

SHIFTING TO A RECOMMENDED DIETARY PATTERN COULD PROMOTE SUSTAINABLE DEVELOPMENT OF THE ENVIRONMENT AND HUMAN HEALTH

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SUPPLEMENTARY MATERIALS

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1 DESCRIPTION OF CALCULATING ENVIRONMENT EFFECTS

1.1 DATA source and method

(1) **Blue water:** Some relevant studies provides the blue water coefficients of major crops and animals at the national level from 1996 to 2005^[1,2]. We refer to their database including green, blue and grey water footprints of crops, derived crop products, biofuels, livestock products, and industrial products. All data are available at national and sub-national level. For the water coefficients of various crops and animals in 2011, we specifically refer to Ali et al.^[3]:

$$VWC_{i,c,n} = VWC_{i,c,2005} * \frac{Y_{i,c,2005}}{Y_{i,c,n}}$$

Where i = country; c = commodity; and Y = crop yield. Yield data from 2011 FAOSTAT data. This method has been used in other studies^[4,5] and relies on the finding that crop water productivity (CWP) for different crops, or the inverse of VWC, has a strong linear relation with crop yield^[6]. Using this method, we can update the blue water coefficients of crops and animals to 2011.

(2) **Land use:** The land use associated with each item is estimated using 2011 FAOSTAT data. FAO provides the harvest field and the production of the main crops produced in each country, and we obtain the unit annual land occupation for these products by taking the ratio of the two. For the primary livestock and poultry products, this method has been used in other research^[7], calculating the land occupation for the concentrated production and grazing production separately, and take the average of the two weighted by the fraction of each in the total production. For possible double counting of feed grains and for concentrated feeding, we assume a zero direct land occupation for the concentrated production; thus the land occupation only comes from the land used for feed production. For the grazing production, the land occupation equals to the grazing land used for production. For aquatic products, only the land occupied for feed production in aquaculture is accounted for.

(3) **GHG emission:** For the GHG emission coefficients of major crops, we collect average

emissions per gram for different types of food from over 300 lifecycle assessment (LCA) studies covering the emissions from cradle¹ to farm gate. And the GHG emission coefficient of each crop is obtained by averaging the collected LCA studies. This method has been used in other research^[7]. For the GHG emission coefficient of main animals, we use the data of FAOSTAT database in 2011.

(4) Calculation of environment effects

When calculating the environment effects of food consumption, food loss and waste should be taken into account since food is lost or wasted throughout the supply chain, from initial agricultural production down to final household consumption. Firstly, we obtain the consumption of various foods per capita per day ($\text{g}\cdot\text{d}^{-1}$) of Chinese adults from CHNS. Secondly, we use the ratios of food loss (Table S1) to calculate the amount of production required for food consumption, which is also used by Guo et al.^[9]. For the Planet Healthy Pattern and the Chinese Dietary Pattern, we can also obtain the corresponding food production according to the above method. And we use the coefficient of China's environmental coefficients (Table S2) to calculate environment effects of changing from the existing dietary patterns to the Planet Healthy Pattern and the Chinese Dietary Pattern.

Table S1 Ratios of food loss occurred during different stages of food production and consumption for various food groups

Food groups	Agricultural production	Post-harvest handling & storage	Processing & packaging	Distribution	Consumption	Left ^a
Cereals	2.0%	10.0%	10.0%	2.0%	20.0%	62.2%
Roots & tubers	20.0%	7.0%	15.0%	9.0%	10.0%	51.8%
Oilseeds & pulses	6.0%	3.0%	5.0%	1.0%	4.0%	82.3%
Fruits & vegetables	10.0%	8.0%	2.0%	8.0%	15.0%	63.5%
Meat	2.9%	0.6%	5.0%	6.0%	8.0%	79.3%
Fish & seafood	15.0%	2.0%	6.0%	11.0%	8.0%	64.1%
Milk	3.5%	1.0%	1.2%	0.5%	5.0%	89.2%
Others	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

Note: ^aLeft = (1–Loss_Agricultural production) × (1– Loss_ Post-harvest and storage) × (1–Loss_Food processing and packaging) × (1–Loss_Food distribution) × (1–Loss_Food consumption). Source: FAO Food Balance Sheets (2011)^[8].

2 DESCRIPTION OF CALCULATING HEALTH EFFECTS

2.1 Description of dose-response meta-analyses and data sources

In this paper, we use results of three dose-response meta-analyses analyses for hypertension^[10], type II diabetes^[11] and coronary heart disease^[12] by internationally recognized medical journals to calculate relative risk reduction of three diseases when shifting to the alternative dietary patterns. These dose-response meta-analyses analyses synthesize the knowledge about the relation between

¹ The 'cradle' here involves the production of fertilizer and pesticides, but not the production of infrastructure and tools for agricultural production.

intake of 12 major food groups and risk of hypertension, type II diabetes and coronary heart disease. We use the results of dose-response meta-analyses in this analysis for several reasons. Firstly, they allow for more direct comparison of the health outcome of different foods in quantities that might be consumed at a single meal. Secondly, dose-response meta-analyses control for confounding variables when reporting the health outcomes of food consumption. For instance, age, sex, race, and economic status are commonly controlled for in meta-analyses because they are known to influence health outcomes. Thirdly, those paper use dose-response meta-analysis that was most recently published when there were multiple dose-response meta-analyses examining the same food because these analyses often contained more studies and more individuals, and are thus more likely to represent the real health impact of consuming an additional serving of food per day.

Table S2 Environmental coefficients of major crops and animals in China

Food groups	Blue water (m ³ per ton product)	Land use (10 ⁻⁵ km ² per kg product)	GHG emission (kg CO ₂ equiv. per kg product)
Wheat	972	0.2548	0.9645
Maize	870	0.1602	0.3627
Rice	724	0.2030	1.9209
Soybean	2452	0.5729	0.1833
Potato	1131	0.0686	0.1849
Oil crop (nut)	4456	0.0036	1.0737
Sugar	1343	0.0288	0.3720
Fruit	795	0.1009	0.1331
Vegetable	166	0.0557	0.6740
Chicken	2314	1.2871	2.2325
Beef	11651	1.4864	19.2852
Pig	2691	1.1312	5.0700
Sheep	2678	1.6673	15.0920
Egg	2211	0.7442	2.3523
Milk	2222	0.3426	1.2350
Oil	3268	0.1898	4.1512

2.2 Calculation of health effects

The method will be presented below as an example of calculating the relative risk change for hypertension with transition of dietary pattern, with the method partially referencing internationally recognized medical journals^[10–12]. Tables S3–S5 shows the risk ratio (RR) for hypertension, type II diabetes and coronary heart disease from non-linear dose-response analysis of the 12 food groups according to servings per day.

Step 1: Calculate the relative risk (RR) change for each dietary pattern compared with non-consumption. Specifically, the potential of dietary patterns to reduce the risk of each disease is calculated by multiplying the RR by selecting risk-reducing foods noted as *RRreduced_i* (*RRreduced* means the value < 1) and risk-increasing foods noted as *RRincreased_i* (*RRincreased* means the value > 1). So the relative risk (RR) change can be calculated with:

$$RR \text{ change} = \left(\sum_{i=1}^n RR_{reduced_i} \times \sum_{i=1}^n RR_{increased_i} \right) - 1$$

For instance, if our current dietary pattern is 90 g whole grains, 160 g fruits, 28 g nuts, 75 g legumes,

and 800 g dairy every day, it will result in a 44% reduction of hypertension (calculated from Table S1 by multiplying the different foods RR) when compared with non-consumption of these foods. It is worth mentioning that for food intake between different servings e.g. intake of fruit 100 g, we fit the regression results to calculate the exact fruit RR.

Table S3 Relative risks from nonlinear dose-response analysis of 12 food groups and risk of hypertension according to intakes of servings per day

Food group and daily serving size	Servings per day						
	0	1	2	3	4	5	6
<i>Inverse association</i>							
Whole grains (30 g)	1.00	0.90	0.87	0.85	NA	NA	NA
Fruits (80 g)	1.00	0.96	0.93	0.93	0.93	0.93	NA
Dairy (200 g)	1.00	0.94	0.90	0.87	0.85	NA	NA
Nuts (28 g)	1.00	0.88	NA	NA	NA	NA	NA
Legumes (100 g)	1.00	0.94	NA	NA	NA	NA	NA
<i>Positive association</i>							
Fish (100 g)	1.00	1.08	NA	NA	NA	NA	NA
Red meat (85 g)	1.00	1.16	1.35	NA	NA	NA	NA
Processed meat (30 g)	1.00	1.07	NA	NA	NA	NA	NA
SSB (250 mL)	1.00	1.06	1.14	NA	NA	NA	NA
<i>No association</i>							
Refined grains (30 g)	1.00	0.96	0.96	0.97	1.00	1.03	NA
Vegetables (80 g)	1.00	0.99	0.98	0.98	0.98	0.99	1.00
<i>Not applicable</i>							
Eggs (55 g)	1.00	NA	NA	NA	NA	NA	NA

Note: NA, not applicable; SSB, sugar-sweetened beverage.

Table S4 Relative risks from nonlinear dose-response analysis of 12 food groups and risk of type II diabetes according to intakes of servings per day

Food group serving per day	Servings per day							
	0	1	2	3	4	5	6	7
<i>Inverse association</i>								
Whole grains (30 g)	1.00	0.78	0.75	0.76	NA	NA	NA	NA
Vegetables (80 g)	1.00	0.96	0.93	0.92	0.92	0.92	0.94	0.95
Fruits (80 g)	1.00	0.95	0.92	0.90	0.90	0.91	0.92	0.93
Dairy (200 g)	1.00	0.97	0.95	0.94	0.94	0.94	NA	NA
<i>Positive association</i>								
Refined grains (30 g)	1.00	1.01	1.01	1.02	1.03	1.04	1.05	1.06
Eggs (55 g)	1.00	1.16	NA	NA	NA	NA	NA	NA
Red meat (85 g)	1.00	1.18	1.37	NA	NA	NA	NA	NA
Processed meat (35 g)		1.29	1.35	1.39	1.43	NA	NA	NA
SSB (250 mL)	1.00	1.19	1.28	1.37	NA	NA	NA	NA
<i>No association</i>								
Nuts (28 g)	1.00	1.01	NA	NA	NA	NA	NA	NA
Legumes (100 g)	1.00	1.00	0.97	NA	NA	NA	NA	NA
Fish (100 g)	1.00	1.03	0.97	NA	NA	NA	NA	NA

Note: NA, not applicable; SSB, sugar-sweetened beverage.

Table S5 Relative risks from nonlinear dose-response analysis of 12 food groups and risk of coronary heart disease according to intakes of servings per day

Food group serving per day	Servings per day						
	0	1	2	3	4	5	6
<i>Inverse association</i>							
Whole grains (30 g)	1.00	0.91	0.86	0.83	0.83	0.83	0.83
Vegetables (80 g)	1.00	0.96	0.92	0.90	0.88	0.88	0.87
Fruits (80 g)	1.00	0.89	0.84	0.83	0.83	0.86	NA
Nuts (28 g)	1.00	0.84	NA	NA	NA	NA	NA
Legumes (100 g)	1.00	0.89	0.90	NA	NA	NA	NA
Dairy (200 g)	1.00	0.96	0.96	1.02	NA	NA	NA
Fish (100 g)	1.00	0.91	0.87	0.83	NA	NA	NA
<i>Positive association</i>							
SSB (250 mL)	1.00	1.15	1.36	NA	NA	NA	NA
<i>No association</i>							
Refined grains (30 g)	1.00	0.99	0.99	0.99	1.01	1.04	1.10
Eggs (55 g)	1.00	1.02	NA	NA	NA	NA	NA
Red meat (85 g)	1.00	1.09	NA	NA	NA	NA	NA
Processed meat (30 g)	1.00	1.11	NA	NA	NA	NA	NA

Note: NA, not applicable; SSB, sugar-sweetened beverage.

Step 2: Calculate the RR reduction for the shift from the existing dietary pattern to the recommended dietary pattern. Because the RR reduction values for different dietary patterns relative to non-consumption are already available in step 1, the RR reduction for the shift from the existing dietary pattern to the recommended dietary pattern can be calculated based on it.

For instance, if our current dietary pattern results in a 44% reduction of hypertension when compared with non-consumption and the recommended dietary pattern results in a 10% reduction of hypertension when compared with non-consumption, then the shift from the existing dietary pattern to the recommended dietary pattern could result in a 34% reduction of hypertension.

3 DESCRIPTION OF CALCULATING ESTIMATED ENERGY REQUIREMENT

Estimated Energy Requirement (EER) is the average dietary energy intake that is predicted to maintain energy balance in healthy, normal weight individuals of a defined age, gender, weight, height, and level of physical activity consistent with good health. EER_i are calculated with the methods adopted by Tabata et al.^[13]. The equations differ for children, adults and elders. For health adults aged 18–49 whose Body Mass Index (BMI) are within the normal range (18.5–24), the EER_i can be calculated with:

$$EER_i = R_i * Weight_i * PAL_i$$

EER_i denote the estimated energy requirement ($\text{kcal}\cdot\text{d}^{-1}$) for each adult i . R_i is the basal energy expenditure per unit of body weight ($\text{kcal}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$), indicating the energy needed for fundamental metabolic functions. This expenditure differs by age and sex groups, as shown in Table S6. $Weight_i$ is the body weight of individual i available from the CHNS data. The product of R_i and $Weight_i$ gives the energy required per day in supporting the basic metabolism for a human being with particular body weight, and the EER_i is then calculated by inflating this basic energy need with the Physical

Activity Level (PAL_i). PAL_i is a non-dimensional factor, and a higher PAL_i indicates more intensive physical activities and higher energy demand Tabata et al.^[13] provides the PALs in three levels (light, moderate and heavy) according to the lifestyle and profession. We associate these levels with the classification of PALs in other research^[7,13], as shown in Table S7.

For people who are underweight, overweight or obese, the energy requirement can be different for adjusting to normal BMI. We need to calculate the EER that suits the normal weight of these people. For underweight individuals, we use the equation as follows:

$$NormalWeight_i = BMI_{norm} * Height_i^2$$

Where BMI_{norm} is the lower bound of the normal weight (18.5), $Height_i$ is the body height of individual i and $NormalWeight_i$ is the normal weight of individual i according to her/his body height. Finally, the EER_i is calculated with $NormalWeight_i$. And the EER for the overweight and obese individuals are calculated accordingly, but with the upper bound of the BMI_{norm} (24).

Table S6 The R_i by sex-age groups (kcal per kg body weight per day)

Gender	Age			
	18–49	50–64	65–80	> 80
Male	22.7	21.5	21.4	21.5
Female	21.4	20.1	20.1	20.1

Table S7 The classes of the PALs in CHNS

Intensity of physical activities	PALs for adults in DRIs 2013	PAL classes in CHNS
Light	1.50	No working ability
		Very light physical activities
		Light physical activities
Moderate	1.75	Moderate physical activities
Heavy	2.00	Heavy physical activities
		Very heavy physical activities

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