

## RESEARCH ARTICLE

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# Estimated Cancer Incidence in Northern Tunisia in 2023: Northern Tunisia Cancer Registry

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### Abstract

**Background:** Cancer is a major cause of morbidity and mortality in Tunisia. The objectives of our study were to estimate the incidence level of the main cancer sites in Northern Tunisia in 2023 and to dress projections till 2040. **Methods:** The population based cancer registry database of northern Tunisia was the source of cases of this study. This registry uses the active method to collect data from all health services that cover cancer patients of both public and private sectors. Incidence rate projections were established using the age-period-cohort model. **Results:** In 2023, according to our estimations, age standardized incidence rate (ASR) including skin cancers other than melanoma was of 165.9 /100,000 in males and 141.4/100,000 in females. In men, the five most common cancer locations (apart from the skin) were: lung with an ASR of 37.6/100,000 habitant, colorectal (29.4/100,000), bladder (24.1/100,000), prostate (15.2/100,000) and stomach (6.0/100,000). Concerning females, the top five locations (apart from the skin) were: breast (55.4/100,000), colorectal (23.0/100,000), corpus uteri (9.3/100,000), thyroid (9.0/100,000) and lung (5.8/100,000). By 2040, the incidence rates of colorectal cancer would reach more than the double in both genders. The ASR of lung and bladder cancers in males would be increasing; however, that of stomach cancer would be stable next decades. In females, while incidence rates of breast, thyroid and corpus uteri cancers would reach more than the double in 2040, cervical cancer incidence is expected to be stable next decades. **Conclusion:** Cancer incidence level in Northern Tunisia place the country in an intermediate level and projections seem to be worrying. Strengthening prevention, screening and early diagnosis are strongly recommended.

**Keywords:** Tumors- Incidence- projections- Tunisia

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### Introduction

Cancer continues to be a major cause of morbidity and mortality worldwide. According to the International Center for Research on Cancer (IARC), cancer was responsible of nearly 20 million new cases and 9.7 million deaths in 2022. The same source estimated that there would be around 29.5 million cases and 16.4 million annual deaths due to cancer by 2040 [1]. Although the overall incidence of cancer is lower in low- and middle-income (LMIC), total cancer-related mortality is significantly higher in LMICs compared to high-income countries, particularly among people younger than 65 years [2]. Cancer was recognized at the latest United Nations high-level meeting on the prevention and control of NCDs as a real scourge. However, until now, there is not yet a global solution [3]. Despite the worldwide commitment to reduce the burden associated with NCDs including cancer, the implementation of known solutions is insufficient to achieve the 2011 political declaration on prevention and

control of NCDs [4]. Cancer Epidemiology is an essential tool to help policy makers on making decisions and adapting prevention strategies [5]. To reduce the burden of cancer, it is recommended to dispose of a National Cancer Control Plans (NLCC). Effective cancer plans should be based on detailed knowledge of the cancer burden across the country and an efficient surveillance program [6].

In Tunisia, like many other countries, the burden of cancer is increasing widely posing major challenges to the health system [7]. Considering demographic developments and the aging of the population, the number of new cases will see a significant increase in the years to come. On the other hand, the economic burden will be very heavy due to the high cost of new cancer treatments. Consequently, guaranteeing the quality, effectiveness, and equality of opportunity of care provision for cancer patients could only be achieved through close and coordinated collaboration between all stakeholders. To fight against this scourge, Tunisia adhered to the conclusion of the World Health Organization (WHO) that the most effective way to

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reduce the incidence and impact of cancer would be the implementation of a national cancer control strategy [8]. Cancer surveillance constitutes a fundamental component of cancer plans in Tunisia. Hence, there are three ongoing Regional Population Based Cancer Registries (PBCRs) in Tunisia (in the Northern, in the center and in the southern region of the country) established since 1997. There is not yet a national registry due to the very low coverage of the southern cancer registry. The data collection involves an active retrospective method, with a laborious and complex process with many challenges including lack of access to data, the quality of medical records, lack of computerized system and a problem of governance [9–11]. Globally, there is always a delay between actual data and cancer registry publication especially in low and middle income countries [12]. Thus, the latest population based cancer registry data dates are back to 2014 in Tunisia. The aim of this study was estimate levels of incidence of main cancer sites in Northern Tunisia in 2023 and to analyze projections till 2040.

## Materials and Methods

### Study design

It was descriptive retrospective study based on data from the Northern Tunisia cancer registry (NCR) which is an ongoing registry. The NCR covers 11 governorates: Tunis, Ben Arous, Ariana, and Manouba constituting Greater Tunis; Zaghuan, Bizerte, and Nabeul are forming the North-East; and Béja, Kef, Siliana, and Jendouba representing the North-West region over an area of 28,162 km<sup>2</sup> (equivalent to one-fifth of the Tunisian national territory) (Figure 1). Demographic data of the population at risk were obtained from the National Institute of Statistics (NIS) [13]. The NIS proceeds by estimates for intercensal years, with publication of annual statistical yearbooks. We used these estimates to calculate the incidence rates for the period 1994-2014. In the general population census carried out in 2014, the Northern Tunisia region encompassed 5,359,500 inhabitants (approximately half of the country's population), including 2,686,100 males and 2,673,400 females. The repartition of the Northern Tunisia population by gender, year and age group are represented in Supplementary materials (Table 1 and 2).

### Data Collection

New cases of cancer in Northern Tunisia were collected by cancer registrars who visited all sources of patients care related to cancer in the region in both public and private sectors. Data collection of the NCR was carried out from the year 2000 until 2022 to collect data from all patient cancer records retrospectively to the period 2010-2014. These physicians have been trained to collect data following the international recommendations of the International Agency for Research on Cancer (IARC). Inclusion criteria covered the definition of primary infiltrating cancer, while exclusion criteria comprised tumor recurrence, metastasis, and basal cell carcinoma. Cancer registrars used a data sheet on cancer corresponding to primary infiltrating cancers diagnosed in Tunisian residents of Northern Tunisia. The mandatory

collected variables concerned data related to the patient (personal identification, sex, date of birth, usual place of residence, full address at the time of diagnosis, date of incidence), and to the characteristics of the tumor (most valid diagnostic basis (histology), topography of the primary tumor, morphology (histological type) and tumor behavior, sources of information...). The recommended variables concerned date of last news, status at last news (alive/deceased), the stage, the grade/differentiation, initial treatment, mode of discovery for tumors benefiting from an organized screening campaign. In addition to these variables, the registry collects additional variables (tumor size, significant tumor markers, treatment start dates, evolutionary status).

Demographic details, such as population statistics categorized by year, age group (in five-year intervals), gender, and governorate, were obtained from the National Institute of Statistics (NIS) (Figure 2) [13].

### Tumor coding

Since 2004, we have consistently coded the location and morphological characteristics of primary tumors using the third version of the International Classification of Diseases for Oncology (ICDO-3). Our approach aligns with the International Agency for Research on Cancer (IARC) recommendations for defining multiple primary tumors incidence [14].

### Data entry and Statistical Analysis

Data entry was performed using EpiData software. All measures to respect confidentiality have been taken. Searches for duplicates were carried out systematically upon entry and periodically throughout the database.

The registry team also regularly verified the completeness of the mandatory variables: sex, age, place of residence and examined the validity of the data.

### Calculation of Incidence Rates

The incidence indicators of the NCR encompassed the crude incidence rate (CIR) and the age standardized incidence rate (ASR). CIR was calculated as follow:

$$CIR = \frac{\text{Number of case}}{\text{Number of population per time periode}}$$

Data about Tunisia population were extracted from the NIS[13]. The ASR was calculated using the standard population method [15]. We used the World Health Organization's (WHO) standard population as a reference to calculate the ASR.

$$ASR = \sum_{i=1}^n (ti * \text{proportion of age class } i \text{ in the reference population})$$

where n represents the number of total age classes and ti the specific incidence rate by age class

$$ti = \frac{\text{number of observed new cases in the class } i}{\text{Total population of the class } i} * 100\ 000$$

*Analysis of Incidence Rate Trends*

We employed the Joinpoint software to analyse trends in the incidence [16, 17]. This analysis facilitated the calculation of the Average Annual Percentage Change (AAPC) with its 95% confidence interval. Additionally, it assessed the significance level of any statistically upward or downward trends.

*Establishment of Incidence Rate Projections*

Projections were formulated based on data analysis from the Northern Tunisia registry for the period 1994-2014, using the age-period-cohort model. We used the Poisson regression which is a type of generalized linear models, treated the number of new cases as the dependent variable. The independent variables included age at diagnosis, period, and birth cohort [18, 19].

*Data quality of NTCR (2010-2014)*

To assess the exhaustiveness, we calculated two parameters:

- an indirect index of exhaustiveness which is the average number of sources of notification per case;
- an indicator of non-exhaustiveness which is the histological verification of the diagnosis.

Concerning the validity of the data, only one indicator was calculated: the rate of missing cases for the mandatory variables (age, sex, place of residence, unknown primary site).

*Ethical considerations*

The confidentiality of personal information's was respected during the collection and the data analysis. It is also important to mention that cancer registries in Tunisia are governed by Decree No. 2008-846 of March 24, 2008; on the other hand, the Northern Tunisia Cancer Registry (NTCR) has the authorization from the National Authority for the Protection of Personal Data on April 27, 2017.

**Results**

*Overall cancer incidence in Northern Tunisia in 2023*

In 2023, according to our estimations, there were 10880 new cases of cancer recorded in Northern Tunisia with a gender ratio of 1.12. The ASR including skin cancers other than melanoma was of 165.9 /100,000 in males and 141.4/100,000 in females (Table 1). The specific incidence rates for all sites of cancer increased with age in both males and females. The highest specific incidence rates were between 70 and 79 years for both genders (Figure 3).

*Cancer incidence trends in Northern Tunisia during the period 1994-2014*

Except for stomach cancer in males and cervical

cancer in females, for which the incidence trend was downward, a significant upward trend was observed for other sites. In males, the highest APC was observed for colorectal cancer (4.5%) (Table 2, Figure 4). For females, cancer of the corpus uteri showed the highest APC (4.1%), followed by colorectal cancer (3.5%) (Table 2, Figure 5).

*Estimated proportion and incidence of top 10 leading cancer sites in Northern Tunisia in 2023*

The proportional distribution of the leading cancer sites in males in 2013 were: trachea, bronchus and lung (23.6%), followed by colorectal (17.6%), then the bladder (11.5%), prostate (9.5%), and skin excluding melanoma (5.9%), stomach ranked sixth place representing 3.6%. In females, the most frequent cancer sites were: the breast (36.9%), followed distantly by colorectal (16.6%), corpus uteri (6.8%), thyroid (5.9%), skin excluding melanoma (5.7%) and trachea, bronchus and lung (4.2%).

In terms of incidence, in men, the five most common cancer locations (apart from the skin) were: lung (37.6/100,000), colorectal (29.4/100,000), bladder (24.1/100,000), prostate (15.2/100,000) and stomach (6.0/100,000) (Table 3, Figure 6). Concerning females,

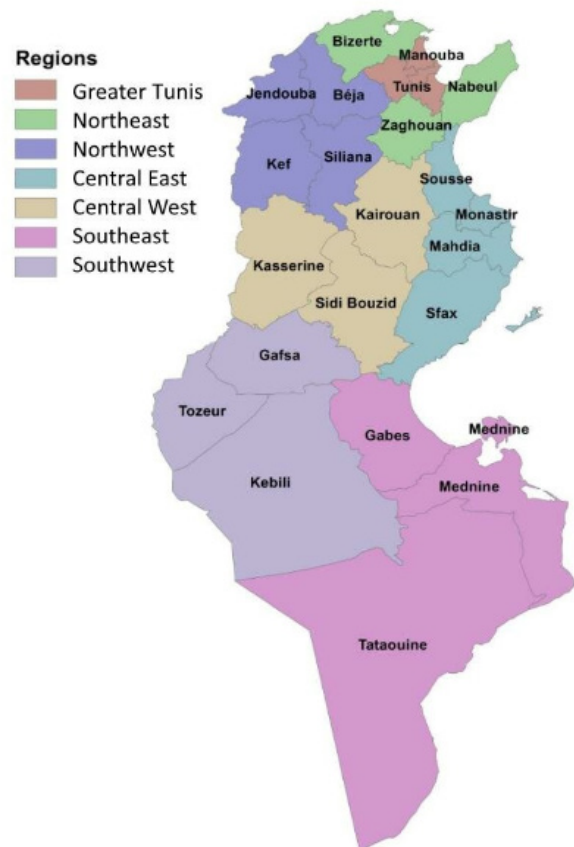


Figure 1. Map of Tunisia Showing Its Different Governorates and Regions

Table 1. All Cancer Sites Incidence in Northern Tunisia, 2023

| Gender | N     | %    | CIR (per 100000)* | CI at 95%     | ASR (per 100000)* | CI at 95%     |
|--------|-------|------|-------------------|---------------|-------------------|---------------|
| Male   | 5,757 | 52.9 | 192.9             | [185.9-200.2] | 165.9             | [159.7-172.4] |
| Female | 5,123 | 47.1 | 167.0             | [160.1-174.2] | 141.4             | [135.4-147.6] |

%, percentage; CIR, crude incidence rate; ASR, age standardized incidence rate; \*, Incidence rate including skin cancers other than melanoma

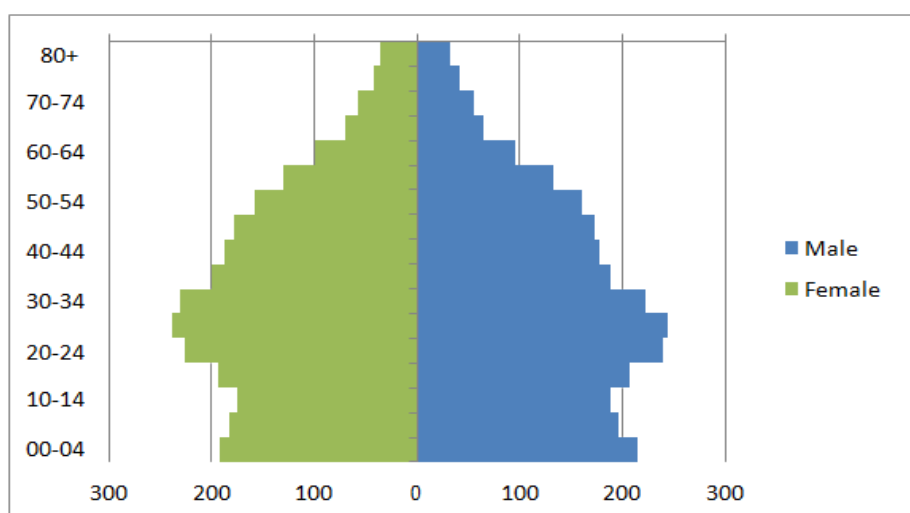


Figure 2. Age Pyramid of the Population of Northern Tunisia: 2010-2014

the first five locations (apart from the skin) were: breast (55.4/100,000), colorectal (23.0/100,000), corpus uteri (9.3/100,000), thyroid (9.0/100,000) and lung (5.8/100,000) (Table 3, Figure 7).

*Projections of cancer incidence in Northern Tunisia, 2020-2040*

The projected incidence rates in males would reach 179.8/100,000 and 165.7/100,000 in females by 2030 for all sites. By 2040, the incidence rates of colorectal cancer would reach more than the double in both genders (from 29.4/100,000 to 79.5/100,000 in males and from 23.0/100,000 to 61.3/100,000 in females). The ASR of lung and bladder cancers in males between 2023 and 2040, would increase respectively from 37.6/100,000 to 54.1/100,000 and from 24.1/100,000 to 38.6/100,000 (Table 4). However, the ASR of stomach cancer is supposed to be stable around 6.0/100,000 in next decades. In females, while incidence rates of breast, thyroid and

corpus uteri cancers would reach more than the double in 2040, cervical cancer incidence would be stable (3.8/100,000 in 2040) (Table 4).

*Data quality indicators of the NCRT*

Concerning the completeness: During the period 2010-2014, we recorded 45,788 notifications for 40,913 new cases (annual average equal to 8,182 per year). Corresponding to an average number of notification sources of 1.11 (1.05 for the Northern cancer registry of the period 2007-2009). The percentage of cases verified histologically (%VH) (Indicator of non-exhaustiveness) was of 94.3 % for males and of 95.5% for females.

*For the validity*

The percentage of unknown age during the period 2010-2014 was of 5.3%. On the other hand, no locations were observed that have a high percentage of unknown age that could underestimate the specific incidences by

Table 2. Trends in the ASR of most Frequent Cancer Sites by Gender, Northern Tunisia: 1994-2014

|               | Incidence<br>(per 100000)<br>1994 | Incidence<br>(per 100000)<br>2010-2014 | AAPC  | Lower limit- at<br>95% confidence<br>interval | Upper Limit- at<br>95% confidence<br>interval | P      |
|---------------|-----------------------------------|--|-------|---|---|--------|
| <b>Male</b>   |                                   |  |       |   |   |        |
| Lung          | 31.4                              | 38.4                                   | 0.6%  | 0.0%  | 1.2%  | p<0.05 |
| Bladder       | 14.0                              | 20.7                                   | 1.4%  | 0.4%  | 2.4%  | p<0.05 |
| Prostate      | 10.1                              | 14.7                                   | 1.00% | -0.5%   | 2.6%  | p<0.05 |
| Colorectal    | 7.7                               | 19.7                                   | 4.5%  | 3.6%  | 5.5%  | p<0.05 |
| Stomach       | 8.0                               | 7.5                                    | -1.3% | -2.0%   | -0.6%   | p<0.05 |
| Total         | 136.6                             | 173.4                                  | 0.7%  | 0.2%  | 1.1%  | p<0.05 |
| <b>Female</b> |                                   |  |       |   |   |        |
| Breast        | 28.4                              | 45.4                                   | 2.1%  | 1.4%  | 2.8%  | p<0.05 |
| Colorectal    | 7.6                               | 15.9                                   | 3.5%  | 2.6%  | 4.4%  | p<0.05 |
| Thyroïde      | 3.7                               | 6.9                                    | 3.1%  | 1.7%  | 4.5%  | p<0.05 |
| Corpus uteri  | 2.4                               | 5.5                                    | 4.1%  | 2.9%  | 5.9%  | p<0.05 |
| Cervix uteri  | 6.6                               | 5.4                                    | -2.3% | -3.7%   | -1.00%  | p<0.05 |
| Total         | 104.6                             | 136.7                                  | 1.2%  | 0.7%  | 1.7%  | p<0.05 |

AAPC, average annual percentage change

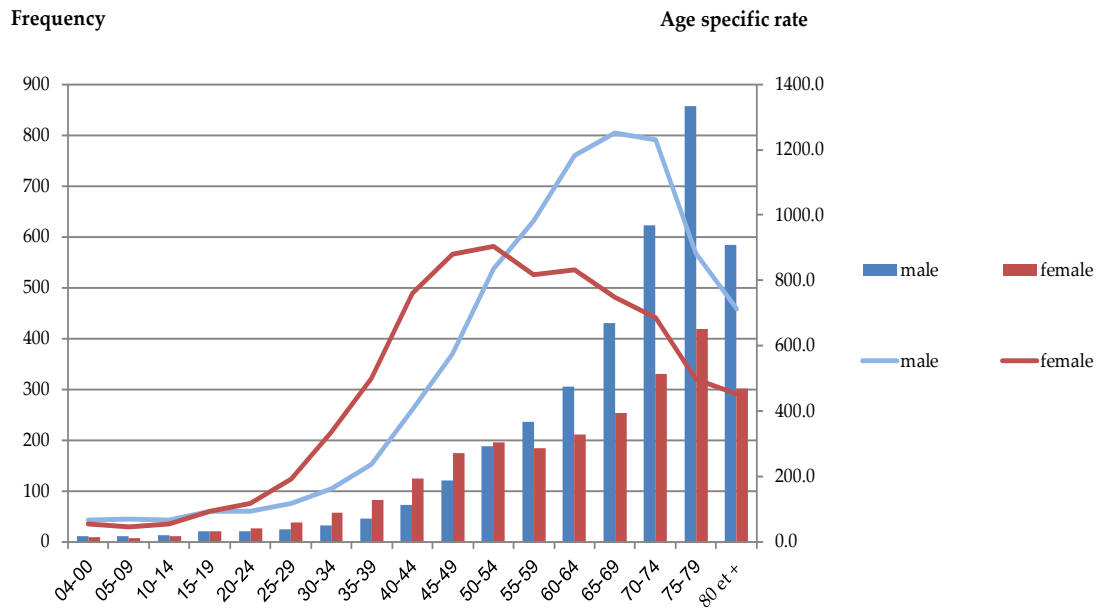


Figure 3. Estimated Age-Distribution Frequency and Incidence Rate for All Sites of Cancer by Gender –Northern Tunisia- 2023

age group. The age distribution did not show an excess of cases with age ending in 0 or 5. The percentage of specified dates of birth exceeds 65% of cases. The variable sex was specified for all patients.

A rate of 3.6% of unknown primary site was recorded by the NCRT for the period 2010-2014. This rate can be considered as additional proof of certain exhaustiveness. Indeed, it is obvious that in a country like Tunisia where autopsies are very rarely performed and where diagnostic means are fairly accessible, a low rate can only suspect

under-registration.

Despite considerable effort, the percentage of cases whose place of residence is unknown remains close to 4%. As with previous periods analyzed within the framework of the NCRT, and given the significant risk of including non-incident cases, we preferred not to include them in the registry file.

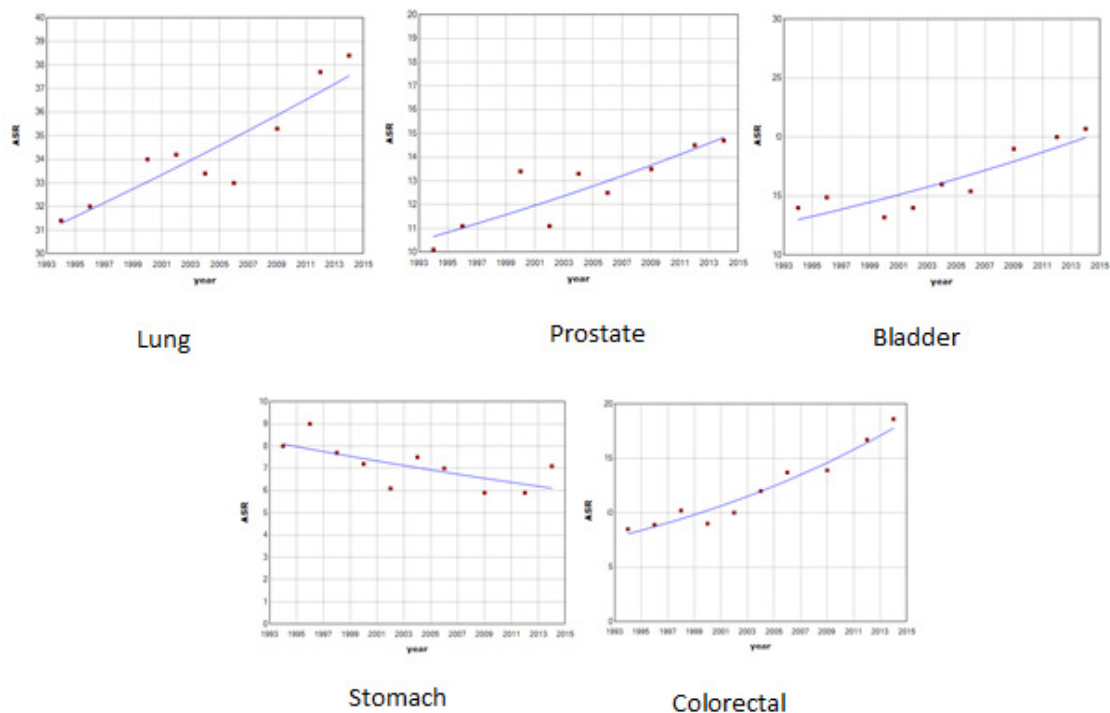


Figure 4. Trends in the Age Standardized Rate of Principal Cancer Sites in Males in Northern Tunisia for the Period 1994-2014



Table 3. Incidence Rates of Main Cancer Sites According to the Gender, Northern Tunisia , 2023

| Location                | Males |      |      | Location                          | Females |      |      |
|-------------------------|-------|------|------|-----------------------------------|---------|------|------|
|                         | N     | CIR  | ASR  |                                   | N       | CIR  | ASR  |
| Trachea, bronchus, Lung | 1,356 | 45.4 | 37.6 | Breast                            | 2,031   | 66.2 | 55.4 |
| Colorectal              | 1,015 | 34.0 | 29.4 | Colorectal                        | 850     | 27.7 | 23.0 |
| Bladder                 | 663   | 22.2 | 24.1 | Corpus uteri                      | 350     | 11.4 | 9.3  |
| Prostate gland          | 527   | 17.7 | 15.2 | Thyroid gland                     | 301     | 9.8  | 9.0  |
| skin excluding melanoma | 340   | 11.4 | 9.9  | skin excluding melanoma           | 293     | 9.6  | 8.0  |
| Stomach                 | 208   | 7.0  | 6.0  | Trachea, bronchus, Lung           | 213     | 6.9  | 5.8  |
| Non Hogdkin lymphoma    | 206   | 6.9  | 6.3  | Non Hogdkin lymphoma              | 166     | 5.4  | 4.8  |
| Larynx                  | 181   | 6.1  | 5.1  | Cervix uteri                      | 143     | 4.7  | 3.9  |
| Pancreas                | 140   | 5.3  | 4.3  | Stomach                           | 116     | 3.8  | 3.2  |
| Kidney                  | 143   | 4.8  | 4.3  | Lip, Hypopharynx, Pharynx*, Mouth | 105     | 3.5  | 3.2  |
| Hodgkin lymphoma        | 110   | 3.7  | 3.7  | Bladder                           | 95      | 3.1  | 2.6  |
| Nasopharynx             | 105   | 3.5  | 3.2  | Pancreas                          | 85      | 2.7  | 2.3  |

N, effectif; %, percentage; CIR, crude incidence rate; SIR, standardized incidence rate

### Discussion

The objectives of the present study were to estimate levels of incidence of main cancer sites in Northern Tunisia in 2023 and to analyze projections till 2040.

In Northern Tunisia, in 2023, the estimated ASR (including skin cancers other than melanoma), was of 165.9 /100,000 in males and 141.4/100,000 in females, with a gender ratio of 1.12. These rates place Northern Tunisia as an intermediate level for cancer [20]. Among males, the five leading cancer sites were: trachea, bronchus and lung (23.6%), followed by colorectal (17.6%), bladder (11.5%), prostate (9.5%), and skin excluding melanoma (5.9%), stomach ranked sixth place representing 3.6%. In females, the most frequent cancer sites were the breast (36.9%), followed distantly by colorectal (16.6%), corpus

uteri (6.8%), thyroid (5.9%), skin excluding melanoma (5.7%) and trachea, bronchus and lung (4.2%). By 2040, the incidence rates of colorectal cancer would reach more than the double in both genders. Incidence rates of lung and bladder cancers would be increasing; however, the ASR of stomach cancer is supposed to be stable in next decades. In females, while incidence rates of breast, thyroid and corpus uteri cancers would reach more than the double in 2040, cervical cancer incidence would be stable.

The methodology used for cancer registration in NTCR complies with IARC recommendations [13]. The use of the active method for data collection ensured satisfactory completeness; this one ensured the exclusion of selection bias. Similarly, elimination of duplicates and correction of incompatibility errors (sex/topography, topography/histology, age/topography/histology) ensured

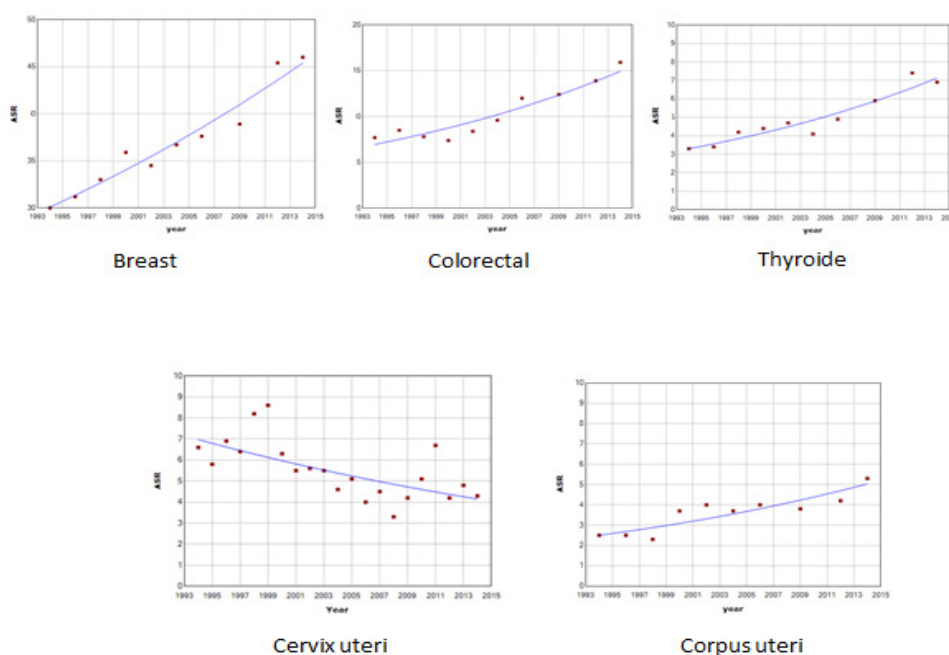


Figure 5. Trends in the Age Standardized Rate of Principal Cancer Sites in Females in Northern Tunisia for the Period 1994-2014

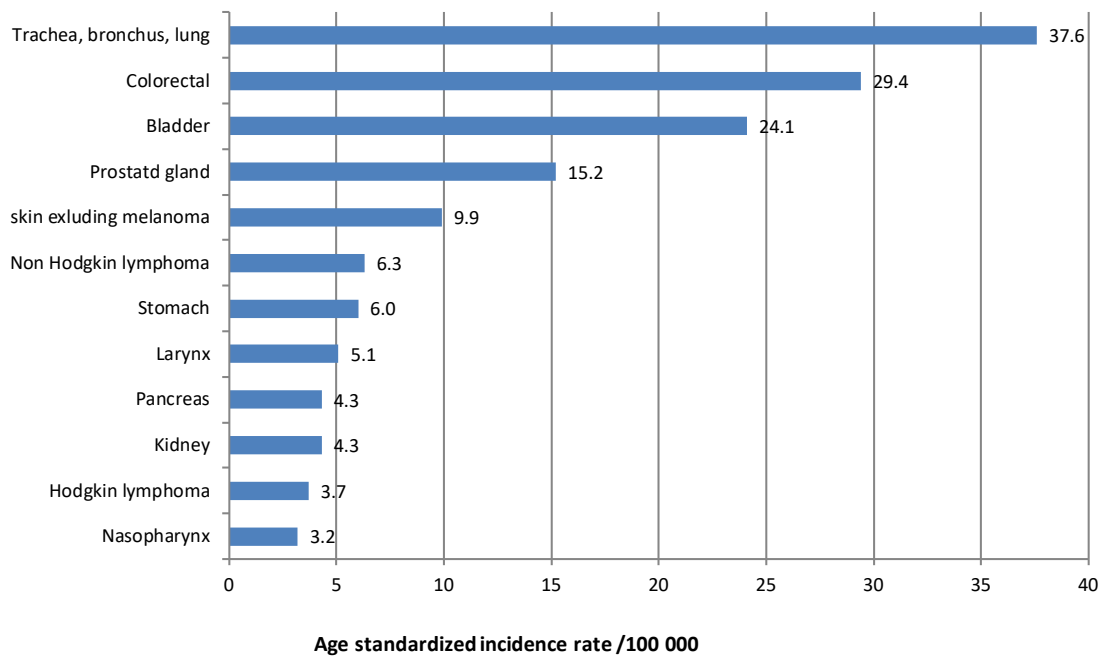


Figure 6. Estimated Age Standardized Incidence Rate of Top 10 Leading Sites of Cancer in Males, Northern Tunisia, 2023

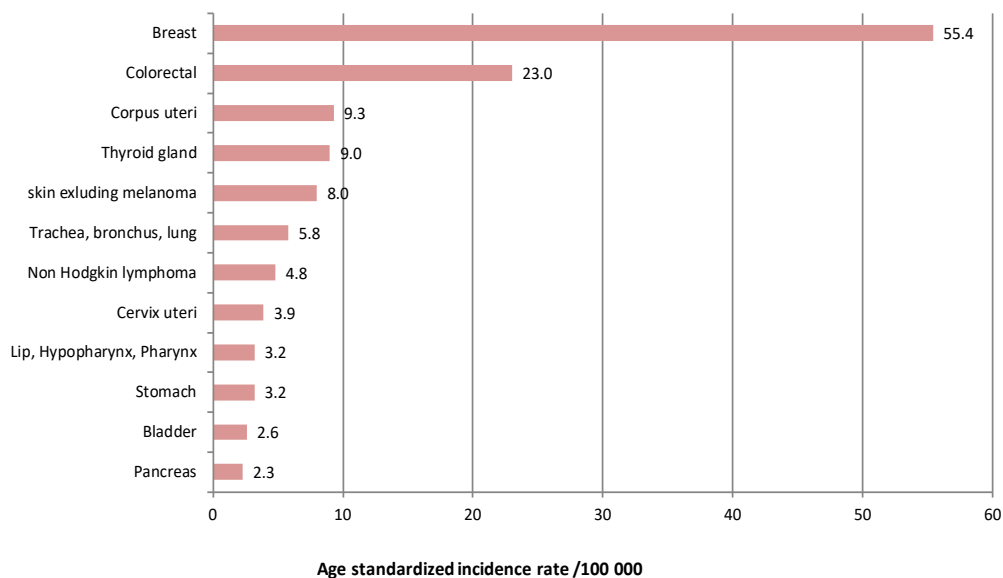


Figure 7. Estimated Age Standardized Incidence Rate of Top 10 Leading Sites of Cancer in Females, Northern Tunisia, 2023

data quality. The principle limitation of this study was the absence of a unique identifier for each citizen which constitutes a problem for efficient duplicate search and the correspondence with deaths certificates [9]. Also, data on cancer survival are limited in Tunisia.

The male predominance (with a gender ratio of 1.12) in this study aligns with global findings [21] where a slight male predominance with a gender ratio of 1.1 in the world [22]. The ASR of cancers in Northern Tunisia showed in this study was a little higher than rates of the GLOBOCAN estimations where it was of 159.4 in males and 115.3 in females [1]. Worldwide rates were comparable to Northern Africa and South- Eastern Asia

in males and North-eastern African, Central America and South-Eastern Asia in females.

The present study revealed that in Northern Tunisia, lung cancer was the most frequent cancer in males with an ASR of 37.6/100,000 and the sixth most common cancer in females with an ASR of 5.8 in 2023. In the world and according to GLOBOCAN, the highest rates of lung cancer were essentially observed in China, Turkey and Russia while the lowest rates were recorded in Central Africa and India [1]. Northern Tunisia is classified as intermediate to high incidence level for lung cancer in males, with an alarming ASR close to those observed in the USA (33.6/100,000), Canada (34.9/100,000) and

Table 4. Projection of Incidence for Main Cancer Sites: 2020-2040

| Year | Standardized incidence rate (per 100000) |      |         |          |            |         |
|------|--|------|---------|----------|------------|---------|
|      | Total                                    | Male |         |          |            |         |
|      |  | Lung | Bladder | Prostate | Colorectal | Stomach |
| 2023 | 165.9                                    | 37.6 | 24.1    | 15.2     | 29.4       | 6.0     |
| 2024 | 168.8                                    | 37.9 | 25.0    | 15.3     | 30.8       | 6.0     |
| 2025 | 168.8                                    | 38.3 | 25.1    | 15.3     | 32.4       | 5.9     |
| 2026 | 170.4                                    | 38.7 | 25.4    | 15.4     | 34.1       | 5.9     |
| 2027 | 172.3                                    | 39.2 | 26.0    | 15.5     | 35.9       | 5.8     |
| 2028 | 174.6                                    | 39.8 | 26.5    | 15.6     | 37.9       | 5.8     |
| 2029 | 177.2                                    | 40.5 | 27.2    | 15.7     | 40.0       | 5.8     |
| 2030 | 179.8                                    | 41.2 | 27.8    | 15.8     | 42.3       | 5.8     |
| 2031 | 182.8                                    | 42.1 | 28.5    | 16.0     | 44.4       | 5.8     |
| 2032 | 186.1                                    | 43.0 | 29.3    | 16.1     | 47.5       | 5.8     |
| 2033 | 189.9                                    | 44.0 | 30.2    | 16.3     | 50.4       | 5.9     |
| 2034 | 194.0                                    | 45.2 | 31.2    | 16.6     | 53.7       | 5.9     |
| 2035 | 198.3                                    | 46.4 | 32.2    | 16.8     | 57.2       | 5.9     |
| 2036 | 203.1                                    | 47.7 | 33.3    | 17.1     | 60.9       | 6.0     |
| 2037 | 208.3                                    | 49.1 | 34.5    | 17.5     | 65.1       | 6.0     |
| 2038 | 213.8                                    | 50.7 | 35.8    | 17.8     | 69.5       | 6.1     |
| 2039 | 219.7                                    | 52.3 | 37.2    | 18.2     | 74.3       | 6.2     |
| 2040 | 225.7                                    | 54.1 | 38.6    | 18.6     | 79.5       | 6.2     |

| Year | Total | Female |            |         |               |              |
|------|-------|--------|------------|---------|---------------|--------------|
|      |       | Breast | Colorectal | Thyroid | Corpus Uterin | Cervix Uteri |
| 2023 | 141.4 | 55.4   | 23.0       | 9.0     | 8.0           | 3.9          |
| 2024 | 146.6 | 58.9   | 24.2       | 9.9     | 8.4           | 3.9          |
| 2025 | 146.9 | 59.4   | 25.4       | 9.9     | 8.9           | 3.8          |
| 2026 | 150.0 | 61.7   | 26.6       | 10.5    | 9.3           | 3.8          |
| 2027 | 153.5 | 64.1   | 28.0       | 11.0    | 9.8           | 3.7          |
| 2028 | 157.2 | 66.9   | 29.5       | 11.6    | 10.4          | 3.7          |
| 2029 | 161.3 | 69.8   | 31.2       | 12.2    | 10.9          | 3.7          |
| 2030 | 165.7 | 73.0   | 32.9       | 12.9    | 11.5          | 3.7          |
| 2031 | 170.4 | 76.5   | 34.7       | 13.6    | 12.2          | 3.7          |
| 2032 | 175.5 | 80.2   | 36.8       | 14.3    | 12.9          | 3.7          |
| 2033 | 181.0 | 84.3   | 39.1       | 15.1    | 13.7          | 3.7          |
| 2034 | 187.0 | 88.7   | 41.5       | 16.0    | 14.5          | 3.7          |
| 2035 | 193.3 | 93.5   | 44.2       | 16.9    | 15.4          | 3.7          |
| 2036 | 200.0 | 98.5   | 47.0       | 17.8    | 16.3          | 3.7          |
| 2037 | 207.2 | 104.0  | 50.1       | 18.8    | 17.4          | 3.8          |
| 2038 | 214.8 | 109.8  | 53.6       | 19.9    | 18.5          | 3.8          |
| 2039 | 222.8 | 116.0  | 57.3       | 21.0    | 19.7          | 3.8          |
| 2040 | 231.1 | 122.5  | 61.3       | 22.1    | 21.0          | 3.9          |

some European countries such as Italy (34.5/100,000) and Germany (35.2/100,000). In females, level of lung cancer in Northern Tunisia was intermediate, close to levels in some Arab countries like Jordan (5.1), United Arab Emirates (5.1) and Iran (7.4) but higher than others North African countries. According to projections, the ASR of lung cancer would reach 51.4 in males in 2040 if effective preventive measures will not be implemented. The high level of incidence of lung cancer in Tunisia

demonstrates the inefficiency of the anti-tobacco program implemented over 30 years. The effective application of legislative measures and the fight against smuggling are strongly recommended.

Colorectal cancer (CRC) ranked as the second most frequent cancer in males (29.4/100,000) and females (23.0/100,000) in Northern Tunisia in 2023. The ASR of this one was much higher than the rate reported in GLOBOCAN. Thus, level of CRC in males is considered as high in



Northern Tunisia and close to rates observed in the USA (30.1/100,000), in South America such as Argentina (30.1/100,000) and in China (24.7/100,000). Female CRC incidence level in Northern Tunisia was also considered as very high and similar to levels observed in the USA (24.2), Canada (24.1) and many European countries [1]. The high level in both genders could be attributed to obesity, high meat and fat consumption, hyperlipidemia, and alcohol consumption [23]. According to projections, the ASR of CRC will double in 2040. Public health policy makers should be aware of the need of urgent measures to stop this scourge. The strategy to fight against this cancer should be effectively applied and the coverage of systematic screening needs to be improved.

Concerning bladder cancer, the ASR was of 24.1/100,000 in men in 2023 which is a very high incidence level close to those observed in the USA (17.3/100,000), Canada (24.2/100,000), Turkey (22.6/100,000), Egypt (26.1/100,000) and Europe. This high level can be attributed to specific risk factors, including the high prevalence of smoking, environmental exposure [24], endemic chronic urinary tract infections caused by *Schistosoma haematobium* [25] and also non modifiable factors including family history and genetics [26–28]. In males, prostate cancer was the fourth most frequent cancer with an ASR of 15.2/100,000 which is in line with GLOBOCAN estimations. Globally, it is considered as low to intermediate level like others North African countries [1]. The ASR of stomach cancer in males in 2023 was of 6.0/100,000 in Northern Tunisian. High salt intake, low consumption of fruit, and *Helicobacter pylori* infection [29] are considered responsible for 63.6% of stomach cancers [30]. Unlike other sites, stomach cancer incidence level is expected to be stable next years according to predictions. This could be likely attributed to changes in food preservation and improved availability of fresh fruits and vegetables [31, 32]. Prevention and treatment of *Helicobacter pylori* infections have also marked a turning point in the reduction of gastric cancer incidence, particularly in several developing countries [31].

In females, breast cancer was the most frequent cancer in Northern Tunisia with an ASR of 55.4/100,000 in 2023. This rate was largely higher than GLOBOCAN estimations. This high rate will double in 2040 according to projections. The upward trend in breast cancer observed in Northern Tunisia and many other low- and middle-income countries could be partially due to westernized lifestyle and reproductive changes. High-income countries with mammography screening programs have recorded a decline in mortality, highlighting the importance of systematic screening and appropriate treatment in the fight against this cancer [33]. Thyroid cancer ranked as the fourth most frequent cancer in Northern Tunisian females with an ASR of 9.0/100,000 and would reach 22.4 in 2040. This upward trend has been observed worldwide predominantly involving papillary carcinoma, possibly due to improved diagnostic techniques like fine-needle aspiration biopsies [34, 35].

Cancer of the corpus uteri ranked third in females with an estimated ASR of 8.0/100,000, in 2023 in

Northern Tunisia. This rate was higher than many African countries. In Northern Tunisia, there was an upward trend of the incidence of cancer of the corpus uteri, contrasting with global trends in some European countries. Similar incidence levels were observed in south America, and Saudi Arabia [36].

This study reported a relatively high cancer burden in North Tunisia which could be explained by the low coverage in of screening programs for breast, cervical and colorectal cancers, as well as the lack of awareness-raising actions among the Tunisian population. Till now four national cancer plans were implemented in Tunisia. However, governance problems and lack of resources limited its implementation, accentuating challenges in prevention, screening, and the capacity to meet the growing demand for care. These obstacles lead to unacceptable delays in diagnosis and treatment, exacerbating inequalities in access to cancer care services in Tunisia.

In conclusion, this was a population-based cancer registry study conducted in Northern Tunisia to estimate cancer incidence levels in 2023. Results of this study highlighted a high burden of morbidity in Tunisia (including skin cancer other than melanoma), incidence levels placed Northern Tunisia in an intermediate incidence level between high and low-incidence countries. The main cancer sites in males were lung, colorectum, bladder, prostate, and stomach. In females, the top five locations were breast, colorectum, thyroid, corpus uteri, and lung. According to projections, while the incidence of stomach and cervical cancers is supposed to be stable next decades, incidence of other sites like breast, colorectal, corpus uteri and thyroid cancers will reach more than the double in 2040. Strengthening primary prevention in particular the fight against tobacco and the fight against overweight and obesity, remains the most promising approach to reduce cancer incidence; Strengthening screening and early diagnosis as well as appropriate treatment constitute also a major public health priority. Faced with this high burden of cancer morbidity, decision-makers should strengthen the implementation of cancer plan and include this plan in the budgetary discussions of the Ministry of Health.

## Author Contribution Statement

H.K. and M.H: Conceptualization, methodology and validation. H.K, E.A and S.A: Data analysis. H.K, E.A, N.M and H.S: Writing. All authors have read and agreed to the published version of the manuscript.

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Not applicable.

## Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due [According to national law: Article 4: The information contained in cancer registries is confidential. Access to this information may only be granted in accordance with the provisions

of this decree and in cases authorized by law] but are available from the corresponding author on reasonable request.

#### Ethical approval

This study was approved by the ethical comity of Jendouba Hospital of Tunisia.

#### Competing interests

The authors declare no competing interests.

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