optimal Diet

As animal product consumption in Switzerland accounts for a significant amount of health burdens and carbon footprint, vegetarian (including pescetarian) and vegan diets had remarkably lower impacts on both health and the environment (Figure 2). The estimates showed that (compared to the average Swiss diet), vegan and vegetarian diets yielded a very similar additional nutritional benefit of more than 40 µDALYs-d which is 23 min of healthy life gained per day, or an extra 1.4 years of healthy life over a lifetime of 85 years (2% increase). This is mostly due to the suppression of processed and red meat in these dietary regimes and increased intakes of nuts and seeds and whole grains, and to a lesser extent with fruits and vegetables. The optimal nutrition to maximize health benefits occurs when the entire population consumes only protective food at maximum



beneficial TMLR level, for example 250 g/d of fruit, which represents the amount above which there is no additional benefit.

The first bar in **Figure 2**, shows a potential of $-88 \mu\text{DALYs-d}$ gained, thus $78 \mu\text{DALYs/d}$ is better than the average diet, corresponding to 40 min of life saved per day. Compared to the vegetarian and vegan diet, the additional benefits of the optimal diet are mostly due to further increases in whole grains and vegetable intakes. For the environmental impacts, **Figure 2** reveals similar patterns. Vegan and vegetarian diets caused significantly lower impacts than regular diets, but while being almost equal on health impacts, a vegan diet was found to be more environmentally sustainable than vegetarian diets. A vegetarian diet enables a 42% reduction in carbon footprint, whereas the vegan diet enables us to reach a 67% reduction in carbon footprint compared to the average Swiss diet (**Table 1**). These estimates correspond to annual GHG impacts of 1.6 tons $\text{CO}_2\text{-eq/person-yr}$ for the average Swiss diet and around 0.95 tons $\text{CO}_2\text{-eq}$ for a vegetarian and pescetarian diets. These impacts are comparable with estimates for Finland and the Netherlands which range between 0.9 and 1 ton annually for a vegetarian diet and 1.4 to 1.7 tons of CO_2eq for an average diet (Risku-Norja et al., 2009; van Dooren et al., 2014). Further details on the contribution of surveyed foods to health and environmental impacts are displayed in **Figure 2**.

Figure 2 shows the very substantial variations in nutritional and environmental impacts of individual diets across the 597 surveys considered. Nutrition impacts range from the optimal-like beneficial diet of $-90 \mu\text{DALYs/person-d}$ gained up to $100 \mu\text{DALYs/person-d}$ of healthy life lost – a potential difference between extremes of 6 years in life expectancy just due to nutrition. Similarly, dietary carbon footprint varies widely by more than a factor 10, from $1 \text{ kgCO}_2\text{-eq/person-d}$ up to close

to $11 \text{ kgCO}_2\text{-eq/person-d}$ for an individual with the largest footprint. The correlation between the health burdens and carbon footprint revealed that health and environmental impacts are coupled in Swiss diets, as indicated by a Pearson's $r = 0.396$, $p < 0.001$ (**Figure 3**), with an average co-benefit of $9 \mu\text{DALYs/kgCO}_2\text{-eq}$ reduced.

Therefore, a healthy diet tends to be a somewhat environmentally sustainable and vice versa, but with significant individual variations. Accordingly, a reduction of $1 \text{ kgCO}_2\text{-eq/-d}$ in anyone's diet is to lower health burdens by $10.25 \mu\text{DALYs/person-d}$, which is equal to around 5 min of healthy life gained as co-benefit from saving $1 \text{ kgCO}_2\text{-day}$. However, vegan and vegetarian diets (diamond and triangle, **Figure 3**) score much lower on both impact dimensions, and thus provide a reliable blueprint toward healthy and sustainable diets, which has also been observed for the Netherlands (van Dooren et al., 2014).

Intentions and Behavior

Comparison Between Intentions for Healthy and Environmentally Sustainable Eating

Comparing intentions showed that the intentions to eat healthy are much more pronounced than for environmentally sustainable eating. Attitudes, subjective norms, and perceived behavioral control were all significantly higher on average and more substantial for a healthy eating than for environmentally sustainable eating. Although two-thirds show equal intentions in this regard, on the third emphasizes healthy eating. At the same time, only 6% have stronger intentions for an environmentally sustainable diet than for healthy eating (**Table 2**).

Therefore, health concerns dominated over environmental concerns in food choices. However, the intentions to eat

healthy were also highly correlated with the intentions to eat environmentally sustainable ($r = 0.648$; $p < 0.001$), which suggests that health and environmental concerns are firmly linked, although the latter is given less emphasis.

Do Intentions for Healthy and Environmentally Sustainable Eating Translate Into Actual Healthy and Sustainable Behavior?

Correlating intentions with respective environmental and health impacts showed that intentions lower impacts for healthy

eating, but not for environmentally sustainable eating. As displayed in **Figure 4**, the intention to eat healthy transmits into actual behavior ($r = -0.379$; $p < 0.001$), which shows that for Switzerland, individuals with stronger intentions achieve healthier eating. For example, the 10% percentile with the lowest intentions risked $20 \mu\text{DALYs/d}$ while the percentile with the most definite intention gained $23 \mu\text{DALYs/d}$, which is a difference of 1.3 years of healthy lifespan. Vegetarians and vegans eat much healthier diets, even if they scatter rather equally around mean intentions, meaning that they do not differ much in intentions, but release significant health benefits through their dietary regime.

In contrast to the case of healthy eating, the intention to eat environmentally sustainable is not associated with lower impacts ($r = -0.067$, non-significant). The 10% group with the lowest intention realizes almost the same carbon footprint, namely $4.62 \text{ kg CO}_2\text{-eq}$ as the 10% group with the most definite intentions $4.68 \text{ kg CO}_2\text{-eq}$. Therefore, intentions didn't contribute to more environmentally sustainable diets. In contrast, vegetarian and particularly vegan diets resulted in much more environmentally sustainable diets, despite that vegans and vegetarians seem to have only moderately stronger intentions as they skew slightly to the right-hand side of the zero (mean) value of the Intention in **Figure 4** (right hand). Overall, we find clear evidence that the intention to eat healthily transforms better into behavior than the intention to eat environmentally sustainable.

TABLE 2 | Comparing the intention and its components for healthy eating (H) with those for an environmentally sustainable diet (E) by Wilcoxon rank-sum test.

	H > E	E > H	ties	Significance (2-tailed)
Attitude ($n = 616$)	220	39	357	$P < 0.001$
Subjective Norm ($n = 612$)	203	33	376	$P < 0.001$
Perceived Behavioral Control ($n = 612$)	208	19	385	$P < 0.001$
Intention ($n = 605$)	198	36	378	$P < 0.001$

$H > E$ indicates the number of individuals with higher rank scores for healthy than for env. sustainable eating.

$E > H$ indicates the number of individuals with higher scores toward env. sustainable eating.

Ties indicate that the values toward healthy eating are the same as toward env. sustainable eating for that number of individuals.

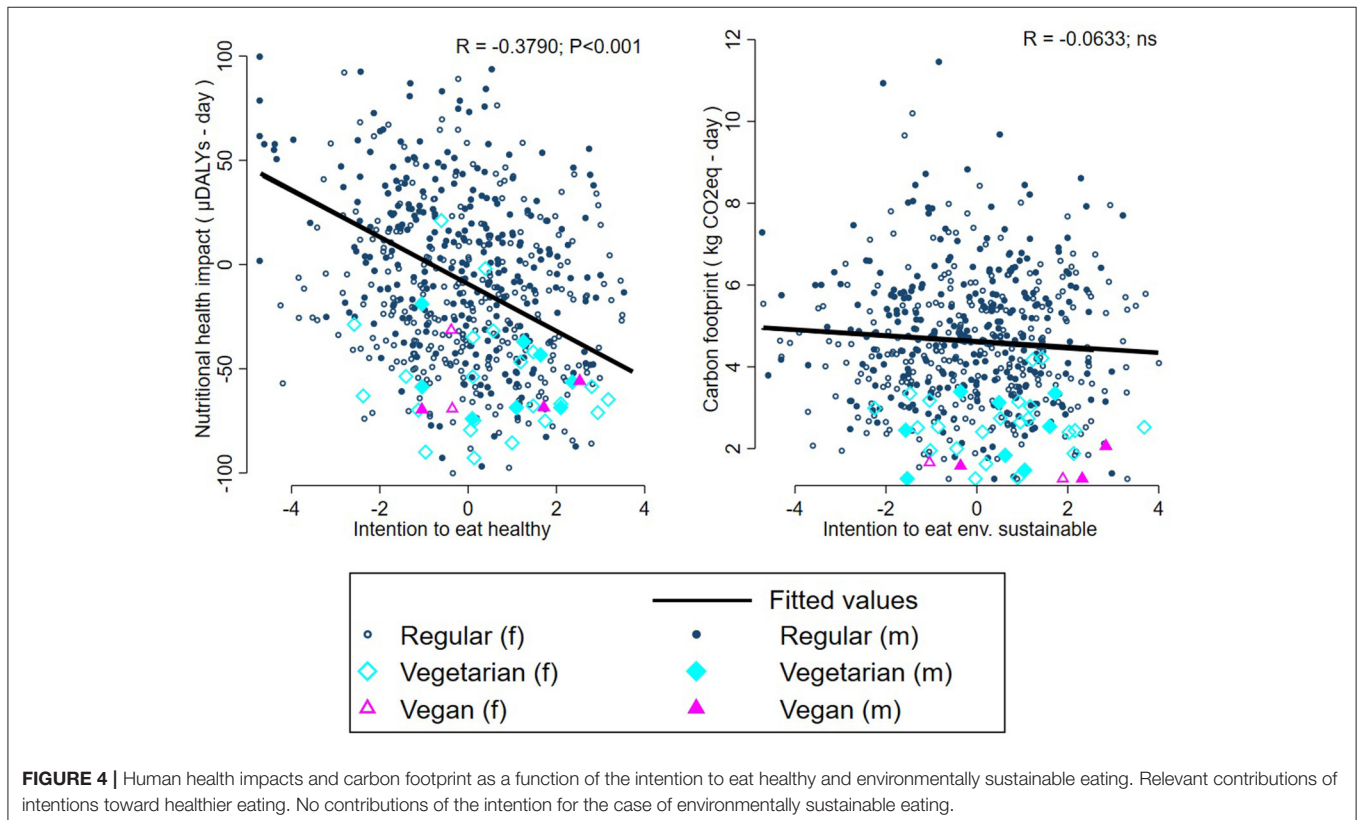


TABLE 3 | Non-parametric tests for identifying priorities in wants, beliefs and perceived constraints related to food choices and particular for healthy and environmentally sustainable eating for the beliefs and constraints.

Rank	(1) Wants			(2) Beliefs			(3) Constraints			
		Gr	Healthy	Gr	Sustainable	Gr	Healthy	Gr	Sustainable	Gr
1	Tasty	a	Vegi & Fruit (h)	a	Regional (e)	a	Time (h)	a	Know (e)	a
2	Healthy	b	Organic (h)	b	Organic (e)	b	Money (h)	b	Money (e)	b
3	Atmos	c	Regional (h)	c	Fruit & Vegi (e)	c	Know (h)	c	Time (e)	c
4	Envfri	d	Veg (h)	d	Veg (e)	d	Shop (h)	d	Shop (e)	d
5	Cheap	e					Rest (h)	e	Rest (e)	d
6	Fast	e								
χ^2	973.59***		802.90***		127.68***		237.13***		152.22***	

Kruskal-Wallis tests for identifying if individuals differ in wants, beliefs, and constraints for healthy and environmentally sustainable eating. Significance of Chi-square tests indicated by asterisk (***) = $p < 0.001$. Friedman rank-sum test to identify cluster priorities. Different letters indicate significant differences in rank sums at $p < 0.05$. Letters in brackets indicate that questions were asked specifically about healthy (h) and environmentally sustainable (e) eating.

Practices and Priorities Toward Healthy and Sustainable Eating

A Friedman rank sum test suggests that participants attached significantly different emphasizes on the wants, beliefs, and perceived constraints for healthy and sustainable eating. Therefore, *post hoc* estimates were applied to cluster the priorities. With regards to desires, the taste is of first, the health of second, the atmosphere of third, and environmentally friendliness the fourth priority. To eat cheap and fast were of least priority, and did not differ significantly (Table 3). Therefore, hedonic satisfaction dominates over practical desires when people make their eating choices.

Concerning beliefs, a vegetarian and fruit-based diet is deemed to be particularly healthy, while local product based diets are considered particularly environmentally sustainable. Organic products based diets are considered both beneficial for health and the environment. Strikingly, the vegetarian diet is considered to offer the least health and environmental benefits (Table 3), whereas it has the highest benefit in practice (Table 1, Figure 2).

When asking individuals how strongly they are constrained in their attempts to eat healthy and sustainable, time constraints for healthy eating and knowhow for environmentally friendly eating achieved the highest scores. Furthermore, money was also considered an essential constraint toward both healthy and sustainable eating. The least important constraints, were the availability of shop and restaurant offers. The two were the only constraints that did not differ significantly for the case of environmentally sustainable eating (Table 3). This suggests that the survey participants felt more constrained by their personal resource endowment – time, money, and knowhow – rather than by infrastructural factors.

Drivers and Barriers Toward Healthy and Sustainable Eating

Regressions Models Explaining Healthy Eating

Overall, the most reliable driver for healthy eating appeared to be attitude (subjective utility from healthy eating), as indicated by the standardized Beta in Table 4, Model 2. Interestingly, the

subjective norm (perceived peer pressure) was weakly negatively associated with healthy eating, suggesting that individuals with less healthy habits experience more social pressure to eat healthier.

For the beliefs, we find that intentions to eat healthily were more influential in individuals considering organic products and fruit and vegetable-based diets to contribute to healthy eating (Table 4, Model 1). These beliefs also contributed to moderately healthier diets. More importantly, the belief that a vegetarian diet is particularly healthy did not relate to stronger intentions but contributed actively to healthier eating habits. Hence, the belief in vegetarian diets leads to relatively healthier eating than intended, as indicated by the significant positive effect in the gap model (Table 4, Model 3). Similar, but less pronounced effects can be observed for the belief in vegetable and fruit rich diets.

With regard to material dimensions, we found that emphasis on cheap meals leads to unhealthy eating and contributed to the intention-behavior gap. The intention to eat healthily is more pronounced in individuals that favor a pleasant atmosphere and environmentally friendly eating, but only the emphasis on environmentally friendly eating contributed to healthier diets.

For dispositions, we found that education formed intentions, and lead to healthier eating, even beyond intentions, as indicated by the coefficient in the gap-model. Furthermore, perceived behavioral control was positively associated with healthy eating, as TPB suggests. Perceived budget restriction [Money (h)] was found to be associated with significantly healthier diets, possibly because individuals feel relinquished from buying higher-priced labeled products, which does not necessarily lead to healthier eating. Furthermore, socio-economic endowment and vegetarian and vegan diets contributed to significantly healthier eating habits. The model suggests that *ceteris paribus*, a vegetarian/vegan diet, saves at least 20 μ Dalys/person-d, which is much beyond the relative intentions of vegans and vegetarians.

For the socio-demographic variables, we found that higher Body-Mass-Index (BMI) was associated with unhealthier diets. Furthermore, regression models confirm a significant gender gap for healthy eating, which is by far the most significant

TABLE 4 | Linear regression analysis explaining the intention, behavior, and the gap between the two regarding healthy eating.

Healthy eating	(1) Intention		(2) Behavior		(3) Gap	
	β	Std. β	β	Std. β	β	Std. β
Sociocultural dimensions						
Attitude (h)			-12.22***	(-0.23)		
Subjective Norm (h)			3.13*	(0.07)		
Pro-env. values	0.03	(0.01)	-0.34	(-0.01)	-0.02	(-0.01)
Modernity	0.12	(0.04)	1.52	(0.02)	0.05	(0.02)
Beliefs						
Organic (h)	0.14**	(0.11)	-3.09*	(-0.08)	-0.06	(-0.06)
Regional (h)	0.08	(0.06)	0.09	(0.00)	0.01	(0.02)
Vegetarian (h)	-0.05	(-0.04)	-4.12***	(-0.12)	-0.14***	(-0.16)
Veg&Fruit (h)	0.16**	(0.11)	-4.69***	(-0.11)	-0.10**	(-0.09)
Material Dimensions						
Fast	-0.02	(-0.03)	0.84	(0.04)	0.03	(0.07)
Tasty	0.06	(0.07)	0.93	(0.04)	0.03	(0.05)
Cheap	-0.05	(-0.07)	1.74**	(0.09)	0.04*	(0.09)
Atmosphere	0.12***	(0.16)	0.38	(0.02)	0.03	(0.06)
Env. friendly	0.14***	(0.22)	-2.16***	(-0.12)	-0.04*	(-0.08)
Dispositions						
Education	0.10**	(0.09)	-4.11***	(-0.13)	-0.10***	(-0.13)
Perc. beh. control (h)			-5.47***	(-0.12)		
Knowhow (h)	-0.00	(-0.00)	1.27	(0.05)	0.04	(0.05)
Lunch-home	0.04	(0.02)	-0.90	(-0.01)	-0.00	(-0.00)
Restaurants (h)	-0.04	(-0.04)	1.06	(0.04)	0.02	(0.03)
Shopping (h)	0.01	(0.01)	-2.09*	(-0.08)	-0.07**	(-0.10)
Time (h)	-0.02	(-0.02)	1.16	(0.04)	0.03	(0.04)
Money (h)	0.01	(0.01)	-3.33***	(-0.12)	-0.08**	(-0.12)
Endowment	0.21**	(0.10)	-6.23**	(-0.10)	-0.14*	(-0.09)
Income	-0.05	(-0.06)	0.73	(0.03)	0.02	(0.03)
Vegan/Vegetarian	0.27	(0.05)	-20.17***	(-0.13)	-0.52***	(-0.13)
Sociodemographics						
BMI	-0.01	(-0.02)	0.72**	(0.08)	0.02**	(0.09)
Age	0.01	(0.07)	-0.06	(-0.03)	0.00	(0.00)
Gender (Male)	-0.05	(-0.02)	16.23***	(0.23)	0.44***	(0.25)
Marital status	-0.09	(-0.03)	-0.88	(-0.01)	-0.01	(-0.00)
Household size	0.16***	(0.12)	1.84	(0.05)	0.07	(0.07)
Region (fr)	0.53***	(0.19)	-0.68	(-0.01)	0.08	(0.04)
Region (it)	0.90***	(0.17)	-0.48	(-0.00)	0.10	(0.02)
Constant	-4.87***	(.)	86.50***	(.)	0.09	(.)
Observations	520		505		505	
R-squared	0.31		0.44		0.29	

Robust normalized beta coefficients in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

contributor to the gap between intention and behavior. Even if there were no difference in the intentions, the male would eat unhealthier, which significantly contributes to the gap between intention and behavior. The model suggests that females manage to save almost 16 μ Dalys a day compared to males. Equally, we find that people in the French and Italian speaking parts have stronger intentions but no regional difference exist in actual impacts.

Regression Models Explaining Environmentally Sustainable Eating

For environmentally sustainable eating, we found that attitudes and subjective norms didn't relate to behavior (Table 5, Model 2), confirming the tendencies observed in Figure 4. This follows as its composite, the intention, did not relate to behavior either. General pro-environmental values contributed toward forming intentions (Table 5, Model 1), but did not affect behavior.

TABLE 5 | Regressions analysis explaining the intention, behavior, and the gap between the two regarding environmentally sustainable eating.

Environmentally sustainable	(1) Intention		(2) Behavior		(3) Gap	
	β	Std. β	β	Std. β	β	Std. β
Sociocultural dimensions						
Attitude(e)			-0.14	(-0.08)		
Subjective Norm(e)			0.14*	(0.09)		
Pro-env. values	0.18**	(0.09)	-0.02	(-0.01)	-0.02	(-0.01)
Modernity	-0.02	(-0.01)	-0.19	(-0.05)	-0.13	(-0.05)
Beliefs						
Organic(e)	0.32***	(0.22)	0.03	(0.02)	0.04	(0.04)
Regional(e)	0.07	(0.05)	0.01	(0.01)	0.01	(0.01)
Vegetarian(e)	-0.09*	(-0.09)	-0.25***	(-0.22)	-0.19***	(-0.24)
Veg&Fruit(e)	0.15**	(0.11)	0.05	(0.03)	0.04	(0.04)
Material dimensions						
Fast	0.01	(0.01)	0.02	(0.02)	0.02	(0.03)
Tasty	-0.04	(-0.04)	0.09*	(0.09)	0.05*	(0.08)
Cheap	-0.04	(-0.06)	0.01	(0.01)	-0.00	(-0.00)
Atmosphere	0.14***	(0.18)	-0.06	(-0.07)	-0.03	(-0.05)
Healthy	0.18***	(0.21)	-0.01	(-0.01)	0.01	(0.01)
Dispositions						
Education	0.02	(0.02)	0.01	(0.01)	0.00	(0.00)
Perc. Beh. Control (e)			0.05	(0.03)		
Knowhow(e)	-0.04	(-0.04)	0.02	(0.01)	0.00	(0.00)
Lunch_home	-0.07	(-0.03)	0.17	(0.06)	0.13	(0.07)
Restaurants(e)	0.07	(0.07)	-0.04	(-0.03)	-0.03	(-0.04)
Shopping(e)	0.07	(0.08)	-0.03	(-0.02)	-0.01	(-0.01)
Time(e)	0.02	(0.02)	0.00	(0.00)	0.00	(0.00)
Money(e)	-0.09*	(-0.09)	0.06	(0.06)	0.04	(0.06)
Endowment	0.22*	(0.10)	-0.06	(-0.02)	-0.02	(-0.01)
Income	-0.00	(-0.01)	0.07*	(0.08)	0.05*	(0.08)
Vegan/Vegetarian	0.30*	(0.05)	-1.72***	(-0.28)	-1.19***	(-0.28)
Sociodemographic						
BMI	-0.00	(-0.01)	0.04**	(0.12)	0.03**	(0.12)
Age	0.01*	(0.10)	-0.00	(-0.03)	-0.00	(-0.01)
Gender (Male)	0.15	(0.06)	0.26*	(0.09)	0.19**	(0.10)
Marital status	-0.19	(-0.07)	0.11	(0.04)	0.08	(0.04)
Household size	0.07	(0.05)	0.10	(0.06)	0.07	(0.06)
Region (fr)	0.44***	(0.15)	0.08	(0.02)	0.07	(0.03)
Region (it)	0.29	(0.05)	0.11	(0.02)	0.05	(0.01)
Constant	-5.40***	(.)	3.41***	(.)	-0.96	(.)
Observations	513		497		497	
R-squared	0.35		0.25		0.24	

Robust normalized beta coefficients in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Again, the belief that an organic product based diet contributes toward more sustainable eating, was strongly associated with intentions but not with reduced impacts. In contrast, the belief that a vegetarian diet is particularly environmentally sustainable was strongly associated with reduced impacts, but not with intentions. As depicted by the standardized coefficient, the belief in the environmental friendliness of vegetarian diets can be considered a key driver

toward environmentally sustainable diets. This consequently suggested that the beneficial environmental effects of not eating meat are severely underestimated.

Regarding the material dimensions, emphasis on tasty eating caused slightly increased environmental impacts, suggesting that meat, and in particular red meat, is considered to be part of a tasty meal. On the other hand, individuals wanting to eat healthily and in an enjoyable atmosphere have stronger intentions, which

are not reflected in behavior. For the dispositional variables, we found that perceived behavioral control did not affect behavior, showing that even those that believe in having good control over their impacts do not manage to eat more sustainably. Again, economic factors such as perceived monetary restrictions, socio-economic endowment, and income related neither to intention, nor to behavior.

For the sociodemographic variables, we again find a strong gender effect. Although intentions do not differ across genders, male diets are higher on environmental impacts, which contributed significantly to the intention-behavior gap. Furthermore, we also found BMI to be positively associated with impacts. And again, in the French and Italian speaking parts, intentions are stronger than in the German-speaking part, but there are not regional differences in the actual impacts.

Overall, the models showed many commonalities for healthy and environmentally eating, notably with regards to beliefs of the contribution of organic and vegetarian diets and the roles of gender, vegetarian/vegan diets in driving healthy and sustainable eating. With regards to model fit, the intention models explain the same amount of variance for healthy and environmentally sustainable eating. But with regards to actual behavior, the model performs much better at predicting healthy eating (44% of variance explained), than environmentally friendly eating (25% of the variance explained). A major part of that difference is caused by the fact that intentions do not relate to behavior for the case of environmentally sustainable eating.

DISCUSSION

The aim of this study was to explore the drivers and barriers toward healthy and environmentally sustainable eating. Existing studies in the field have focused on proxies for healthy and environmentally sustainable eating such as buying organic, reducing meat intake, avoid packaged or processed foods, and have then linked these “proxies” to some behavioral drivers (e.g., Jungbluth et al., 2000; Eshel et al., 2014; Woythal, 2015). This study differs from these previous approaches, as we put major efforts into actually measuring the health and environmental impacts associated with individuals’ dietary habits. To do so, we coupled the information from a food frequency survey with LCA data and health burden datasets from nutritional epidemiology. Taking a psychological approach based on TPB allowed measuring the strength of the individuals’ intention to eat healthy and sustainable, and to explore how intentions relate to behavior and impacts. Based on a practice theory approach, we then identified a set of socio-cultural, dispositional, and material factors that drive or hinder healthy and sustainable eating.

Reasons for the Differences in the Intentions

Intentions to eat healthy were found to be significantly more pronounced than intentions to eat environmentally sustainable. Albeit health concerns dominate over environmental concern both intentions correlated, which points to the existence of certain degrees of consciousness in consumers and overlaps in

the motivations for healthy and sustainable eating. Furthermore, it has been shown that in the perception of consumers, a healthy diet also corresponds to an environmentally sustainable diet (Van Loo et al., 2017), and generally speaking this assumption seems justified according to our analysis.

As reasons for the discrepancies in the intentions toward healthy vs. environmentally sustainable eating, we see two main reasons: first, healthy eating is in one’s self-interest. In contrast, environmentally sustainable eating is rather an altruistic motive. For the case of organic products, it has been clearly shown that health related egoistic motives are much stronger drivers for purchasing behaviors than altruistic motives related to environmental considerations (Magnusson et al., 2003). Assuming rational consumers, it seems logical to put the self-first, which manifests in stronger intentions toward healthy eating. Second, dietary recommendations are much more focused on health rather than on environmental aspects. This imbalance is possibly also mirrored in the intention formation. With climate impacts gaining much public attention and raising consumer awareness on environmental matters this may however change over time.

Gaps Between Intentions and Behaviors

Intentions to eat healthy become actually manifest in healthier food consumption according to the findings of this study, whereas no relationship between intentions for environmentally sustainable eating and the measured environmental impact of the self-reported nutrition behavior was found. These results suggest that health intentions drive healthy eating, but sustainability related food consumption intentions do not lead to environmentally sustainable eating. This finding stands in contrast to other studies summarized in Vermeir and Verbeke (2008) which summarize that intentions relate rather strongly to sustainable food behaviors. The intention-behavior prediction for sustainable consumption is likely to hold as long as intentions are related to the hypothetically stated consumptions of products with sustainability labels or aspects. In contrast, our study clearly shows that for environmentally sustainable eating, when actual impacts are measured, intentions appear no longer to be relevant predictors for behavioral impacts. On the one hand, this points to methodological caveats when using the information on self-reported consumption behaviors to capture sustainable food consumption, and on the other hand, reveals obvious difficulties of Swiss consumers to influence the environmental impacts associated with their food choices.

Such an intention-behavior gap can result from diverse factors. Sheeran and Webb (2016) and Sheeran (2002) suggest that an intention-behavior gap is caused by the high occurrence of individuals that intend to change behavior but don’t (see also Godin and Conner, 2008; Rhodes and de Bruijn, 2013 for similar findings). Other scholars argued that “situational factors” such as economic constraints, as well as lack of opportunities to take different actions, can cause the intention-behavior gap (Kollmuss and Agyeman, 2002). Other causes for the intention-behavior gap relate to the type of behavioral goal. For example, weakly or fuzzily defined goals (Locke and Latham, 2013), overly ambitious goal setting, or goal setting

difficulties (Buehler et al., 1994; Sheeran et al., 2003) contribute to the intention behavior gap. Our analyses suggest that the complexity of eating environmentally sustainably makes it indeed a rather “fuzzy” goal. Given that, in general, norms and dietary recommendations in Switzerland focus on healthy eating rather than on environmentally sound food consumption (Godin and Sahakian, 2018), it is likely that people are much better informed about the health than about environmental impacts of foods. Accordingly, there may be a substantial knowledge deficit regarding the environmental aspects of eating. For example, people seem to underestimate the environmental impact of meat consumption as vegetarian diets were not believed to bring substantial environmental sustainability compared with other dietary recommendations by many participants. Contrary to this, the quantified carbon footprints showed that vegetarian and vegan diets lower environmental impacts substantially.

Drivers and Barriers for Healthy and Sustainable Eating

Except for the role of intentions, drivers for healthy and environmentally sustainable eating are similar. A surprising finding was that a vegetarian diet is considered to be of lower benefit for health and the environment compared to other dietary guidelines such as organic or regional product-based diets. While one can follow that individuals consider no-meat-diets to lead to nutritional deficits, and are thus less healthy, it is puzzling that participants do not acknowledge the well-established environmental benefits of vegetarian diets (Mullee et al., 2017). In contrast, we have reasons to suspect that many consumers use organic products as a behavioral shortcut for sustainable behavior, which does not manifest in the desired reduction of impacts. This is aligned with other studies showing that the health and sustainability dimensions of diets are much stronger determined by the dietary composition than by-product origin and production methods (Weber and Matthews, 2008; Mullee et al., 2017; Poore and Nemecek, 2018).

Another major influential factor for healthy and sustainable eating is gender. Although intentions do not differ across gender, males account for much higher health and environmental impacts. This points to the existence of male-specific eating patterns, such as animal protein and alcohol rich diets (see also Sych et al., 2019). Furthermore, we find that in the French and Italian speaking parts of Switzerland, intentions are higher to eat healthy and sustainable, but are not realized. However, the finding of similar nutritional quality is in contrast with other observations that suggest that diets in the French and Italian speaking parts are slightly healthier if assessed by eating index methods (Pestoni et al., 2019).

A minor barrier to healthy eating is the desire to eat cheap, suggesting that the wish to save money leads people to make less healthy choices. Increasing the availability of healthy and cheap “fast-foods” could help to counteract. With regards to environmentally sustainable eating, we find that emphasis on tasty eating is associated with increased environmental impacts, suggesting the notion of tasty food for Switzerland is associated with (beef) meat. Since income was not related to healthy eating

and even contributed slightly to less sustainable eating practices, it can be concluded that it is rather a matter of preferences on spending than real budgetary constraints that lead to less healthy choices. On the environmental impacts, we even found that was associated with slightly higher GHG impacts, as income seems to trigger red meat consumption. Furthermore, our results suggest that healthy eating is related to education and that environmental impacts are potentially caused by consumers lacking the knowledge on the environmental impacts of food. Therefore, information and education toward aligning perceived and actual environmental impacts should be key policy targets.

Policy Implications

Our findings suggest to target two points: (a) narrowing the gap between intention and behavior for environmentally sustainable eating, and (b) increase the acceptance of a vegetarian or low meat diets to provide health and environmental benefits.

Considering that intentions drive healthy but not environmentally sustainable eating, policies targeting health may well focus on individuals and their intentions, in particular on attitudes. In contrast, policies aiming at fostering sustainable eating should focus on societal factors such as knowledge generation or changes in the incentive structures. Special attention should be given to the dichotomous nature of the behavioral motives. While healthy eating is in everyone’s own best interest, environmentally-friendly eating is a public good contribution. Therefore, people have no or minimal direct benefit from avoiding emissions, thus few incentives. Altering the incentive structure by internalizing the benefits/costs of avoided/generated emissions is key. Possible tools include taxes or other market interventions aiming at internalizing costs of emitted greenhouse gases. Another option is rewards for low GHG-baskets through the bonus programs of retailers. Since we found that healthy and sustainable diets are not income and thus not price-sensitive, and as other studies found that “soft” interventions such as labeling and information campaigns generate higher acceptance in Switzerland than more restrictive interventions such as taxes (Hagmann et al., 2018), a voluntary reward system is likely to be more efficient in triggering behavioral change than top-down market interventions. However, given the self-reported lack of knowledge on environmentally friendly eating, any incentive program should be accompanied by GHG-labels or points on food packages or at least on animal products.

Furthermore, our analysis points to a big difference between the perceived and actual health and environmental benefits of vegan and vegetarian diets. While the actual health and environmental impacts are much lower under these dietary regimes (Van Loo et al., 2017; Chen et al., 2019), consumers seem not sufficiently aware of the beneficial health and environmental impacts of avoiding or reducing animal products. Given this low acceptance of vegetarian diets, the promotion of vegetarian or flexitarian (low meat) diets, through campaigns and dietary recommendations, should be considered a relevant policy lever and intensified. As demonstrated by Stylianou et al. (2021) for the US, substituting 10% of daily caloric intake from beef and processed meat to fruits, vegetables, nuts, and select seafood

offer substantial targeted health improvements of 50 min gained per person per day and a 36% reduction in dietary carbon footprint. Any campaigns and recommendations may increase in effectiveness when specifically tailored to change male-specific eating patterns.

Limitations and Further Research

To measure what people eat is challenging. We used a food frequency survey consisting of 12 food categories. Validating our results against the insights from a 24-h national recall showed that participants underreported their caloric intake, but also that underreporting is not biased toward “bad” or “good” foods. Instead, the portion size seemingly affected the participants’ ability to estimate intake – as for smaller portions estimates were less accurate. The recall method surely provides a more precise picture at the population level. Still, it is inadequate in providing individual-level information, due to the one-time snapshot generated. Therefore, a more promising method could be a “diary-approach” where people would record over a certain time-span what they ate, which could then be related to survey information further.

To estimate the health impacts, two main methodological strands exist, nutritionist index-based assessment and the epidemiological approach, which is focused on nutrition-related diseases and early mortality. Index-based assessments such as the Healthy Eating Index (HEI) or the Alternate Healthy Eating Index (AHEI) measure the compliance with some dietary recommendations for intakes of different food categories and macronutrients (Gil et al., 2015; Schwingshackl et al., 2018). Accordingly, index-based assessments assume homogenous needs and do not account for regional specificities of actual health consequences of diets (Kennedy et al., 1995; Schwingshackl et al., 2018). It has shown that dietary risks from low or high intake of certain foods depend on circumstances. Therefore, we believe that the epidemiological based approach used herein provides a better approximation to measure the healthiness of a diet. Future studies investigating healthy eating may put efforts in comparing the health impacts as calculated with index-based approaches to those based on the epidemiological based approach. However, independent of the approach chosen, they provide a uniform blueprint for measuring the healthiness of a diet. Since understandings of what constitutes a healthy diet can vary greatly across individuals, and in some cases may differ significantly from an “objective measure”, it can well be that the intentions translate into behavior for the subjectivity of the individual itself, but not from the objective perspective of the researcher.

Furthermore, our analysis uses carbon footprint as a measure of environmental impacts. As our LCA data covers only the production process, we are not able to fully cover the CO₂ emissions associated with the consumption along the complete value chain of a product. We could also not control for effects related to factors such as the origin of the product, and transport method. Controlling for such factors could reduce uncertainties in the impact assessment, which was not feasible in this study.

Furthermore, since other life cycle impacts like water use, or ecosystem degradation, and human- and ecotoxicity impacts show higher uncertainties and are more dependent on product origins, we decided to focus only on GHG emissions rather than using a compound index. This means that this study is not covering the full range of possible environmental impacts, and further studies are needed in particular for water footprint that can differ substantially from carbon.

For future research, we suggest that the relationship between health and environmental impacts deserves further exploration (Behrens et al., 2017). Although our analysis suggests a positive relationship between health and environmental impacts, a healthy diet is not *per se* an environmentally sustainable diet and vice versa. Thus, trade-offs and synergies between health and environmental aspects deserve further explorations to make dietary recommendations that balance health and environmental impacts.

Finally, our study is limited to the Swiss context, and since eating is culturally determined, the drivers and barriers in other countries may be very different. For Switzerland, healthy and sustainable diets were not found to depend on socio-economic factors. Instead, they were rather associated with wants, knowledge surrounding food choices, gender, and dietary guidelines that one follows. Therefore, it would be valuable to explore for other countries if the drivers and barriers toward healthy and sustainable eating differ from those observed herein for Switzerland.

CONCLUSION

This study aimed at shedding light on the question of how our eating habits affect the environment and our health and to what degree these impacts align with our intentions. By linking actual dietary impacts to motivational factors, we bridged between two adjacent research fields which are not often studied together allowing for analyzing trade-offs and differences in intention, drivers and practices concerning healthy and environmentally sustainable diets, and thus provide valuable information to facilitate healthy and sustainable eating.

Our analysis shows that individuals prioritize healthy over environmentally sustainable eating. Furthermore, consumers intending to eat healthy manage to do so, while environmentally sustainable eating was not related to intentions. We presented two explanations; the first refers to the type of motivations (self vs. altruistic) behind food choices, and the other to the dominance of health over environmental aspects in dietary recommendations. Consequently, policies promoting healthy eating can target factors affecting intentions. In contrast, measures targeting environmentally sustainable eating should rather aim at overcoming the intention-behavior gap and inform on e.g., the importance of reducing meat consumption toward environmental sustainability. The present analysis reveals major synergies between health and environmental impacts of diets, meaning that individuals managing to eat healthier are very likely to reduce their environmental impacts and vice versa.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Human Research Ethics Committee (HREC) of EPFL. The patients/participants provided their written informed consent to participate in this study.

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AUTHOR CONTRIBUTIONS

The survey was developed by IB, RH, and CB. IB had the lead in the writing of the article draft. All authors contributed to the writing of the article.

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Conflict of Interest: AE and OJ were employed by Quantis.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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