



REVIEW ARTICLE

An overview on the nutrition transition and its health implications: Tunisia case

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Abstract

Background: In the last decades, Tunisia has undergone major demographic, socio-economic and lifestyle (including diet) changes, with drastic increases in excess adiposity and nutrition related non-communicable diseases (NCDs). This review provides an update of the nutritional situation in Tunisia. **Methods:** Several Tunisian datasets or international databases were used to assess availability and consumption of foods and health outcomes. **Results:** Both from national aggregated availability data and individual food consumption data, there was a trend both of increasing food intake and modernization/westernization of the diet (especially in urban areas), towards more consumption of dairy and meat products, sugar, fat and salt. But consumption of fruits and vegetables was still above WHO recommendations. Except for iodine, micronutrients deficiency (iron, vitamin A and D) was markedly, but unevenly, present among specific groups (e.g., a third of adult women had anemia). Among infants, both exclusive and predominant breastfeeding were low, while the minimum diet diversification rate was 63%. Among children, stunting was residual but increase of overweight was a concern. In 2016 17.6% of men and 34.6 % of women over 15 y. were obese and 15.5% had diabetes, a twofold increase in the last decades. These prevalence were much higher in urban and more developed areas. Also, 86% of the mortality rate was attributable to NCDs. **Conclusion:** Addressing the double burden of malnutrition and NCDs is a priority and should be based on a sustainability framework, involve a diversity of stakeholders and emphasize double duty actions and reduction of nutrition and health inequalities.

Keywords: Tunisia, diet, food insecurity, micronutrient deficiencies, nutritional status, obesity, non-communicable diseases.

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1 Introduction

1.1 Territory & population

Tunisia is the smallest North African country, located between Algeria and Libya. It features a long coastline in the north and the east vs. more mountainous regions on the south-east, and the desert to the south. Due to a marked climatic gradient, from the Mediterranean in the north to a semi-arid and then the desert in the south, Tunisia is especially at risk regarding sustainability issues and the negative impact of climate change ¹⁻³.

In 2017, the Tunisian population (not including a 0.9 million diaspora) was estimated at 11.5 million inhabitants, which is a threefold increase since the independence in 1956, but which has

considerably slowed due to decreasing fertility rates. Currently, the median age in Tunisia is now around 31 y. In 2017, more than 70% of the population lived in urban areas. A quarter of the population resides in the Greater Tunis urban or peri-urban area around the capital and a significant part along the eastern coast, while the west and the south are much less populated. Common socio-cultural values linked to the Arab-Muslim culture result in a strong common core of traditions and social norms, but they also integrate various historical and geographical influences ^{2, 4-6}.

1.2 Economic and human development

According to the Human Development Index, in 2019 Tunisia was ranked 91th of 189 countries worldwide, thus at the lower end of the “high human development” group of countries but higher than other North African countries, except Algeria ⁷. In 2015 the poverty rate was 15.2% ⁵. The steady development undergone in the last decades was based on a diversified economy including significant agricultural, mining, tourism, and manufacturing sectors ². Significant sectors are still state-controlled (energy, water distribution, public transportation). The state provides a social safety net and health insurance to a large proportion of the population and subsidizes basic food products such as pasta, bread, couscous seed oil, skimmed milk, sugar, tomato paste ⁸. Nowadays, after the post-2011 revolution recession, due to the political and security situation, the economic recovery was slow. The high deficit, external and internal debt as well as inflation and unemployment (15.5% in 2017) are of concern ^{9,10}.

Based on national surveys on budget, consumption expense and the living standard of households, conducted by the National Institute of Statistics ¹¹, the proportion of the population living below the poverty line of 3.20 USD/d has considerably regressed in Tunisia from 23.1% in 2005 to 15.2% in 2015 (compared to the 3% accepted as the global poverty line). In absolute terms, the number of poor is currently about 2 million among them 300.000 are living below the extreme poverty threshold of 1.90 USD/d.

The economic and human development is unevenly distributed. Tunisia ranks 58th worldwide and above most countries in the MENA region regarding the Gender Inequality Index ⁷. But gender inequality persists e.g., in 2015 the proportion with secondary education and the labor force participation was much lower for women vs. men. There are still strong geographic development inequalities (which triggered the 2011 revolution): the poverty rate in rural areas is more than twice that in urban areas (26.0% vs. 10.1% in 2015) ⁵. There are also marked regional inequalities: e.g., in 2015 the inland north-west and center-west regions had poverty rates twice the national average (e.g., more than 45% in the Center-West) as well as much higher unemployment rates. Unemployment is also especially high among young people ^{5,10}.

The lack of an equitable distribution of wealth between regions and the inequality of public investments in health, education, and other social programs targeting the most deprived population lead, to a large extent, to the widening of the socio-economic and health gap and to dividing the Tunisian society. In 2020, the consequences of the COVID-19 pandemic added to the existing political and socio-economic further difficulties.

1.3 Nutrition and public health stakeholders

Stakeholders in the field of nutrition traditionally mostly relate to the Ministry of Health. The main institution is the National Institute of Nutrition and Food Technology, (INNNTA) in Tunis, which has a variety of missions including monitoring the nutrition situation, designing and monitoring interventions, informing the public, training health professional, controlling the quality of food products, clinical management of obese and diabetic patients, performing nutrition research activities. The National Institute of Health (INSP) has rather analogous missions regarding a wide range of public health issues including nutrition-related non-communicable diseases. The Directorate of Basic Healthcare (DSSB) is in charge of nationwide programs for treatment and prevention of a large range of pathologies including those nutrition-related. As for academic training, there are nutrition courses in universities (e.g., El Manar University) or at specific institutions e.g., such as the High School of Health Sciences and techniques of Tunis (ESSTST).

Due to the now well recognized multifactorial nature of nutrition-related issues (e.g., the food system concept ¹², beyond the public health field a number of other stakeholders are also involved in the assessment of nutrition-related issues including institutions from the Ministry of Agriculture, the Ministry of Commerce and others. The national Tunisian strategy to prevent and control obesity ¹³, launched in 2013 and experimented for a 5-year duration in a pilot region, is now being extended under the leadership of INNNTA by a specific committee gathering such a variety of stakeholders.

1.4 Progress in the achievement of Scaling Up Nutrition (SUN) and Sustainable Development Goals (SDGs)

The country is not formally a member of the SUN initiative. Nevertheless, several of the nutrition programs and policies are in line with the themes identified by the SUN partnership (e.g., the main axes and detailed proposed action of the National Strategy for the prevention of obesity).

As for SDGs, Tunisia has contributed to their definition and has committed itself to their implementation by integrating them in its 2016-2020 development plan and by involving both state institutions and civil society. It has committed itself to a voluntary national review of SDGs indicators in 2019 ¹⁴.

In 2020 Tunisia had an overall SDG score of 71.3 (out of 100) and was ranked 64th out of 166 countries ¹⁵. SDGs goals were achieved (green status) only regarding #13 “Climate action” and #17 “Partnership for the goals”. Major challenges remained (red status) for #2 “Zero hunger” (mainly due to a high prevalence of obesity and nitrogen management issues), for #3 “Health and well-being” (including low scores regarding traffic death and subjective well-being), #8 “decent work and economic growth” (with a major unemployment issue), #9 “Reduced inequalities”,

#10 “Sustainability of cities and communities”. Other indicators had either yellow status (challenges remain) or orange status (significant challenges remain) such e.g., as #5 “Gender Equality” (mostly due to unequal participation to the workforce) or #16 “Peace, justice and strong institutions” (e.g., due to high perceived insecurity and corruption).

2 Methods

The review is mostly organized along with a classical conceptual framework for causes of nutrition-related non-communicable diseases, which usually takes into account: - distal causes such as those linked to general social, economic, and political context (which is already addressed in the background session above) – proximal causes e.g. lifestyle factors such as dietary intake and physical activity, - intermediate health outcomes (nutritional status, diabetes, hypertension, etc.), - health outcomes such as cardiovascular diseases and cancer and related mortality. We thus address in sequence the issues of food security (including availability), dietary intake at household and subject level, micronutrient deficiencies, non-communicable diseases, and risk factors. A specific section is dedicated to nutrition issues among infants and preschool children. A variety of already published data, international databases, or specific Tunisian datasets were used to assess the availability and consumption of foods and health outcomes (as referenced in the different paragraphs).

3 Results and Discussion

3.1 Food security and food availability

3.1.1 Hunger and food insecurity

According to the FAO estimation ¹⁶, the prevalence of undernourished people in Tunisia has declined from 4.4% in 2000-2002 to 2.7% in 2013-2015. About 1 million individuals are currently severely food insecure, i.e., they have a caloric intake below the minimum energy requirements continuously.

3.1.2 Food availability, accessibility, and utilization

Availability. The average dietary energy supply adequacy increased from 136% in 2000-2002 to 145% in 2013-2015 ¹⁷. This means that the average dietary energy supply is over the average dietary energy requirement estimated for the Tunisian population. Analyzed together with the prevalence of undernourishment, it allows discerning that undernourishment is mainly due to bad distribution and not to insufficiency of the food supply. In general, food availability does not present a significant challenge in Tunisia: food is mostly available, either domestically produced or imported and agriculture has achieved self-sufficiency in certain products (milk, meat, fruit, and vegetables). Nevertheless, risks to availability exist and are particularly due to climate change and natural resources degradation (mainly lack of water) and the dependence on cereals imports (about 60%) ¹⁸.

Accessibility. Physical access is guaranteed at a national level: The public sector controls the distribution of agricultural production and fisheries while the private sector manages poultry products

distribution. The road network provides almost all of the people's mobility and accounts for about 80% of domestic freight transport.

Eating outside has become an everyday aspect of the lives of Tunisian urban dwellers. According to the 2015 national survey of household budgets, living standards, and food consumption, 5.2% of the average family budget is earmarked for food expenditure outside the home in Greater Tunis, out of total food expenditure of 26.1% ¹⁹.

Utilization. The supply of foods estimated by weight has increased by 94% when expressed by g/capita/d (from 1132 to 2392). The increase is due to the increase in vegetables, fish and seafood, fruits, eggs, meat, and starchy roots. In addition, the supply of vegetable oils increased by 95% from about 30 to 58 g/capita/d, mostly due to an increase in the availability of imported soybean and rapeseed seed oils while the availability of olive oil decreased (Figure 1).

The “Food Diversification Index”, measuring the share of non-starchy foods (all foods other than cereals, roots, and tubers) in total dietary energy consumption ²⁰, increased by +11.7 points showing a decline in the starchy food supply and higher availability of more nutritious foods (dairy, fruits, vegetables, meat). Thus, dietary profiles are changing with an increase in products of animal origin, in particular milk and dairy products, but cereals still account for almost 50% of energy intake.

Food waste constitutes a serious problem and bread (which is subsidized) is the most wasted product (16%). In food retailing, food waste reaches 1.2 million USD per year and in households an average of 25 USD/person/month, which represents about 18% of total food expenditure ²¹.

3.2 Food consumption and physical activity

3.2.1 Trends in household food consumption

Data from household food consumption surveys, conducted every 5 years between 1967 and 2015 ¹⁹, displayed an increase in the consumption of animal-source foods (meat, milk, eggs, fish, and seafood) as well as in vegetable-source foods (fruits, vegetables, vegetable oil) and sweeteners. In contrast, the consumption of pulses was relatively stable while that of cereals showed a decrease since the end of the 1980s (Table 1).

3.2.2 Trends in subject-level food and nutrient intake

This section is mainly based on data from the individual food consumption surveys conducted in 1996/97 and 2005 ^{22,23}. Other regional sources were also used. Overall, the data from individual consumption surveys revealed an increase in food intake of about 260 g/d/adult. Of note, 34% of this increase came from animal products (milk, eggs, poultry meat and fish and seafood by order of importance), 33% from fruits and vegetables, 13% from sugar and sweeteners, 9% from starchy foods and cereals and 6% from

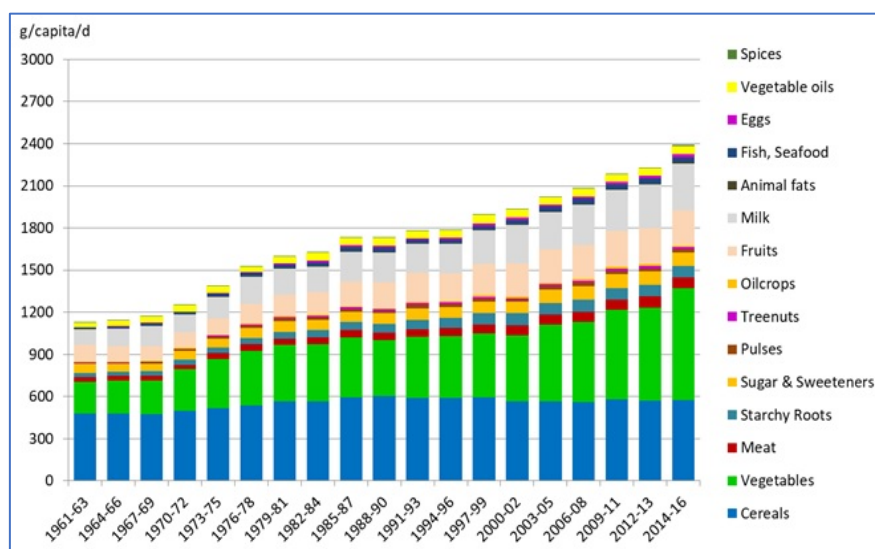


Figure 1: Trends in total food weight supply (g/capita/d) between 1961-03 and 2014-16 (from aggregated national data, source FAOSTAT) ¹⁶

Table 1: Trends in food group consumption by g/capita/d from 1967 to 2015 (from household food consumption surveys ¹⁹)

	1967	1975	1980	1985	1990	1995	2000	2005	2010	2015
Cereals	395.61	413.68	432.58	541.54	512.79	488.15	330.27	391.26	335.26	392.71
Wheat and products	364.13	393.43	418.89	518.54	497.46	476.63	321.15	380.20	325.54	380.20
Rice	1.37	1.09	1.91	2.73	3.83	3.28	4.11	7.40	5.71	7.40
Barley and products	30.11	19.16	11.77	20.26	11.49	7.93	4.27	3.97	2.81	3.97
Maize and products	–	–	–	–	–	–	0.09	0.19	0.11	0.19
Starchy roots	23.96	45.72	52.57	51.47	52.84	49.71	48.87	48.26	49.61	58.89
Treenuts	3.56	3.83	3.56	4.11	4.02	4.11	2.62	3.85	3.97	3.36
Pulses	9.86	8.49	8.76	8.76	8.76	7.12	8.36	8.92	9.95	9.75
Sugar & sweeteners	34.22	34.22	39.43	38.33	35.32	44.35	45.64	88.71	88.04	101.04
Sugar	33.68	33.68	38.60	37.23	33.68	34.08	34.30	38.01	38.56	36.90
Honey	–	–	–	–	–	–	0.29	0.27	0.27	0.28
Other sweeteners	–	–	–	–	–	–	11.24	50.43	49.21	79.96
Oils crops	–	–	–	–	–	–	1.57	1.23	1.68	1.95
Sunflower seed	–	–	–	–	–	–	0.08	0.25	0.46	0.18
Sesame seed	–	–	–	–	–	–	0.01	0.01	0.01	0.01
Olives	–	–	–	–	–	–	1.18	0.98	1.23	1.35
Vegetables oils	52.02	60.78	55.03	53.94	58.04	69.12	70.71	71.81	72.59	73.96
Soyabean oil	41.07	46.00	42.71	41.34	45.17	52.42	50.43	50.80	52.18	51.33
Olive oil	10.95	14.78	12.32	12.59	12.87	16.70	20.28	21.01	20.41	22.63
Vegetables	310.40	323.87	326.75	340.08	366.06	343.31	358.74	379.94	381.02	408.21
Fruits	93.63	90.62	101.57	106.23	138.26	118.54	167.84	218.63	180.63	227.76
Meat	10.40	7.12	17.80	15.06	21.08	22.45	52.56	57.89	67.47	95.85
Meat (beef, mutton, offal and other)	6.30	1.92	2.19	3.01	3.29	3.56	27.95	25.69	29.77	42.88
Poultry meat	4.11	5.20	15.61	12.05	17.80	18.89	24.60	32.20	37.70	52.97
Eggs	4.19	4.19	8.87	9.61	11.95	12.07	14.42	16.01	21.68	28.19
Animal fats	1.05	1.37	1.92	0.82	1.64	–	1.89	3.42	2.53	2.51
Milk	68.45	88.71	113.35	103.76	107.60	162.63	114.87	177.56	184.05	240.13
Fish and seafood	12.05	13.96	14.78	16.70	17.44	15.88	14.31	17.63	13.36	18.61

olive oil (Table 2). While this implies a slight increase of the share of animal products in the diet, the average diet of a Tunisian adult remains mainly plant-based and contains higher fruits and vegetables than the WHO recommendations (494 g/d in 1996-97 vs. 579 g/d in 2005).

risk of chronic diseases, while protective antioxidant micronutrients like vitamin C decreased notably²³. A recent urban survey has shown that more than half of school-age children consumed excess fat and saturated fat and ultra-processed foods

Table 2: Food group intakes by gender consumed of adults in 1996-97 and 2005 (g/d) and differences in the amount of nutrient densities (per 1000 kcal of energy intake)

	Food group intakes of adults (g/d)				¹ Difference of intake (g/d) 2005 vs. 1996		P-value ²
	1996/97 ¹⁷ (n=2294)		2005 ¹⁸ (n=7209)				
Cereals	401.53	4.04	412.9	3.3	11.4	4.7	0.015
• Wheat and products	390.9	4.1	404.0	3.3	13.0	4.7	0.006
• Rice	3.61	0.52	3.80	0.13	0.18	0.52	0.856
• Barley and products	6.05	0.48	4.71	0.22	-1.33	0.49	0.007
• Other Cereals	0.90	0.15	0.41	0.04	-0.49	0.13	<0.001
Starchy roots	71.6	1.4	84.7	1.2	13.09	1.80	<0.001
Tree nuts	0.90	0.17	0.31	0.03	-0.59	0.17	0.001
Pulses	20.3	0.6	26.0	0.5	5.75	0.69	<0.001
Sugar and sweeteners	59.7	2.3	92.7	1.4	33.0	2.7	<0.001
Oil crops	3.59	0.24	9.16	0.24	5.57	0.33	<0.001
• Other Oil crops	0.48	0.12	1.27	0.07	0.80	0.14	<0.001
• Sesame seeds (mg/day)	2.61	0.52	2.55	0.21	-0.06	0.57	0.918
• Olives (including preserved)	3.11	0.21	7.89	0.22	4.77	0.30	<0.001
Vegetable oils	42.4	0.6	58.3	0.6	15.9	0.8	<0.001
• Soybean oil	29.3	0.3	29.5	0.7	0.23	0.75	0.758
• Olive oil	13.1	0.6	28.8	0.6	15.7	0.7	<0.001
Vegetables	320.0	4.0	355.4	4.8	35.4	6.1	<0.001
Fruits	174.3	8.7	223.8	5.3	49.5	8.2	<0.001
Meat	53.5	1.6	66.9	1.1	13.3	1.9	<0.001
• Red meat	28.6	1.3	23.2	0.6	-5.37	1.42	<0.001
• Poultry meat	25.0	1.1	43.7	0.8	18.7	1.3	<0.001
Eggs	17.6	0.7	40.1	0.6	22.5	1.0	<0.001
Animal fats	3.1	0.2	9.36	0.28	6.21	0.36	<0.001
Milk	133.6	4.4	171.3	3.0	37.7	5.2	<0.001
Fish and seafoods	15.6	1.1	25.5	0.7	9.88	1.32	<0.001

¹ Daily difference of intake (mean values of 2005 – value of 1996/97) taking into account the study design; ² P value derived from the comparison of mean daily intake observed in 2005 and 1996; ³ Weighted mean; ⁴ standard error of mean.

The same database revealed a little decrease in the quality of the diet that can be highlighted by the increase of the densities of total sugars and saturated fatty acids and the decrease of the densities of protein, fiber, polyunsaturated fatty acids, beta-carotene, most of the vitamins B (except vitamin B12 and pantothenic acid), copper, iron, and zinc (Table 3).

This is in line with a trend towards a modernization/westernization of dietary intake, which was especially observed in urban areas among adults (with also a lower diet quality for women vs. men)²⁴. Furthermore, among adolescents, a modernization gradient of diet featured a linear decrease in consumption of traditional foods such as vegetable oil, cereals, grains, legumes and vegetables and an increase of white bread, dairy products, confectionery, and generally sugar or added fats (mostly found in ultra-processed products). This gradient also showed an increase of energy and saturated fat involving a higher

(mainly cheese and cakes, pies, and biscuits) were the greatest source of these macronutrients (*to be published*).

3.2.3 Physical activity

As a consequence of socio-economic changes and urbanization and despite limited available data, decrease in physical activity and prevalence of sedentary behavior (including among children and adolescents) are of concern as in all MENA countries²⁵⁻²⁷.

3.3 Micronutrient deficiencies

Iron. In a national survey conducted during 1996-97, the prevalence of anemia was found to affect deeply childbearing women (26%)²². The assessment of anemia causes among childbearing women showed that inadequate iron intake is the main etiology and accounted for up to 78% of the national prevalence²⁸.

Table 3: Energy, macro- and micronutrient intakes of adults in 1996/97 and 2005 and differences in the amount of nutrient densities (per 1000 kcal of energy intake)

	Energy and Nutrient intake per adult				Differences in the amount of nutrient densities (/1000 kcal of energy intake)		P-value ²
	1996/97 ¹⁷ (n=2294)		2005 ¹⁸ (n=7209)				
Energy & Macronutrients							
Energy (kcal/d)	2292 ³	17 ⁴	2803	16	---	---	---
Protein (g/d)	73.7	0.6	85.7	0.5	-1.62	0.15	0.548
Carbohydrates (g/d)	345.3	2.4	394.6	2.2	-9.57	0.60	0.920
Total sugar (g/d)	73.1	1.1	101.8	0.9	4.65	0.42	0.534
Dietary fiber (g/d)	32.8	0.3	35.1	0.3	-1.84	0.11	0.641
Total fat (g/d)	75.4	0.8	106.0	0.8	4.69	0.24	0.451
• SFA ⁴ (g/d)	16.7	0.2	24.8	0.2	1.46	0.10	0.293
• MUFA ³ (g/d)	28.9	0.5	46.0	0.5	3.69	0.18	0.008
• PUFA ⁶ (g/d)	24.6	0.2	28.3	0.4	-0.64	0.14	0.071
Vitamins							
Vitamin A (RAE) (µg/d)	645.3	10.3	902.1	11.8	35.5	4.9	<0.001
Beta-carotene (µg/d)	4954	97	5662	81	-167.6	40.8	0.003
Vitamin E-α-tocopherol (mg/d)	15.7	0.3	20.9	0.2	0.59	0.11	0.027
Vitamin B1 (mg/d)	2.45	0.02	2.53	0.02	-0.16	0.01	0.123
Vitamin B2 (mg/d)	1.93	0.02	2.21	0.02	-0.05	0.01	0.037
Vitamin B3 (mg/d)	27.2	0.3	29.4	0.2	-1.32	0.08	0.016
Vitamin B6 (mg/d)	1.67	0.02	2.01	0.02	-0.02	0.01	0.845
Vitamin B12 (µg/d)	2.78	0.11	5.00	0.13	0.56	0.06	0.008
Folate (µg/d)	654.4	6.7	686.5	6.4	-39.1	2.6	0.103
Pantothenic acid (mg/d)	4.86	0.05	6.24	0.04	0.11	0.01	0.098
Vitamin C (mg/d)	146.8	2.0	181.3	1.8	0.54	0.89	0.620
Minerals							
Calcium (mg/d)	722.4	8.8	869.0	5.9	-3.60	3.46	0.070
Copper (mg/d)	1.81	0.01	2.07	0.02	-0.05	0.00	0.131
Iron (mg/d)	17.9	0.1	19.7	0.1	-0.80	0.04	0.026
Magnesium (mg/d)	1213	13	1545	19	18.6	7.2	0.190
Phosphorus (mg/d)	1191	10	1458	9	0.50	2.94	0.051
Potassium (mg/d)	2883	27	3513	28	-5.56	9.96	0.850
Sodium (mg/d)	3833	38	4471	27	-75.0	9.7	0.237
Zinc (mg/d)	8.96	0.08	10.4	0.1	-0.20	0.02	0.916

¹ Daily difference of nutrient intake (mean values of 2005 – value of 1996/97) taking into account the study design; ² P value derived from the comparison of mean daily intake observed in 2005 and 1996; ³ Weighted mean; ⁴ standard error of mean

Recently, the Tunisian Health Survey Examination survey (2016) has reported a high prevalence of anemia among childbearing women (19-39 y., 33% to 36%)²⁹. The cost line and the South Western part of the country were the most affected. Regarding the social determinants, anemia was markedly more prevalent among men in low socio-economic classes (22% vs. 17% for the highest category), and less instructed. Among women, the main determinants were age and professional status²⁹. While anemia progressed during the last three decades, no fortification program is undergoing to overcome the problem³⁰.

Vitamin A. In 2006, a regional survey that included 6677 children (5-7y.) was conducted by measuring the plasma retinol. While moderate vitamin A status was non-significant (2.3%) according to the public health standards, low vitamin A was more common at the rate of 17%³¹. It was denoted that the risk of deficiency was associated with the children's age. Among neonates

(preterm and neonate term) vitamin A deficiency reaches an alarming rate of more than 60%³².

Vitamin D. Deficiency was reported to prevail among infants with a rate of 65%³². In 2002, a cross-sectional study conducted among adults (n=389, 20-60 y.) showed that 48% were deficient. Multiparity and menopause were found to be negative predictors³³. In Tunisia, 71% of vitamin D intake came from pelagic fish³⁴. It was modeled that the milk fortification, as a food carrier, with vitamin would allow enough intake³⁴.

Zinc. Today, a unique cross-sectional study has been conducted for the assessment of zinc status among childbearing women (n=1688, 20-49y)³⁵. Zinc deficiency was found to affect 38.8% of women.

Iodine. After the surveys of 1973-75 and 1983, it was established that iodine deficiency is a public health issue in Tunisia³⁶. In 1984, the Ministry of Health emitted a first decree for the

compulsory commercialization of iodized salt in the West region. In 1995, salt commercialization was generalized to reach out to the whole country regions (decree n° 95-1633 of 4th September 1995). In 1996, Tunisia was recognized free from iodine deficiency disorders³⁶. In 2012, the latest national survey (6-12y.) showed an optimal iodine intake with a median urinary iodine concentration of 220 µg/L³⁷. During the same year, a national survey for monitoring salt iodization across the country reported an unsatisfactory coverage of iodized salt (55.4%)³⁸. Next to that, of the suspicious reasons of iodine excess in the Southside of the country, is believed to be the high iodine content in salt³⁸ as well as an excess of iodine content in water³⁹. Lastly, it is important to mention that the iodized salt is the only active food fortification program (25–45 ppm of potassium iodate) in Tunisia.

3.4 Non-Communicable Diseases

Due to the burden of disease that they entail, Non-communicable Diseases (NCDs) represent a public health concern in Tunisia; they are assessed to be responsible for 86% of mortality⁴⁰ and for the major part of health expenditures (65% of the Ministry of Health budget is allocated for the therapeutic care)⁴¹.

Cardiovascular diseases represent the most frequent NCD in Tunisia in 2016 and remain the leading causes of death and still causing the most premature deaths⁴². Ischemic heart diseases are the leading cause of death and disability; in 2016 its age-standardized disability (DALYS) is assessed at 2,917.8 per 100,000. Cardiovascular diseases were much more prevalent in urban areas and in the more developed coastal areas respectively vs. the rural or inland regions where the prevalence were nevertheless of concern (detailed data not shown). There is also a strong economic patterning of these conditions, but which evolved (e.g., the prevalence of obesity was initially much higher among the more affluent but nowadays concerns all socio-economic strata).

Diabetes is increasing and the prevalence doubled during the last decades, from 7.5% in 1996 to 15.5% in 2016^{22,29}.

Cancer: Based on Globocan assessments⁴³, the number of new cancer cases in 2018 was 15894; the Age-standardized incidence rate (World) was about 115.4 (per 100 000 persons), higher among men: 131.7 vs. 102.0 among women. The number of cancer deaths was 6 075 among men and 4 017 among women corresponding to respective age-standardized mortality rate 92.2 and 53.2 (per 100 000 persons). According to the Tunisian Northern Cancer register, the annual cancer incidence increased during 1994-2009 was 1.16% [1.16-1.31] for men and 0.74% [0.10-0.38] for women⁴⁴.

NCD risk factors. Over the past two decades the prevalence of *overweight*, *obesity* doubled (Table 4). So that according to the latest national survey in 2016²⁹, among Tunisians aged 15 years old and above, about two-thirds were overweight, about one out of four were obese; Women were twice more prone to obesity than

men so that in 2016 a third were obese. Similar results were observed for *abdominal obesity* (women: 37,9%; men: 18,7%). On the other hand, the prevalence of thinness (BMI ≤18.5 kg/m²) was only 2.9% (men: 3.4%, women: 2.3%).

About one-quarter of Tunisians 15y and over, in 1996 and almost one-third in 2016 presented *high blood pressure*. Notwithstanding methodological differences, *hypertension* prevalence increased across the period 1996-2016 (Table 4).

Table 4: Prevalence of obesity, overweight, and diabetes by gender (age: 15 years and over)

	National Survey					
	1996 ¹⁷			2016 ²⁶		
	Men n=1600	Women n=3019	Total	Men n=4362	Women n=4850	Total
Obesity (%) (BMI≥30						
kg/m²)	5.7	19.7	13.9	17.6	34.6	26.2
Overweight						
(%) (BMI≥25	25.5	52.5	37.9	52.5	67.1	59.9
kg/m²)						
Diabetes (%)	6.0	8.7	7.5	16.1	14.8	15.5
Hypertension						
(%)	20.4	24.2	22.5	26.5	30.8	28.7

According to the latest published data by the Global Burden of Disease (GBD) workgroup, nutritional deficiencies regressed markedly (-31%) among Tunisian adults (15 – 49 y), from the 18th to the 19th cause of disability-adjusted life year (DALYs) between 1990 and 2019. However, the dietary risk factors of disability still high irrespective of the country's income level (including Tunisia). The nutrition transition experienced by the Tunisian population is inclusive of several behavior changes. Of the nutritional behaviors, excess of sodium intake has been recently documented to reach about 10 g per day among adults⁴⁵. Excess of sodium intake is proved to be one of the leading dietary risk factors for deaths and DALYs. Again, fat and saturated fatty acids intakes have increased by 5g and 1.5 per 1000 kcal between 1996 and 2005. In a recently conducted study, high amounts of trans-fatty acids were found in fast-food and industrial products. The increase in fat intake has been well documented as one of the correlates of obesity and cardiovascular diseases. Diet quality has an important impact on the emergence of non-communicable diseases, however, the changes that occurred during the last decades are more profound and affect different aspects of lifestyle behaviors. As for example, physical activity has declined while a sedentary lifestyle shapes the daily life of youth and adults²⁷.

Table 5: Trends of low birth weight, stunting and wasting among children under five years⁵²

	1988		2000		2006		2012		2018	
	(EDS Tunisia)		(MICS II)		(MICS III)		(MICS IV)		(MICS VI)	
	n	%	n	%	n	%	n	%	n	%
Stunting¹	2015	18.5	10553	16.8	2842	9.0	2589	10.1	3302	8.4
Wasting²	2015	3.1	10553	2.9	2842	3.4	2677	2.8	3340	2.1
Underweight³	2015	7.9	10553	3.5	2842	3.3	2677	2.3	3340	1.6

¹: Children under 5 who are below 2SD relative to the median height-for-age of the WHO reference population.

²: Children under 5 who are below 2SD relative to the median weight-for-height of the WHO reference population.

³: Children under 5 who are below 2SD relative to the median weight-for-age of the WHO reference population.

3.5 Special focus on infant and children < 5 years

The last Multiple Indicator Cluster Surveys (MICS) carried out during 2018 collected the breastfeeding practices information the day before the survey⁴⁶. Exclusive breastfeeding rate at 6 months of age was very low (only 14%). Exclusive breastfeeding rates were reported to fluctuate significantly according to regions (5% in the North West vs. 19% in the South West) and to gradually decline in parallel to the increase of mother instruction level (17%, primary education vs. 10% university education)⁴⁶. Predominant breastfeeding was reported only among 30.5% with higher practice in rural settings (35% vs. 28% in urban). Consistently, the predominant breastfeeding declined in parallel with the mother instruction level and the household economic level (40% for the poorest category vs. 24% for the rich category). The breastfeeding is relatively stable during the first year, from 44% for 0-5 months to 45% for the 12-15 months. Then, the practice declined dramatically to reach 18% for children aged 20-23 months. The cumulated percentage of infants receiving adequate breastfeeding within the age of 0-23 months is only about 34%⁴⁶.

At 6 to 23 months, the minimum diet diversification was reached among 63% of infants irrespective of their breastfeeding status⁴⁶. A net discrepancy was reported according to the living area (66% in urban vs. 58% in rural). The highest diversification rate was found in the North-East region (74%) and the lowest value was reported in the Centre-West region (56%). The percentage of infants that met the minimal diet diversification criteria (4 to 7 food groups) increased with the mother instruction level (35%, primary education vs. 77% university education) and the household economic level (54% for poorest category vs. 76% for the rich category). Minimum meal frequency was satisfactory among 86% of infants and was similar according to the regions and the living area. Almost, the frequency seems to not fluctuate according to the mother instruction level⁴⁶.

The current situation does not differ significantly from the last MICS conducted in 2011-12⁴⁷. For example, exclusive breastfeeding increased slightly (+5%) among 0-5 months and decreased by 4% for infants aged between 12-15 months.

Interestingly, the minimum meal frequency meal doubled (48% in 2011-12)⁴⁷.

Birthweight and nutritional status. The prevalence of low birth weight (defined as a weight of less than 2,500 grams and predisposing to higher mortality during adolescence and to increased risk of chronic diseases such as obesity, diabetes, and cardiovascular diseases^{48,49}, varied slightly from 5.0% in 2000 to 7.4% in 2018. Based on Demographic and Health Survey Tunisia 1988 and MICS surveys⁵⁰, the prevalence of the three indicators of child nutritional status decreased globally across the last 50 years (1988-2018) with light trends difference: contrary to underweight prevalence which decreased continuously from 7.9 in 1988 to 1.5 in 2018, the decreasing trend of stunting (low height for age; according to WHO⁵¹, it reflects a failure process to reach linear growth potential resulting of suboptimal nutritional conditions and/or health) and wasting (low weight for height, according to WHO, in most cases wasting is due to a recent and severe process of weight loss, which is often associated with acute undernourishment and/or severe disease or may also be the result of a chronic unfavorable condition) prevalence was reversed transitorily during 2006-2012 (Table 5).

While underweight decreased considerably, overweight prevalence increased from 1.4% in 1997 to 8.8% in 2006 to 14.3% in 2012⁵², thus exposing to a higher risk of obesity, premature death and disability in adulthood and also to increased future risks; breathing difficulties, increased risk of fractures, hypertension, early markers of cardiovascular disease, insulin resistance, and psychological effects can be observed among obese children experience⁵³.

4 Conclusions

Tunisia is at an advanced stage of the nutritional transition with major shifts in lifestyle and diet resulting in increased consumption of dairy and meat products and generally of foods with high fat, sugar, and salt content. Nevertheless, intakes of fruit and vegetables remain rather high. Micronutrient related deficiencies are still an issue, e.g., a woman out of three had anemia. An increase in sedentary behavior is of concern. Among children, stunting and wasting are no more an issue but

overweight is increasing. A fifth of the men and a third of the women are obese and one out of six Tunisians have diabetes as rates doubled in 20 years. Overall, about 90% of the mortality rate is attributable to NCDs. Most indicators feature a marked gender, socio-economic or regional patterning.

5 Recommendations

Generally, factors that impact diet, nutrition, and health encompass different levels of causes. So that solutions cannot be envisioned outside the sustainability framework and policies and interventions should take into account all dimensions of sustainability (health, economic, social, and environment) for the promotion of food systems that can provide healthy and sustainable diets to all (e.g., “fork to farm” approaches⁵⁴).

This implies that developing and implementing nutrition interventions as part of primary prevention should be multisectoral with the involvement of a variety of stakeholders at all levels. Sustainability also implies that for reasons of equity and social justice, policies and interventions should also monitor and tackle the major observed inequalities in nutrition-related health outcomes, in particular gender, socio-economic regional inequalities which are especially acute in Tunisia. Moreover, Tunisia is characterized by a double or even triple burden of nutrition-related health issues, so that sustainable policies and interventions will have to monitor and address these contradictory issues at the same time (double-duty actions).

For example, improving the nutritional quality of agri-food products and reducing their content of salt, added sugar and saturated and trans fatty acids remain one of the Government's priorities for the next years: it should be a good opportunity to put into practice all the above principles.

Finally, in 2020 when the pandemic of the COVID-19 engulfs the planet, a last and major recommendation would be that preventing all forms of malnutrition and NCDs while improving the environmental issues still be kept on top of the prevention agenda. Being optimistic, the current crisis may even offer opportunities to shift lifestyles and food systems towards more sustainability including better nutrition and health.

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