Original Article

# Epidemiological Shifts and Transitions in the Oncological Burden in Morocco

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## ABSTRACT

### Background

Cancer remains one of the leading causes of global morbidity and mortality, representing a critical public health challenge. This disease is defined by the uncontrolled proliferation of abnormal cells, which can invade adjacent tissues and form metastases.

### Objectives

The primary objective of this study is to characterize the epidemiological evolution of cancer in Morocco between 2021 and 2025, using data from the National Institute of Oncology (INO).

### Methodology

Key variables analyzed include sex, age, and tumor histological type. Statistical analysis reveals a striking rise in malignant hemopathies, whose proportion surged from less than 1% in 2021 to 20.1% in 2025, overtaking breast cancer to become the most frequently diagnosed entity. This shift coincides with a progressive masculinization of the tumor burden, with the proportion of male patients increasing from 40.78% to 42.81%. Concurrently, age distribution patterns highlight a dual dynamic: sustained predominance in the 51–69 age group alongside a concerning rise in cases among young adults aged 19–30, with 141 cases recorded in the first six months of 2025 alone. Additionally, data quality has markedly improved, evidenced by a reduction of over 50% in the rate of cases with missing information.

### Results

These findings delineate an emerging national oncological landscape shaped by three interdependent transitions. The  is characterized by the emergence of hematologic malignancies and early-onset cancers, likely driven by environmental and nutritional shifts tied to rapid urbanization. The *diagnostic transition* reflects institutional advancements in detection capabilities—particularly in hematologic oncology—fueled by expanded access to flow cytometry, molecular profiling, and multidisciplinary collaboration. Finally, the *demographic transition* manifests through the masculinization of cancer incidence and the aging profile of affected populations, mirroring broader societal changes.

### Conclusion

Together, these trends underscore the urgent need to reorient cancer control strategies toward sex- and age-tailored interventions, while reinforcing hospital-based cancer registries as indispensable tools for evidence-based public health decision-making.

## Keywords

Cancer epidemiology; Epidemiological transition; Hospital registry; Malignant hemopathies

## INTRODUCTION

Cancer is a very complicated disease that its development is mainly based on the gradual accumulation of genetic changes in the cellular genome[1]. These mutations occur one after another and cancer cells gradually replace normal cells in the disrupted homeostatic mechanisms which usually control the cell cycle causing the latter to be out of control and anarchic clonal proliferation[2]. Currently, cancer is among the top causes of avoidable death and diseases in middle-income countries and, at the same time, it travels along with the epidemiological transition to become the most challenging side of this transition. In Morocco, as well as other developing countries, the oncological burden is characterized by a double challenge scenario: infection-related neoplasms caused by poverty and lack of healthcare access on one hand and rapid tumor development related to urbanization, nutrition changes, demographic aging, and modern environmental exposures on the other side[3].

In such circumstances, the importance of hospital registries, not only as clinical monitoring tools

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but as real-time epidemiological sentinels that can detect the first signs of cancer trends changes, cannot be overemphasized[4]. The Sidi Mohamed Ben Abdellah National Cancer Institute (INO) in Rabat, Morocco's leading reference center for cancer care, offers a privileged vantage point to observe this transition in real time.

The objective of this research is to epidemiological shifts describing, analyzing, and interpreting through a rigorous methodology and linking them with health transitions phenomena at a regional level in MENA region.

## METHODOLOGY

### Study framework and data sources

This study is based on a secondary analysis of prospectively collected data from the Hospital Cancer Registry (HCR) of the National Institute of Oncology (INO), Morocco's premier oncology reference institution. The geographic scope is limited to the Rabat-Salé-Kénitra (RSK) administrative region, in alignment with the guidelines of the Global Initiative for Cancer Registry Development (GICR/WHO). These guidelines emphasize the importance of geographically anchored hospital registries during the initial phases of epidemiological maturation.

The data span the period from January 2021 to June 2025 and include all incident cases of malignant neoplasms newly diagnosed and managed at the INO among RSK residents. Diagnoses were confirmed through histological or cytopathological examination, adhering to the International Classification of Diseases for Oncology (ICD-O-3) criteria.

### Study population

The study population encompasses all patients residing in the Rabat-Salé-Kénitra (RSK) region, aged 0 to over 90 years, who received an incident cancer diagnosis (first diagnosis, with no prior history of homolateral or contralateral malignant tumors) during the observation period.

### Inclusion criteria

To be included, patients must have habitually resided within one of the RSK region's prefectures or provinces—a condition verified via official administrative address records at diagnosis. Histological or cytological confirmation of malignancy was mandatory. Additionally, cases required complete or partial registration in the INO's cancer registry information system.

### Exclusion criteria

Excluded cases comprised benign tumors or lesions of uncertain malignant potential. Metastases without an identified primary site were excluded unless later reclassified through molecular investigation. Cases transferred from external centers without local diagnostic confirmation were also omitted.

### Data collection

Data were extracted from the INO's Hospital Cancer Registry, adhering to frameworks established by the African Cancer Registry Network (ACRN) and international standards set by the International Agency for Research on Cancer (IARC). This alignment ensures methodological rigor and global comparability.

Variables collected included:

- Sociodemographic profiles: age at diagnosis, sex, and residential location;
- Tumor characteristics: anatomical site (classified per ICD-O-3), histological subtype, and differentiation grade as a marker of aggressiveness;
- Registry quality indicators: proportion of incompletely documented cases, used to assess data reliability and completeness.

Particular emphasis was placed on longitudinal consistency. To enable valid interannual comparisons, strict adherence to uniform definitions for cancer categories and staging criteria was enforced throughout the study period.

### Statistical analysis

Quantitative variables were analyzed using R software (version 4.4.0). Intergroup mean comparisons were performed via one-way analysis of variance (ANOVA), with Tukey's post hoc test applied to identify specific between-group differences. Statistical significance was defined at $p < 0.05$. This approach balances sensitivity to detect true effects while controlling for Type I error inflation in multiple comparisons.

### Ethical Clearence

The study complies with the ethical principles of the Declaration of Helsinki and Moroccan national data protection regulations. All analyses utilized anonymized, aggregated data; no personally identifiable information was accessed or retained. Ethical approval was granted

by the INO's Medical Directorate following review by the Biomedical Research Ethics Committee (reference: CERB 133-25). Data access protocols were designed to uphold patient confidentiality while enabling robust epidemiological surveillance.

## RESULTS AND DISCUSSION

### Cancer distribution by patient gender

The gradual rise in the proportion of men among newly diagnosed cancer cases at the National Institute of Oncology (INO) (from 40.78% in 2021 to 42.81% in the first half of 2025) reflects a well-documented global pattern: men consistently experience higher cancer incidence and mortality rates than women, even when excluding cancers tied to reproductive organs. According to GLOBOCAN 2022 data, overall cancer incidence (across all sites, excluding sex-specific cancers) is roughly 20% higher among men in middle-income countries. This disparity stems from a complex interplay of biological, behavioral, and systemic factors[5]. In Morocco, this trend is now becoming evident in hospital-based cancer registries (Rabat and Casablanca Cancer Registry), driven not only by men's greater exposure to modifiable risk factors (such as tobacco use, alcohol consumption, and occupational hazards) but also by improved detection of male-predominant tumor types[6,7] (Table 1).

When compared with population-based cancer registries in Rabat and Casablanca, INO data reveal a distinct epidemiological trajectory. The Rabat registry (2005) reported an almost balanced male-to-female ratio of 1.01 (384 men vs. 379 women), with slightly higher age-standardized incidence rates among men (132.9 vs. 112.2 per 100,000), reflecting the relatively uniform cancer distribution in this administrative capital with concentrated healthcare infrastructure. In contrast, the Greater Casablanca registry—the country's main economic hub—has shown a progressive decline in the male-to-female ratio over time: from 0.81 during 2008–2012 (44.7% men, 55.3% women) to 0.57 in 2018–2021 (36% men, 64% women). This persistent and growing female predominance is likely attributable to the high burden of gynecological and breast cancers in this densely populated urban area. Against this backdrop, INO's shift toward 42.81% male cases (ratio ≈ 0.75) by 2025 suggests a convergence toward an intermediate profile between Rabat and Casablanca (one marked by a gradual "masculinization" of the caseload). This evolution likely reflects both enhanced diagnosis of male-predominant cancers and the maturation of Morocco's national referral system directing more complex cases to this tertiary oncology center.

A key driver of this shift is the rising prominence of hematologic malignancies, which became the most frequently diagnosed cancer category at INO in 2025. These neoplasms (particularly non-Hodgkin lymphomas and myeloid leukemias) typically occur 1.3 to 1.7 times more often in men across most populations, a pattern linked to sex-based differences in immune function influenced by sex chromosomes and steroid hormones[8]. Improved diagnostic capabilities in oncologic hematology at INO have therefore mechanically increased male representation in cancer statistics (not due to a surge in new cases, but by uncovering previously underdiagnosed disease). Similar patterns have been observed during cancer registry maturation in other transitional settings, such as Turkey and Tunisia, where enhanced reporting revealed a previously hidden burden of predominantly male hematologic cancers[9].

Moreover, entrenched behavioral risk patterns among Moroccan men continue to fuel incidence of male-predominant cancers, including those of the lung, esophagus, liver, and pancreas. Adult male smoking prevalence exceeds 30%, and a recent meta-analysis confirmed that men are generally less likely to seek medical care early in response to symptoms, leading to delayed diagnosis and overrepresentation in hospital registries at advanced disease stages[10]. Meanwhile, the historically high female predominance in cancer statistics has been somewhat tempered by the relative stability in breast cancer rates and modest improvements in urban access to screening—though significant geographic and socioeconomic disparities persist, particularly in rural areas[11].

Ultimately, these trends signal a paradigm shift in Morocco's oncological transition. Whereas earlier phases were dominated by infection- and fertility-related cancers affecting women (e.g., HPV-associated cervical cancer), the country is now entering a new stage in which lifestyle- and aging-related malignancies (impacting both sexes more equally, or even disproportionately affecting men) are gaining prominence. This aligns with WHO projections for the MENA region, which anticipate a gradual convergence toward high-income-country cancer profiles, characterized by rising shares of non-communicable, behavior-linked cancers[12].

**Table 1:** Evolution of sex distribution of new cancer cases at the Sidi Mohamed Ben Abdellah National Cancer Institutefrom 2021 to the first semester of 2025

| Year | 2021 n (%) | 2022 n (%) | 2023 n (%) | 2024 n (%) | 1st semester 2025 n (%) |
|---|---|---|---|---|---|
| Man | 1676 (40,78)a | 1696 (39,10)a | 1693 (40,23)a | 1892 (40,89)a | 1095 (42,81)a |
| Women | 2434 (59,22)b | 2642 (60,90)b | 2515 (59,77)b | 2735 (59,11)b | 1463 (57,19)b |
| Total | 4110 (100) | 4338 (100) | 4208 (100) | 4627 (100) | 2558 (100) |

Means within the same column sharing identical superscript letters do not differ significantly at the 5% significance level.

## Cancer prevalence by patient age

Longitudinal analysis of newly diagnosed cancer cases at the National Institute of Oncology (INO) between 2021 and the first semester of 2025 reveals a progressive reconfiguration of the age distribution of the oncological burden. This shift is characterized by both the persistent peak incidence in the 51–69 age group and a concerning rise in diagnoses among young adults. Over the study period, the absolute number of cases in the 51–69 cohort increased from 1,947 (2021) to 2,208 (2024), while cases among patients aged 70 and older rose from 890 to 1,057. This trend mirrors Morocco's accelerated demographic aging. A process corroborated by national data indicating that individuals aged 60 and older now constitute over 11% of the population. The concentration of diagnoses in older age brackets aligns with classical epidemiological models, wherein epithelial cancers (breast, prostate, lung, colorectal, pancreatic) exhibit exponential incidence growth due to cumulative somatic mutations, immunosenescence, and prolonged exposure to environmental risk factors[13] (Table 2).

The most striking trend, however, is the significant rise in cancer diagnoses among young adults aged 19–30. Following relative stability between 2021 and 2022 (130–131 annual cases), this cohort recorded 158 cases in 2024 and 141 cases in just the first six months of 2025 (a trajectory suggesting a potential acceleration in early-onset cancer incidence). This phenomenon cannot be attributed to data artifacts or minor demographic fluctuations. Rather, it aligns with an emerging global epidemiological syndrome marked by rising cancer rates among individuals born after 1990, particularly for colorectal, thyroid, hematologic, and certain gynecological malignancies[14]. Etiological hypotheses increasingly converge on prolonged early-life exposure to drivers of nutritional transition: diets rich in ultra-processed foods and low in fiber, endocrine-disrupting chemicals, gut microbiome dysbiosis, and juvenile obesity[15,16].

In contrast, pediatric cancer incidence (0–18 years) remains stable, fluctuating between 63 and 77 annual cases, a pattern consistent with global expectations given the intrinsic rarity of childhood malignancies (acute leukemias, embryonal tumors, sarcomas). This stability also reflects consolidated diagnostic capabilities in pediatric oncology[9].

Critically, unlike high-income countries where peak cancer incidence occurs after age 70, Morocco's burden remains concentrated in the 51–69 range. This disparity reflects not only a moderate life expectancy (76.5 years in 2024) but also high rates of premature mortality from non-cancer causes. Clinically and socially, this age distribution carries profound implications: patients are often diagnosed during their economically active years, serving as family breadwinners while confronting complex therapeutic decisions involving fertility preservation, functional outcomes, and quality of life[17].

**Table 2:** Evolution of the age distribution of new cancer cases (2021–2025)

| Year | 2021 n (%) | 2022 n (%) | 2023 n (%) | 2024 n (%) | 1st semester 2025 n (%) |
|---|---|---|---|---|---|
| [0–18] | 70 (1,70) a | 63 (1,45) a | 73 (1,73) a | 77 (1,66) a | 38 (1,49) a |
| [19–30] | 130 (3,16) a | 131 (3,02) ab | 119 (2,83) a | 158 (3,41) a | 141 (5,51) b |
| [31–50] | 1073 (26,11) c | 1100 (25,36) c | 1061 (25,21) bc | 1127 (24,36) b | 636 (24,86) c |
| [51–69] | 1947 (47,37) cd | 2070 (47,72) d | 2028 (48,19) d | 2208 (47,72) c | 1165 (45,54) d |
| [70 and plus] | 890 (21,65) b | 974 (22,45) b | 927 (22,03) b | 1057 (22,84) b | 578 (22,60) c |
| Total | 4110 (100,00) | 4338 (100,00) | 4208 (100,00) | 4627 (100,00) | 2558 (100,00) |

Means within the same column sharing identical superscript letters do not differ significantly at the 5% significance level.

### III.3 Cancer prevalence by anatomical site in 2021

Analysis of 2021 data from the National Institute of Oncology (INO) Cancer Registry reveals a pronounced predominance of breast cancer, accounting for nearly one-quarter of new cases. This underscores the urgent need to strengthen organized screening programs and develop targeted therapeutic strategies tailored to the Moroccan population. The substantial burden of digestive tract cancers (particularly colorectal malignancies) aligns with international observations regarding rising incidence among young patients, as documented by Gefen et al. (2023) and Dinaux et al. (2017) (Table 3).

The persistence of preventable cancers, notably cervical carcinoma, represents a critical public health challenge. As emphasized by Bouassa et al. (2017), the viral etiology of these pathologies necessitates accelerated HPV vaccination coverage. This imperative remains unfulfilled due to persistent implementation barriers described by Bishop et al. (2025). Similarly, the incidence of Epstein-Barr virus-associated malignancies, particularly nasopharyngeal carcinoma, highlights the urgent need for vaccine development in this domain, consistent with the pathogenic mechanisms outlined by Farrell (2019).

A non-negligible proportion of cancers of unknown primary site further underscores the necessity for advanced molecular diagnostic platforms. Such technologies would enable personalized therapeutic approaches that transcend anatomical localization alone. Collectively, these findings advocate for deeper integration of primary prevention, early detection initiatives, and therapeutic innovation to effectively address the unique dimensions of Morocco's oncological burden.

### Cancer prevalence by anatomical site in 2022

Analysis of 4,338 new cancer cases recorded at the National Institute of Oncology (INO) in 2022 highlights the persistence of hormone-dependent malignancies and tumors linked to infectious or environmental factors, hallmarks of nations undergoing epidemiological transition. Breast cancer remained the most frequent incident neoplasm, with 1,090 cases (25.13%), confirming its endemic status in Morocco and the Maghreb region. This high incidence aligns with global trends—breast cancer ranks as the leading cause of female oncological morbidity in 157 countries per GLOBOCAN 2022 [23]—yet starkly contrasts with survival profiles in high-income nations. Studies across the Middle East and North Africa (MENA) region report over 60% of cases diagnosed at locally advanced or metastatic stages due to structural barriers (limited mammography access), cultural factors (stigmatization, delayed consultation), and economic constraints (treatment costs)[24]. This reality underscores the urgency of implementing a national organized screening program, coupled with rapid diagnostic pathways and integration of targeted therapies (anti-HER2 agents, CDK4/6 inhibitors) into care protocols (Table 3).

Bronchopulmonary tumors ranked as the second most

frequent entity (n = 413, 9.52%), reflecting the enduring impact of tobacco use (prevalence among Moroccan adult males exceeds 30% [25] and rising exposure to urban air pollution and fine particulate matter (PM2.5). While recent therapeutic advances (immunotherapy, EGFR/ALK/ROS1 mutation-targeted therapies) have transformed outcomes for specific molecular subgroups, the absence of tumor genomic profiling data in this registry limits assessment of treatment alignment with local tumor biology. Initiatives such as the MENA Lung Cancer Genomics Consortium (2024) emphasize the need to map Maghrebi-specific molecular alterations to optimize therapeutic strategies[26].

Digestive cancers collectively accounted for nearly 20% of cases (stomach: 4.63%, colon: 5.81%, rectum: 3.94%, pancreas: 3.85%, liver: 2.37%). Gastric cancer incidence, though globally declining, remains notable, likely tied to persistently high *Helicobacter pylori* prevalence (estimated at 70–80% in Moroccan cohorts)[27]. Concurrently, rising colorectal cancer incidence among adults under 50 (a phenomenon now termed a silent epidemic in middle-income countries[28] is emerging in Moroccan hospital registries, suggesting rapid nutritional transition toward diets rich in saturated fats, added sugars, and ultra-processed foods. Pancreatic cancer retains a dismal prognosis, with metastatic cases exhibiting median survival below six months due to the lack of reliable early-detection biomarkers[29].

Infectious agent-related cancers constitute another critical epidemiological axis. Cervical cancer (5.65%, n = 245) remains a key indicator of high-risk human papillomavirus (HPV) endemicity. WHO models suggest ≥90% vaccination coverage among adolescent girls could eliminate cervical cancer by 2100 [30]. Similarly, nasopharyngeal carcinoma (2.07%, n = 90) shows elevated incidence consistent with its Mediterranean endemicity, strongly associated with Epstein-Barr virus (EBV), genetic factors (HLA polymorphisms), and dietary habits (consumption of fermented salted foods) [31].

Among men, prostate cancer (5.09%, n = 221) dominated diagnoses, reflecting both aging demographics and improved prostate-specific antigen (PSA) testing access. However, the absence of standardized protocols for targeted biopsy or risk stratification (per D'Amico criteria or EAU risk groups) heightens the risk of overdiagnosing indolent forms, a well-documented dilemma[32]. Conversely, urothelial tumors (bladder: 1.54%; kidney: 0.90%) remained underrepresented, potentially indicating referrals to specialized centers or underreporting due to incomplete histological diagnoses.

Notably, 6.73% of cases (n = 292) were classified as unspecified, and 0.35% as non-applicable. This missing data rate aligns with other hospital registries in resource-limited settings genome[33].

This tumor profile epitomizes the dual oncological burden characteristic of epidemiological transition: coexistence of traditional cancers (infection-linked, poverty-associated, care-access-limited) and modern cancers (urbanization-, obesity-, and aging-related). Addressing this duality demands a stratified cancer control strategy integrating high-impact public health interventions (HPV/HBV vaccination, breast/colorectal cancer screening, tobacco control) and contextualized precision oncology grounded in accessible biomarkers and therapeutic algorithms tailored to both tumor molecular profiles and socioeconomic realities. Only such an approach, aligned with the Global Initiative for Cancer Registry Development (GICR) and Morocco's National Cancer Prevention and Control Plan (2020–2029), can transform epidemiological data into equitable, targeted action[34].

## Cancer prevalence by anatomical site in 2023

Data from the National Institute of Oncology (INO) for 2023, encompassing 4,208 new cancer cases, depict an evolving oncological landscape marked by the persistence of neoplasms linked to infectious and socioeconomic determinants alongside the accelerated emergence of tumors associated with demographic shifts and contemporary lifestyles. Breast cancer remained the most frequent incident pathology (n = 1,013, 24.07%), reaffirming its status as the leading cause of female cancer morbidity in Morocco. While this prevalence aligns with well-documented regional trends, it coexists with a critical disparity between incidence rates and therapeutic outcomes. Unlike high-income countries where organized screening has significantly reduced mortality, Moroccan data continue to suggest a high proportion of advanced-stage diagnoses, a finding corroborated by recent hospital-based studies[35] (Table 3).

A notable trend in 2023 was the relative rise in bronchopulmonary cancers, accounting for 11.69% of cases (n = 492) and ranking as the second most frequent tumor entity. This increase (contrasting with prior years' stability or slight decline) may

reflect enhanced diagnostic comprehensiveness but also a genuine escalation in exposure to risk factors, particularly active smoking (prevalent in over 30% of adult males) and deteriorating urban air quality. Despite therapeutic breakthroughs such as targeted therapies and immunotherapy, which have reshaped prognoses for specific molecular subgroups, the near-absence of routine biomarker testing (PD-L1, EGFR, ALK) drastically limits population-level impact[36].

Colorectal cancer (colon + rectum = 429 cases, 10.19%) continued its upward trajectory, with colon cancer incidence (6.82%) exceeding rectal cancer (3.37%). This anatomical distribution (inverse to patterns observed in some Asian populations) may stem from differences in dietary habits, gut microbiome composition, or genetic factors genome[21]. Concurrently, pancreatic cancer (4.75%) and hepatobiliary tumors (3.92%) showed rising incidence compared to prior years, presenting major prognostic challenges as these neoplasms are frequently diagnosed at unresectable stages[37]. Gynecological cancers collectively constituted a substantial burden (cervix: 5.39%, uterine corpus: 3.14%, ovary: 3.73%, vulva: 0.45%), totaling nearly 13% of cases.

Prostate cancer (5.20%) remained the most frequent solid tumor in men, exhibiting relative stability compared to previous years. However, the lack of standardized risk stratification protocols (per European Association of Urology criteria) heightens the risk of overtreatment for indolent forms, a dilemma extensively documented in international literature[28]. Conversely, central nervous system tumors (brain: 2.19%, spinal cord: 0.29%) gained visibility, likely due to improved access to magnetic resonance imaging, though specialized management remains centralized in a few centers[38].

Strikingly, the rate of unspecified cases dropped to 2.73% (n = 115) in 2023, down from over 5% in prior years. Though modest, this improvement reflects institutional efforts to enhance data quality—a prerequisite for evidence-based policymaking. Nevertheless, persistent gaps in key variables (age, TNM staging, molecular status, comorbidities) continue to impede granular epidemiological analyses and cross-registry comparisons aligned with IARC standards[1].

## Cancer prevalence by anatomical site in 2024

The year 2024 marks a significant inflection point in Morocco's oncological landscape, reflected in 4,627 new cases recorded at the National Institute of Oncology (INO). While breast cancer remained the most frequent incident neoplasm (n = 1,012, 21.87%), the extraordinary emergence of tumors of the hematopoietic and reticuloendothelial systems (primarily leukemias, lymphomas, and myelomas) demands attention, with 553 cases (11.95%) representing a substantial increase over prior years. This rise likely reflects not a sudden epidemiological surge but significant diagnostic capacity enhancement. In an era where targeted therapies (BTK inhibitors, anti-CD20 agents, CAR-T cells) are transforming outcomes for hematologic malignancies, this evolution signals progressive alignment with international standards of care[12] (Table 3).

Breast cancer, though slightly reduced proportionally (from 24% in 2023 to 21.87% in 2024), remains central to the female oncological burden. This relative stabilization (amid an overall increase in total case volume) may indicate modest screening improvements or epidemiological saturation related to age and reproductive factors. However, missing clinical data (stage, hormone receptor status, HER2, Ki67) prevent assessment of whether this shift correlates with earlier diagnoses. Recent MENA-region studies indicate nearly 65% of Moroccan women still receive diagnoses at stage III or IV [39], underscoring how socioeconomic and geographic barriers continue to dictate care access.

Bronchopulmonary cancers persisted as the third leading incident neoplasm (9.40%, n = 435), though their proportion slightly declined from 2023 levels. This fluctuation may stem from normal annual variation or improved histological differentiation between primary lung carcinoma and metastases from other sites[40]. Regardless, tobacco exposure and urban air pollution remain dominant pathogenic drivers[41].

Colorectal cancer retained prominence (colon + rectum = 393 cases, 8.49%), with colon cancer (5.27%) substantially exceeding rectal cancer (3.22%). Gynecological malignancies remained concerning (cervix: 4.34%, ovary: 3.76%, uterine corpus: 2.23%, vulva: 0.26%), collectively exceeding 10% of cases. The relative increase in ovarian cancer incidence highlights urgent needs for reliable early-detection biomarkers and genetic management strategies (BRCA1/2 testing) for hereditary forms[42].

Prostate cancer (4.73%) maintained its position as the most frequent solid tumor in men, reflecting both demographic aging and improved PSA testing

accessibility. Without standardized MRI-guided biopsy protocols or internationally validated risk stratification criteria, however, overdiagnosis and overtreatment of indolent forms remain significant concerns[18].

Notably, the rate of unspecified cases reached a historic low of 2.62% (n = 121), reflecting sustained institutional commitment to data quality enhancement. While modest, this progress represents a critical foundation for evidence-based oncological planning in resource-constrained settings.

## Cancer prevalence by anatomical site in 2025

Data from the first semester of 2025, encompassing 2,558 new cancer cases registered at the National Institute of Oncology (INO), reveal a historic inversion in the hierarchy of incident neoplasms. For the first time in available annual or semester series, tumors of the hematopoietic and reticuloendothelial systems (primarily leukemias, lymphomas, and myelomas) surpassed breast cancer in relative frequency, with 513 cases (20.05%) compared to 467 cases (18.26%) for the latter. This inversion likely reflects not a true surge in malignant hemopathy incidence but continued maturation of the Institute's diagnostic and organizational capabilities. Enhanced access to flow cytometry, immunophenotyping, cytogenetics, and strengthened collaboration among hematologists, pathologists, and molecular biologists underpin this shift (Table 3).

Breast cancer, though proportionally reduced, remains an absolute public health priority. Its stable absolute case count over six months (467 cases) appears diminished solely due to the high volume of hematologic malignancies during this period. Nevertheless, the persistent burden underscores the urgency of strengthening organized screening programs. Recent MENA-region studies indicate over 60% of Moroccan women still receive diagnoses at advanced stages[43], highlighting enduring structural and sociocultural barriers to early detection.

Bronchopulmonary cancers retained prominence among frequent tumors (7.70%, n = 197), though semester incidence suggests possible stabilization or slight decline compared to prior years. This relative slowdown may stem from improved differentiation between primary and metastatic tumors or modest advances in tobacco control policies. However, until molecular testing (EGFR, ALK, ROS1, PD-L1) becomes systematically integrated into diagnostic algorithms, access to targeted therapies and immunotherapy will remain limited to a minority of patients, primarily in urban centers[41].

Colorectal cancer persisted as a major entity (colon + rectum = 188 cases, 7.35%), with colon cancer (4.50%) markedly exceeding rectal cancer (2.85%). Gynecological malignancies continued to constitute a substantial portion of the female oncological burden: cervical (3.79%), ovarian (3.01%), uterine corpus (2.15%), and vulvar (0.43%) cancers collectively accounted for nearly 9.4% of cases. The relatively high incidence of ovarian cancer emphasizes the urgent need for early detection strategies and genetic management protocols for hereditary forms[44].

Prostate cancer (3.91%, n = 100) remained the most frequent solid tumor among men during this semester. Notably, the rate of unspecified cases rose slightly to 3.91% (n = 100) compared to 2024, potentially reflecting heightened diagnostic service pressures in the first half of the year or increased complexity in patient influx. This modest regression warrants monitoring as institutional capacity expands to meet growing demands.

**Table 3:** Evolution of anatomical cancer sites from 2021 to the first semester of 2025

| Anatomical Sites | 2021 n(%) | 2022 n(%) | 2023 n(%) | 2024 n(%) | 2025* n(%) |
|---|---|---|---|---|---|
| Breast | 959 (23,39)g | 1090 (25,13)h | 1013 (24,07)ef | 1012 (21,87)f | 467 (18,26)e |
| Bronchus and lung | 418 (10,20)g | 413 (9,52)g | 492 (11,69)e | 435 (9,40)e | 197 (7,70)d |
| Colon | 266 (6,49)f | 252 (5,81)f | 287 (6,82)e | 244 (5,27)d | 115 (4,50)c |
| Cervix uteri | 227 (5,54)f | 245 (5,65)f | 227 (5,39)d | 201 (4,34)d | 97 (3,79)c |
| Prostate | 214 (5,22)f | 221 (5,09)ef | 219 (5,20)d | 219 (4,73)d | 100 (3,91)c |
| Rectum | 185 (4,51)ef | 171 (3,94)e | 142 (3,37)bc | 149 (3,22)c | 73 (2,85)bc |

| Anatomical Sites | 2021 n(%) | 2022 n(%) | 2023 n(%) | 2024 n(%) | 2025* n(%) |
|---|---|---|---|---|---|
| Pancreas | 174 (4,24)ef | 167 (3,85)e | 200 (4,75)d | 154 (3,33)c | 69 (2,70)bc |
| Stomach | 172 (4,20)ef | 201 (4,63)e | 186 (4,42)d | 179 (3,87)cd | 87 (3,40)c |
| Ovary | 156 (3,80)e | 143 (3,30)e | 157 (3,73)c | 174 (3,76)cd | 77 (3,01)bc |
| Liver and intrahepatic bile ducts | 107 (2,61)de | 103 (2,37)de | 165 (3,92)c | 148 (3,20)c | 79 (3,09)bc |
| Uterine corpus | 95 (2,32)d | 95 (2,19)d | 132 (3,14)c | 103 (2,23)c | 55 (2,15)b |
| Thyroid gland | 93 (2,27)d | 97 (2,24)d | 103 (2,45)b | 91 (1,97)c | 72 (2,81)bc |
| Nasopharynx | 81 (1,98)d | 90 (2,07)d | 79 (1,88)b | 103 (2,23)c | 37 (1,45)a |
| Bladder | 45 (1,10)c | 67 (1,54)c | 80 (1,90)b | 75 (1,62)bc | 40 (1,56)a |
| Skin | 44 (1,07)c | 62 (1,43)c | 72 (1,71)b | 66 (1,43)bc | 32 (1,25)a |
| Larynx | 49 (1,20)c | 51 (1,18)c | 42 (1,00)b | 42 (0,91)b | 30 (1,17)a |
| Unknown primary site | 47 (1,15)c | 62 (1,43)c | 77 (1,83)b | 43 (0,93)b | 18 (0,70)a |
| Brain | 44 (1,07)c | 54 (1,24)c | 92 (2,19)b | 52 (1,12)b | 31 (1,21)a |
| Connective tissue, subcutaneous tissue, and other soft tissues | 45 (1,10)c | 52 (1,20)c | 27 (0,64)a | 25 (0,54)a | 16 (0,63)a |
| Gallbladder | 40 (0,98)c | 39 (0,90)bc | 34 (0,81)a | 47 (1,02)b | 34 (1,33)b |
| Kidney | 39 (0,95)c | 39 (0,90)bc | 39 (0,93)a | 43 (0,93)b | 19 (0,74)a |
| Esophagus | 35 (0,85)c | 29 (0,67)b | 29 (0,69)a | 35 (0,76)a | 18 (0,70)a |
| Small intestine | 28 (0,68)ab | 25 (0,58)b | 22 (0,52)a | 17 (0,37)a | 10 (0,39)a |
| Lymph nodes | 25 (0,61)ab | 18 (0,41)ab | 17 (0,40)a | 24 (0,52)a | 11 (0,43)a |
| Spinal cord, cranial nerves, and other central nervous system regions | 23 (0,56)ab | 16 (0,37)ab | 12 (0,29)a | 11 (0,24)a | 5 (0,20)a |
| Vulva | 22 (0,54)ab | 14 (0,32)ab | 19 (0,45)a | 12 (0,26)a | 11 (0,43)a |
| Anus and anal canal | 20 (0,49)ab | 20 (0,46)b | 16 (0,38)a | 16 (0,35)a | 7 (0,27)a |
| Bone, joints, and articular cartilage of other unspecified sites | 17 (0,41)ab | 7 (0,16)a | 5 (0,12)a | 11 (0,24)a | 3 (0,12)a |
| Testis | 17 (0,41)ab | 24 (0,55)b | 12 (0,29)a | 14 (0,30)a | 1 (0,04)a |
| Lip | 14 (0,34)ab | 8 (0,18)a | 19 (0,45)a | 7 (0,15)a | 6 (0,23)a |
| Other and ill-defined sites of the lip, oral cavity, and pharynx | 14 (0,34)ab | 8 (0,18)a | 11 (0,26)a | 9 (0,19)a | 3 (0,12)a |
| Hematopoietic and reticuloendothelial system | 12 (0,29)ab | 7 (0,16)a | 21 (0,50)a | 553 (11,95)c | 513 (20,05)d |
| Base of the tongue | 11 (0,27)a | 12 (0,28)ab | 24 (0,57)a | 12 (0,26)a | 7 (0,27)a |
| Floor of the mouth | 9 (0,22)a | 2 (0,05)a | 1 (0,02)a | - | 1 (0,04)a |

| Anatomical Sites | 2021 n(%) | 2022 n(%) | 2023 n(%) | 2024 n(%) | 2025* n(%) |
|---|---|---|---|---|---|
| Other and ill-defined sites of the digestive organs | 8 (0,20)a | 5 (0,12)a | 13 (0,31)a | 13 (0,28)a | 4 (0,16)a |
| Other and unspecified sites of the biliary tract | 8 (0,20)a | 11 (0,25)a | 15 (0,36)a | 8 (0,17)a | 10 (0,39)a |
| Accessory sinuses of the face | 8 (0,20)a | 3 (0,07)a | 7 (0,17)a | 7 (0,15)a | 7 (0,27)a |
| Parotid gland | 7 (0,17)a | 11 (0,25)ab | 10 (0,24)a | 8 (0,17)a | 9 (0,35)a |
| Thymus | 6 (0,15)a | 5 (0,12)a | 11 (0,26)a | 2 (0,04)a | 4 (0,16)a |
| Peripheral nerves and autonomic nervous system | 6 (0,15)a | 1 (0,02)a | 5 (0,12)a | 7 (0,15)a | 2 (0,08)a |
| Vagina | 6 (0,15)a | 5 (0,12)a | 7 (0,17)a | 5 (0,11)a | 2 (0,08)a |
| Nasal cavity and middle ear | 5 (0,12)a | 8 (0,18)a | 11 (0,26)a | 12 (0,26)a | 2 (0,08)a |
| Other and ill-defined sites | 2 (0,05)a | 7 (0,16)a | 10 (0,24)a | 3 (0,06)a | 2 (0,08)a |
| Eye and adnexa | 5 (0,12)a | 2 (0,05)a | 1 (0,02)a | 3 (0,06)a | 2 (0,08)a |
| Other major salivary glands and unspecified major salivary glands | 5 (0,12)a | 3 (0,07)a | 6 (0,14)a | 3 (0,06)a | 1 (0,04)a |
| Oropharynx | 3 (0,07)a | 2 (0,05)a | 1 (0,02)a | 4 (0,09)a | 2 (0,08)a |
| Hypopharynx | 3 (0,07)a | 3 (0,07)a | 4 (0,10)a | 2 (0,04)a | 2 (0,08)a |
| Heart, mediastinum, and pleura | 3 (0,07)a | 7 (0,16)a | 1 (0,02)a | 2 (0,04)a | 1 (0,04)a |
| Bone, joints, and articular cartilage of the limbs | 3 (0,07)a | 7 (0,16)a | 27 (0,64)a | 15 (0,32)a | 15 (0,59)a |
| Uterus, not otherwise specified | 3 (0,07)a | 2 (0,05)a | - | 16 (0,35)a | - |
| Adrenal gland | 3 (0,07)a | 11 (0,25)a | 10 (0,24)a | - | 2 (0,08)a |
| Gingiva | 2 (0,05)a | 2 (0,05)a | 1 (0,02)a | 2 (0,04)a | - |
| Palate | 2 (0,05)a | 5 (0,12)a | 8 (0,19)a | 3 (0,06)a | 3 (0,12)a |
| Other and unspecified sites of the tongue | 2 (0,05)a | 6 (0,14)a | 10 (0,24)a | 12 (0,26)a | 3 (0,12)a |
| Piriform sinus | 2 (0,05)a | - | - | 1 (0,02)a | - |
| Other and ill-defined sites of the respiratory system and intrathoracic organs | 2 (0,05)a | 1 (0,02)a | 4 (0,10)a | 1 (0,02)a | - |
| Tonsil | 1 (0,02)a | - | - | - | - |
| Retroperitoneum and peritoneum | 31 (0,76)b | 21 (0,48)a | - | 36 (0,78)a | 35 (1,37)a |
| Not applicable | 7 (0,17)a | 15 (0,35)a | 14 (0,33)a | - | 5 (0,20)a |
| Not specified | 215 (5,24)f | 292 (6,73)c | 115 (2,73)a | 121 (2,62)b | 100 (3,91) |

Means within the same column sharing identical superscript letters do not differ significantly at the 5% significance level.

## CONCLUSION

Analysis of data from the Sidi Mohamed Ben Abdellah National Cancer Institute(2021–2025) reveals a structural transformation of Morocco's oncological landscape, defined by three interdependent transitions. The epidemiological transition is characterized by the emergence of malignant hemopathies as the leading diagnosed entity (20.1% in 2025) and a concerning rise in cancers among young adults aged 19–30 years. This trend is likely driven by nutritional and environmental shifts tied to rapid urbanization, including diets rich in ultra-processed foods, exposure to endocrine disruptors, and gut microbiome alterations.

The diagnostic transition reflects significant institutional maturation, evidenced by a reduction of over 50% in the rate of unspecified cases and enhanced capabilities in hematologic oncology. These technical advances, though concentrated in specialized centers, lay the groundwork for personalized oncology approaches tailored to molecular tumor profiles and local resource constraints.

The demographic transition manifests through a progressive masculinization of the cancer burden (male proportion rising from 40.78% to 42.81%) and a sustained incidence peak in the 51–69 age group. These patterns mirror both men's heightened exposure to behavioral risks (notably tobacco use) and Morocco's accelerating demographic aging. Clinically, this demands reconfigured care pathways addressing working-age patients' unique needs, including fertility preservation, functional outcomes, and socioeconomic support.

Together, these dynamics necessitate a paradigm shift in national cancer control strategies. Effective responses must integrate population-level interventions (such as HPV vaccination, tobacco control policies, and organized screening) with precision oncology frameworks incorporating accessible biomarkers and targeted therapies. Concurrently, hospital registries require systematic enhancement through the inclusion of clinical variables (TNM staging, molecular markers) and socioeconomic determinants to enable evidence-based policymaking. Such efforts, aligned with the Global Initiative for Cancer Registry Development (GICR) and Morocco's National Cancer Prevention and Control Plan (2020–2029), represent critical steps toward equitable, adaptive cancer care in a rapidly evolving epidemiological context.

### Competing Interests

The Authors declare no conflicts of interest.

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### Authors' contributions

Bouchra Guerouaoui, Badreddine Dahou and Amine Rkhaila participated in the conceptualization of the questionnaire. Sara ennaceri, Salma najem, Hanane inghaoun, Siham khoyaali and Ibrahim El Ghissassi participated in the collection of the data. Hanane Inrhaoun and Hassan Errihani designed the study, realized the data analysis, wrote the paper, and decided on the submission of the manuscript. Hanane Inrhaoun and Hassan Errihani and Badreddine Dahou supervised the writing of the paper. All authors contributed to the article and approved it for submission and publication.

### Data statement

All data are available with a reasonable request to the author, due to the ethical condition to ensure confidentiality of the patients' data.

### Disclaimer

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