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Incidence, Mortality, Sex Differences, and Demographic Projections for Six Selected Head and Neck Cancer Site Groups in Indonesia: A Secondary Analysis of GLOBOCAN 2024 Modeled Estimates

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ABSTRACT

Background: Nationally representative data on the heterogeneous malignancies managed in head and neck oncology remain limited in Indonesia.

Objective: To estimate incidence, mortality, sex differences, and demographic change for six selected head and neck cancer site groups in Indonesia.

Methods: We performed a descriptive secondary analysis of GLOBOCAN 2024 aggregate modeled estimates (version 08 July 2026). The definition included lip and oral cavity (C00–C06), salivary glands (C07–C08), oropharynx (C09–C10), nasopharynx (C11), hypopharynx (C12–C13), and larynx (C32). Counts and age-standardized rates were aggregated across mutually exclusive sites. Indonesia was compared descriptively with four reference populations. Constant-rate Cancer Tomorrow projections and two definitional sensitivity analyses were evaluated. Source uncertainty distributions were unavailable; therefore, confidence intervals were not constructed.

Results: An estimated 28,226 cases and 16,025 deaths occurred in 2024; summed ASIR and ASMR were 8.91 and 5.06 per 100,000. Nasopharyngeal cancer contributed 16,064 cases (56.9%) and 8,718 deaths (54.4%). Male rates exceeded female rates: ASIR 13.19 versus 5.18 and ASMR 7.73 versus 2.77. With 2024 rates held constant, annual cases increased to 46,895 (+66.1%) and deaths to 27,900 (+74.1%) by 2050. All 21 validation checks passed.

Conclusion: Indonesia's selected head and neck cancer burden is dominated by nasopharyngeal cancer and higher male rates. These modeled estimates support prevention, registry strengthening, and planning hypotheses but do not measure stage, utilization, treatment need, survival, cost, or causal effects.

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1. Introduction

The global cancer burden is increasing as populations grow and age, while exposures, diagnostic capacity, and survival evolve unevenly. GLOBOCAN 2024 estimated 20.6 million new cancer cases and 9.8 million cancer deaths worldwide and projected 34.4 million new cases by 2050 [1]. Head and neck cancer is not a single disease: population-based analyses show marked variation by anatomical site, sex, calendar period, and survival.[2] The group includes malignancies arising from the oral cavity, major salivary glands, pharynx, nasopharynx, hypopharynx, and larynx, among other sites. These tumors differ in histology, molecular drivers, risk factors, clinical presentation, treatment, and prognosis. Most mucosal cancers are squamous cell carcinomas, whereas salivary gland cancers encompass diverse histologic entities. This heterogeneity makes subsite-specific assessment necessary.

The exposure profile is equally heterogeneous. Alcohol contributes materially to cancer burden at the population level,[3] while smokeless tobacco and areca nut account for a substantial share of oral cancer in exposed populations.[4] Air-pollution associations have also been reported, although ecological designs cannot establish individual causation.[5] Oncogenic human papillomavirus (HPV) drives a subset of oropharyngeal cancers; international registry analyses and tumor-characterized cohorts show that HPV-related patterns vary considerably across countries.[6,7] Epstein–Barr virus (EBV) is central to endemic non-keratinizing nasopharyngeal carcinoma. A single combined estimate can inform system

planning, but it should not erase the distinct prevention and clinical pathways of the component diseases.

Indonesia is a crucial setting for head and neck cancer research because it is a large, geographically dispersed archipelagic country with uneven access to diagnostic and specialist services. A contemporary Indonesian cohort found that multidisciplinary management was associated with improved quality of care and survival for nasopharyngeal cancer.[8] Recent burden analyses continue to identify nasopharyngeal carcinoma as an important disease globally and show a distinctive head and neck cancer profile in Southeast Asia.[9,10] Hospital and pathology-registry evidence is indispensable for stage, treatment, and outcomes, but it cannot by itself provide complete national incidence and mortality. Referral-center data can overrepresent complex or advanced disease, while incomplete population-based registration limits direct enumeration of cases and outcomes.

Reliable epidemiology is required for rational cancer control. Counts describe population burden and a potential upper-level planning input, while age-standardized rates permit comparisons across populations with different age structures. Neither directly measures service workload because stage, treatment eligibility, patient preference, access, and care completion are absent. Projections based on fixed rates answer a narrow question: how many cases or deaths would occur if only population size and age structure changed? They do not predict future exposure, screening, diagnosis, treatment, or survival.

Indonesia launched a National Cancer Control Plan for 2024–2034 within a broader health-system transformation agenda.[11] The plan prioritizes selected high-burden cancers and childhood cancer, while also recognizing the need for stronger registration, diagnostic services, treatment capacity, financing protection, and equitable access. Head and neck cancers are not presented as a single priority group in that framework, but their aggregate burden intersects directly with tobacco control, vaccination, early diagnosis, pathology, surgery, and radiotherapy. A contemporary, reproducible subsite analysis can therefore fill an evidence gap without implying that modeled estimates replace registries or administrative data.

This study aimed to quantify the 2024 incidence and mortality of six prespecified anatomical site groups in Indonesia, determine their composition, describe sex differences, compare age-standardized rates with selected reference populations, and estimate changes in annual counts to 2050 under constant 2024 rates. A secondary aim was to document the source-to-analysis mapping, aggregation assumptions, sensitivity analyses, uncertainty limitations, and validation steps in a reproducible workflow. We did not estimate utilization, treatment, survival, costs, productivity loss, or household financial burden because GLOBOCAN contains none of those outcomes.

2. Methods

Study design and reporting framework

We performed a descriptive secondary analysis of publicly available aggregate modeled cancer estimates from GLOBOCAN 2024, produced by the International Agency for Research on Cancer (IARC). This was neither a patient cohort nor a primary population-based registry study. The analytical unit was a cancer-site–sex–measure stratum for Indonesia or a predefined aggregate reference population. No individual records were accessed. Reporting followed the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER); a completed 18-item checklist is supplied in the Supplementary Material.[12]

Data source and version

GLOBOCAN provides country-level estimates of cancer incidence and mortality by cancer site, sex, and age group. The 2024 release covers 34 cancer types in 186 countries.[1] We accessed GLOBOCAN 2024 data version 08 July 2026 from Cancer Today and Cancer Tomorrow on 23 July 2026. Raw JSON response files were retained unchanged. For every file, the accompanying provenance manifest records the filename, data family, selection parameters, reproducible public visualization route, version, access date, byte size, and SHA-256 checksum. The cancer and population metadata enumerations and the complete source-to-analysis code map are supplied in the Supplementary Material.

GLOBOCAN estimates must not be interpreted uniformly as directly observed national counts. Estimation methods differ according to the availability and quality of cancer registration and mortality data. For Indonesia, the GLOBOCAN metadata state that incidence rates were based on a weighted average of selected population-based registry rates from Jakarta, Bantul, Cimahi, Yogyakarta, Semarang, and Sleman for years between 2013 and 2017, scaled using all-site rates from Brunei Darussalam and Penang, Malaysia, and applied to the 2024 population. Mortality was estimated from incidence using survival-based mortality-to-incidence ratios. These methodological features are integral to the interpretation of every result in this study.

Population and cancer definition

The target population was Indonesia as represented in GLOBOCAN 2024 (approximately 283.5 million people). We mapped internal GLOBOCAN cancer codes 1, 2, 3, 4, 5, and 14 to six mutually exclusive anatomical site groups: lip and oral cavity (ICD-10 C00–C06), salivary glands (C07–C08), oropharynx (C09–C10), nasopharynx (C11), hypopharynx (C12–C13), and larynx (C32). This is an operational study definition, not the entire clinical field of head and neck oncology. The C07–C08 category principally identifies major salivary-gland sites and does not capture every malignancy of minor salivary-gland origin because those tumors are coded by their anatomical location.

The definition deliberately excludes thyroid cancer, esophageal cancer, cancers of the nasal cavity and paranasal sinuses when not separately available in the chosen extraction, eye tumors, central nervous system tumors, skin cancer of the head and neck, lymphoma, and metastatic neck disease from an unknown primary. ICD-10 C14 (other and ill-defined sites in the lip, oral cavity, and pharynx) was not a separate GLOBOCAN cancer category and was not imputed. Consequently, the term "head and neck cancers" in this manuscript refers only to the six enumerated groups, not every malignancy managed by a head and neck oncology service.

Outcomes

The primary outcomes were estimated incident cases, deaths, ASIR, and ASMR in 2024. Rates are per 100,000 and age-standardized using the world standard population employed by GLOBOCAN. Secondary outcomes were crude rates, each site group's percentage contribution, percentage shares of national all-cancer incidence and mortality, sex-specific rates, absolute male minus female rate differences, descriptive male-to-female rate ratios for the combined definition, and projected counts through 2050. The all-cancer denominator used GLOBOCAN code 40, "all cancers excluding non-melanoma skin cancer" (C00–C97 excluding C44), consistently for incidence and mortality. We did not report cumulative risk or mortality-to-incidence metrics because they were not required for the study aims and the latter would be especially vulnerable to circular interpretation where mortality is modeled from incidence.

Aggregation and sex comparisons

For each sex stratum, we summed site-specific counts. We also summed site-specific ASIRs, ASMRs, and crude rates because the categories were mutually exclusive, used the same population, standard weights, calendar year, and rate scale. This produces the rate for the union of the selected sites, subject to source rounding. Each source ASR was published to two decimal places; summing six rates yields a worst-case rounding interval of ±0.03 per 100,000. We therefore report 8.88–8.94 around the summed ASIR of 8.91 and 5.03–5.09 around the summed ASMR of 5.06 as arithmetic rounding bounds, not statistical confidence intervals. Sex comparisons emphasize absolute male minus female differences; combined rate ratios are secondary descriptive measures. Both-sex counts were checked against male plus female counts for every site.

$$ASR\sim selected\sim = \Sigma_{s=1}^{6} ASR_s$$

$$\Delta ASR = ASR_{male} - ASR\sim female\sim$$

$$\text{Percentage change} = [(N_{2050} - N_{2024}) / N_{2024}] \times 100$$

ASR denotes age-standardized rate; s indexes the six mutually exclusive site groups; N denotes the annual count.

The percentage contribution of each site group used the six-site total as denominator. National cancer shares used 466,849 incident cancers and 281,908 cancer deaths from GLOBOCAN code 40 for both sexes. Percentages are descriptive and inherit the modeling assumptions of numerator and denominator. Sensitivity analyses repeated aggregation after excluding salivary glands to approximate a mucosal-only definition and after excluding nasopharynx to show how the dominant Indonesian site influenced the combined result.

Reference-population comparisons

We extracted equivalent estimates for the world, WHO South-East Asia Region, lower-middle-income countries, and high-HDI countries. These GLOBOCAN groupings are overlapping aggregates rather than independent samples: Indonesia contributes to the regional, income, and world aggregates, while categories answer different geographic or development questions. The same six-site definition was applied to every population. Comparisons are contextual, not causal or inferential, and no rank-based claim was made. Contemporary nationwide and multi-registry studies illustrate why population definition, registry coverage, and site composition must be explicit in cross-population comparisons.[13,14]

Demographic projections

We extracted Cancer Tomorrow outputs for incidence and mortality for both sexes combined and separately at 2024, 2025, and five-year intervals from 2030 through 2050. The source applies baseline age-specific rates to future population size and age structure from United Nations demographic projections.[1] The application's annual percentage change parameter was fixed at zero (APC=0). Site-specific outputs were retained and aggregated; we report 2024, 2030, 2040, and 2050 combined values plus 2024-to-2050 change for every site group.

The projection is a constant-rate demographic scenario. It applies the baseline GLOBOCAN rates to future population structures and therefore isolates the effect of growth and aging embedded in the source projection. It does not model future changes in tobacco or areca-nut use, EBV- or HPV-associated disease, vaccination, environmental exposure, diagnostic intensity, stage distribution, treatment access, treatment effectiveness, or survival. The word "projected" is used throughout rather than "predicted" to reinforce this limited interpretation.

Statistical analysis and uncertainty

All analyses were descriptive. We did not calculate p values or fabricate confidence intervals from extracted counts. The public outputs did not provide site-country-sex uncertainty distributions that could be propagated through the sums; quantitative uncertainty is therefore incompletely characterized, as explicitly recorded for GATHER item 16. We addressed definitional sensitivity, ASR rounding bounds, source-method appraisal, provenance, and internal reconciliation, none of which substitutes for full model uncertainty.

Python was used for transformation, validation, tabulation, and visualization. The workflow retained raw JSON, processed comma-separated files, an executed notebook, publication figures, and source hashes. Numeric results were rounded only for presentation. Counts are whole numbers, rates and rate differences have two decimals, and narrative percentages generally have one decimal.

Data-quality validation

Twenty-one automated checks evaluated analytical integrity: expected site codes and sex strata; unique analytical grain; completeness; nonnegative values; exact cancer-label and ICD mapping; required Cancer Today and Cancer Tomorrow schemas; sex-count additivity; projection country, year, APC, uniqueness, and completeness rules; agreement between projection baselines and 2024 estimates; reconciliation of combined counts; confirmation of the code-40 all-cancer denominator; and complete unique SHA-256 hashes. A hard stop prevented publication tables and figures from being generated after any failure. The Supplementary Material reports every check and result.

These checks assess internal consistency, not external validity. They cannot determine whether source registries are nationally representative, whether diagnoses were missed, or whether model assumptions are correct. Data-quality assessment therefore combined automated reconciliation with a qualitative appraisal of source coverage and estimation method.

Ethics

The analysis used publicly accessible, aggregate, deidentified estimates and involved no contact with participants and no access to personal health information. No ethics approval was sought. Requirements may differ across institutions; investigators adapting this workflow should follow their local governance rules. The analysis adhered to IARC source attribution and avoided attempts to reidentify individuals because no individual-level information was present.

3. Results

Overall burden in 2024

The six selected site groups accounted for an estimated 28,226 incident cases and 16,025 deaths in Indonesia in 2024. Their summed ASIR was 8.91 per 100,000 and summed ASMR was 5.06 per 100,000; the corresponding crude rates were 9.95 and 5.65. The source-rounding bounds were 8.88–8.94 for ASIR and 5.03–5.09 for ASMR. Against 466,849 incident cancers and 281,908 cancer deaths excluding non-melanoma skin cancer, the selected sites represented 6.05% and 5.68%, respectively. The combined row and the complete subsite breakdown are detailed in Table 1.

Subsite composition

Nasopharyngeal cancer was the largest component by a wide margin. It accounted for 16,064 incident cases and 8,718 deaths, corresponding to 56.9% of cases and 54.4% of deaths within the selected definition. Its ASIR was 5.00 and ASMR was 2.72 per 100,000. The contrast in site-specific cases and deaths is visualized in Figure 1, while the corresponding counts and rates are detailed in Table 1. The anatomical category alone does not provide an EBV-attributable fraction, histology, or biomarker status.

Lip and oral cavity cancer ranked second, with 4,745 incident cases, 2,872 deaths, an ASIR of 1.52, and an ASMR of 0.92 per 100,000. It contributed 16.8% of cases and 17.9% of deaths. Laryngeal cancer ranked third by incidence, with 3,179 cases and 2,020 deaths; its ASIR and ASMR were 1.03 and 0.65. Salivary gland cancers accounted for 2,355 cases and 1,278 deaths, or 8.3% and 8.0% of the respective totals. Oropharyngeal cancer accounted for 1,337 cases and 816 deaths. Hypopharyngeal cancer was the smallest group, with 546 cases and 321 deaths.

Table 1. Estimated incidence and mortality by selected cancer site group, Indonesia, 2024.

Cancer group	ICD-10	Cases	Deaths	ASIR	ASMR
Nasopharynx	C11	16,064	8,718	5.00	2.72
Lip, oral cavity	C00-06	4,745	2,872	1.52	0.92
Larynx	C32	3,179	2,020	1.03	0.65
Salivary glands	C07-08	2,355	1,278	0.75	0.40
Oropharynx	C09-10	1,337	816	0.43	0.26
Hypopharynx	C12-13	546	321	0.18	0.11
Combined	Specified sites	28,226	16,025	8.91	5.06

Notes: ASIR, age-standardized incidence rate; ASMR, age-standardized mortality rate. Rates per 100,000. Values are modeled GLOBOCAN 2024 estimates.

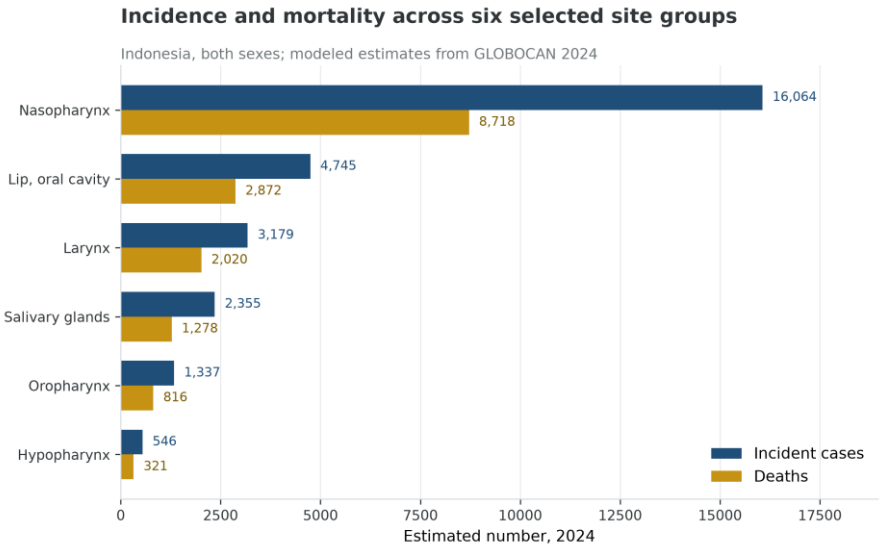

Figure 1. Estimated incident cases and deaths by selected anatomical site group, Indonesia, both sexes, 2024. Modeled GLOBOCAN 2024 estimates.

Sex differences

The male ASIR was 13.19 per 100,000 compared with 5.18 in females, an absolute difference of 8.01 and descriptive male-to-female ratio of 2.55. The male ASMR was 7.73 versus 2.77, an absolute difference of 4.96 and ratio of 2.79. Site-specific absolute differences are detailed in Table 2 and visualized in Figure 2. Age standardization reduces confounding by differing age structures but does not adjust for tobacco, occupational, infectious, behavioral, or healthcare factors.

The largest absolute ASIR differences were observed for nasopharynx (4.66 per 100,000), larynx (1.77), and salivary glands (0.55), followed closely by lip/oral cavity (0.51). Relative contrasts were large for laryngeal and hypopharyngeal cancer partly because female rates were low; absolute and relative measures should therefore be read together. The ecological pattern is compatible with several sex-differentiated exposures but does not attribute any portion of the difference to tobacco, infection, occupation, behavior, or care.

Table 2. Sex-specific age-standardized rates and absolute male minus female differences.

Cancer group	Male ASIR	Female ASIR	Difference	Male ASMR	Female ASMR	Difference
Nasopharynx	7.42	2.76	4.66	4.05	1.50	2.55
Larynx	2.03	0.26	1.77	1.32	0.14	1.18
Lip, oral cavity	1.79	1.28	0.51	1.19	0.68	0.51
Salivary glands	1.05	0.50	0.55	0.59	0.25	0.34
Oropharynx	0.57	0.33	0.24	0.38	0.17	0.21
Hypopharynx	0.33	0.05	0.28	0.20	0.03	0.17

Notes: Rates and differences per 100,000. Values are descriptive modeled estimates and were not adjusted for individual exposures.

Reference-population comparisons

Indonesia's combined ASIR of 8.91 per 100,000 was below the world estimate of 10.15, the lower-middle-income country estimate of 14.38, and the WHO South-East Asia regional estimate of 18.01, but above the high-HDI country estimate of 6.73. Indonesia's ASMR of 5.06 was slightly above the world estimate of 4.59 and above the high-HDI estimate of 3.41, while remaining below the lower-middle-income and South-East Asia estimates of 7.21 and 8.69. The complete benchmark values are detailed in Table 3 and compared graphically in Figure 3.

These overlapping GLOBOCAN aggregates are not independent comparison cohorts: Indonesia contributes to regional, income, and world groupings, and the high-HDI grouping answers a different development-context question. Indonesia's profile was distinctive less because of a single combined rank than because nasopharyngeal cancer contributed most of the selected burden. Aggregate comparisons cannot substitute for site-specific analyses or evaluation of observed Indonesian outcomes.

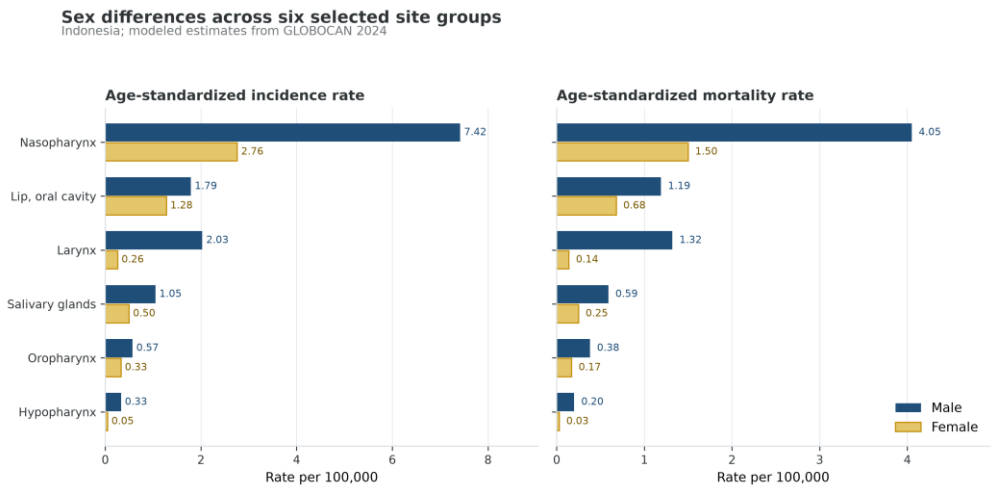

Figure 2. Sex-specific age-standardized incidence and mortality rates by selected site. Rates per 100,000; modeled GLOBOCAN 2024 estimates.

Table 3. Combined rates in Indonesia and selected reference populations.

Population	Summed ASIR	Summed ASMR
Indonesia	8.91	5.06
WHO South-East Asia region	18.01	8.69
Lower-middle-income countries	14.38	7.21
High-HDI countries	6.73	3.41
World	10.15	4.59

Notes: The same six sites were aggregated for every population. Groupings overlap and comparisons are descriptive because source availability and estimation methods differ.

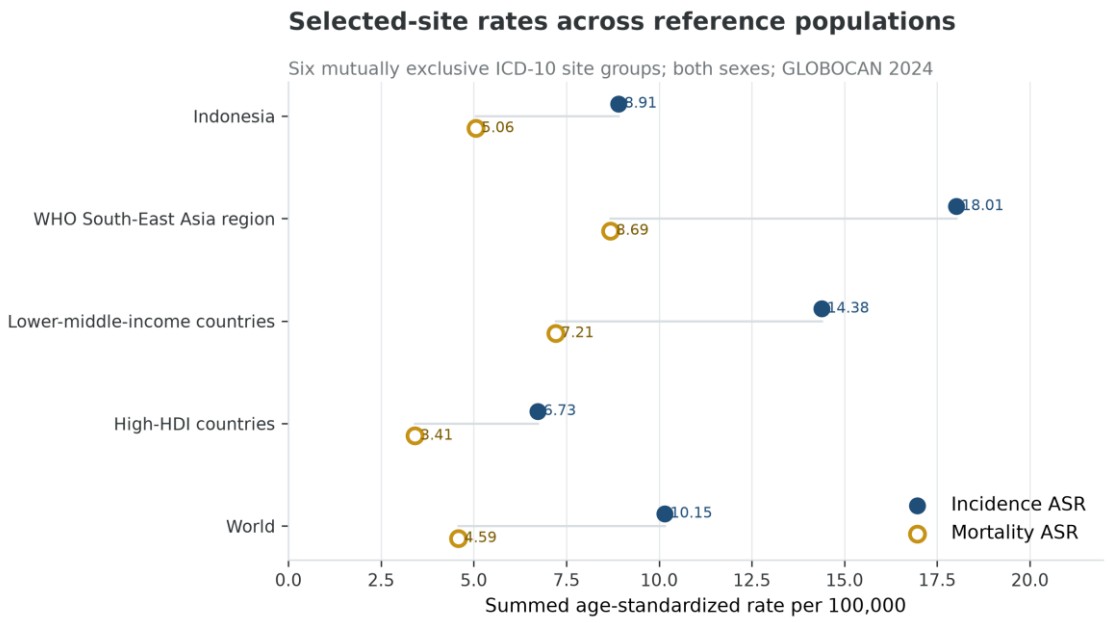

Figure 3. Combined age-standardized rates in Indonesia and reference populations. The same six ICD-10 groups were used throughout.

Demographic projections to 2050

With 2024 rates held constant, annual incident cases increased from 28,226 in 2024 to 32,677 in 2030, 40,216 in 2040, and 46,895 in 2050. The 2050 value represented 18,669 additional cases per year and a 66.1% increase from baseline. Projected deaths increased from 16,025 in 2024 to 18,825 in 2030, 23,635 in 2040, and 27,900 in 2050. The 2050 estimate represented 11,875 additional annual deaths and a 74.1% increase. These aggregate trajectories are detailed in Table 4 and visualized in Figure 4.

The projected incidence increases differed by site: nasopharynx rose to 25,119 cases (+56.4%), lip/oral

cavity to 7,979 (+68.2%), salivary glands to 3,968 (+68.5%), oropharynx to 2,427 (+81.5%), larynx to 6,281 (+97.6%), and hypopharynx to 1,121 (+105.3%). Projected deaths rose by 62.8% for nasopharynx and by 76.8%–109.0% for the other site groups. Site-specific baseline and 2050 values are detailed in Table 5. The larger percentage increase in deaths than cases reflects baseline age-specific mortality patterns interacting with population aging; it is not a modeled deterioration in care or survival. These counts are a demographic planning scenario, not estimates of treatment demand.

Table 4. Demographic projection of annual head and neck cancer burden.

Year	Cases	Change	Deaths	Change
2024	28,226	0.0%	16,025	0.0%
2030	32,677	15.8%	18,825	17.5%
2040	40,216	42.5%	23,635	47.5%
2050	46,895	66.1%	27,900	74.1%

Notes: GLOBOCAN projection with 2024 rates held constant. Changes are relative to 2024 and do not model future risk factors, diagnosis, treatment, or survival.

Table 5. Site-specific demographic projections, 2024–2050.

Cancer group	Cases 2024	Cases 2050	Change	Deaths 2024	Deaths 2050	Change
Nasopharynx	16,064	25,119	56.4%	8,718	14,196	62.8%
Lip, oral cavity	4,745	7,979	68.2%	2,872	5,093	77.3%
Larynx	3,179	6,281	97.6%	2,020	4,096	102.8%
Salivary glands	2,355	3,968	68.5%	1,278	2,259	76.8%
Oropharynx	1,337	2,427	81.5%	816	1,585	94.2%
Hypopharynx	546	1,121	105.3%	321	671	109.0%

Notes: Cancer Tomorrow scenario with APC=0 and baseline rates applied to future population structures. Percent changes are not forecasts of risk or care.

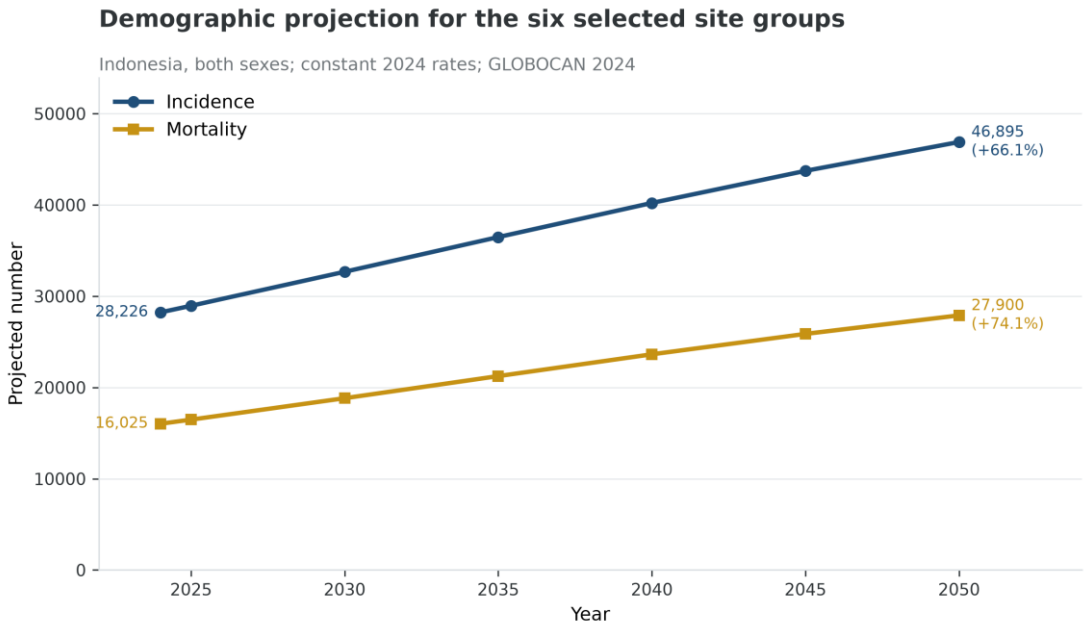

Figure 4. Projected annual cases and deaths to 2050 under constant 2024 rates. The change represents population growth and aging only.

Sensitivity analyses

Excluding salivary glands yielded 25,871 incident cases, 14,747 deaths, an ASIR of 8.16, and an ASMR of 4.66; this mucosal-only definition retained 91.7% of primary-definition cases. Excluding nasopharynx yielded 12,162 cases, 7,307 deaths, an ASIR of 3.91, and an ASMR of 2.34, retaining 43.1% of cases. The primary and alternative definitions are compared directly in Table 6. These analyses confirmed that inclusion of salivary glands had a modest effect on the aggregate, whereas the national profile and combined rate were highly sensitive to nasopharyngeal cancer.

Table 6. Sensitivity of burden estimates to the operational cancer definition.

Definition	Cases	Deaths	ASIR	ASMR	Cases retained
Primary six-site definition	28,226	16,025	8.91	5.06	100.0%
Mucosal sites only	25,871	14,747	8.16	4.66	91.7%
Non-nasopharyngeal sites	12,162	7,307	3.91	2.34	43.1%

Notes: Mucosal-only excludes C07–C08; non-nasopharyngeal excludes C11. Rates per 100,000.

Validation results

All 21 checks passed. The cancer-code-to-label and ICD map was exact; raw schemas contained required fields; analytical records were complete, nonnegative, and unique; sex-specific counts reconciled to both-sex counts; projection country, years, and APC were as specified; 2024 projection baselines matched Cancer Today values; combined totals reconciled; the code-40 denominator was confirmed; and all 15 retained raw files had unique valid SHA-256 hashes. Passing these checks supports computational integrity but not national representativeness or model validity.

4. Discussion

Principal findings

This secondary analysis estimated 28,226 incident cases and 16,025 deaths across six selected site groups in Indonesia in 2024. Nasopharyngeal cancer contributed more than half of both totals; rates were higher in males; and population growth and aging raised the constant-rate scenario to almost 46,900 cases and 27,900 deaths by 2050. The results describe modeled burden, not observed service use or need. The mucosal-only sensitivity analysis changed totals modestly, whereas removal of nasopharynx reduced cases by 56.9%, confirming that the combined Indonesian estimate is dominated by one anatomical site.

The findings also illustrate why precise case definitions matter. "Head and neck cancer" can include different combinations of oral cavity, pharyngeal, laryngeal, sinonasal, salivary, thyroid, cutaneous, and unknown-primary tumors. Including thyroid cancer would have changed the sex profile and clinical implications; including esophageal cancer would have crossed an anatomic and treatment boundary; and inferring C14 would have introduced unsupported data. By reporting six exact ICD-10 groups, the present study offers reproducible totals while preserving the possibility of subsite-specific interpretation.

Nasopharyngeal cancer as the defining Indonesian subsite

The dominance of nasopharyngeal cancer is consistent with contemporary Indonesian, regional, and global evidence that this disease is a defining subsite in the country and the surrounding region.[8–10] The present estimate differs in absolute count from hospital series because the data source, catchment, reference year, and estimation procedures differ. Comparisons across GLOBOCAN releases or referral-center cohorts should not be treated as a time trend unless the underlying methods and coverage are made comparable.

Nasopharyngeal carcinoma is biologically distinct from most tobacco- and alcohol-associated mucosal head and neck squamous cell carcinomas. EBV is strongly linked to non-keratinizing nasopharyngeal carcinoma, while inherited susceptibility, preserved foods, smoking, occupational exposures, and other environmental factors may modify risk. This distinctive etiology has practical implications. Public education must address symptoms that can be nonspecific or anatomically remote from the primary tumor, including a persistent neck mass, nasal obstruction or bleeding, unilateral ear symptoms, cranial neuropathy, or headache. Primary-care and first-contact clinicians need referral pathways that reduce delay when these features persist.

Diagnosis typically requires endoscopic examination, imaging, tissue confirmation, and pathology capable of appropriate classification. Treatment often depends heavily on radiotherapy, with concurrent systemic therapy for many locoregionally advanced presentations. Consequently, national planning based only on total cancer cases can underestimate the particular equipment, quality assurance, immobilization, imaging, contouring, treatment-planning, chemotherapy, nutritional, dental, and supportive-care needs generated by an endemic nasopharyngeal cancer burden. A high count in geographically distant populations also creates travel and accommodation burdens that aggregate epidemiology does not capture.

EBV biomarkers are promising for risk stratification and earlier detection in endemic settings. Recent studies have evaluated anti-BNLF2b serology, directly compared alternative EBV-based screening strategies, and examined plasma EBV DNA as a marker of future nasopharyngeal cancer risk.[15–17] Translating these findings into a national program nevertheless requires caution. Screening performance depends on background incidence, biomarker algorithm, repeat-testing strategy, confirmatory imaging and endoscopy, adherence, and the capacity to investigate false-positive results. Indonesia should prioritize implementation research that tests feasible pathways in higher-risk populations and regions before assuming nationwide benefit or cost-effectiveness. GLOBOCAN cannot identify which provinces or ethnic groups should be targeted; that requires

geographically representative registries and prospective studies.

Sex differences and preventable exposure

The observed sex disparity was both substantial and heterogeneous. Overall ASIR was 2.55 times higher in males and ASMR 2.79 times higher. The largest differences occurred in laryngeal and hypopharyngeal cancers, sites closely linked to inhaled tobacco and alcohol in many populations. Population-attributable analyses support the importance of preventable exposure, but the present ecological analysis cannot calculate an Indonesia-specific tobacco- or alcohol-attributable fraction or prove that either exposure caused the measured sex ratios.[3] Occupational exposure, diet, healthcare-seeking, diagnostic practice, and biological factors may also contribute.

The prevention implication is nevertheless clear: comprehensive tobacco control is central to reducing future head and neck cancer burden. Effective policy extends beyond advice to individual smokers. It includes excise taxation, smoke-free environments, restrictions on advertising and promotion, prominent health warnings, cessation support, control of illicit trade, and protection from industry interference. Because cancers have long latency, reductions in smoking prevalence will not immediately eliminate burden, but delaying action locks in future disease. The very low reported tobacco use among women should be protected through policies that prevent targeted marketing and uptake rather than interpreted as grounds for complacency.

The sex pattern also suggests the importance of incorporating head and neck cancer into cessation encounters. Dental services, primary care, otorhinolaryngology clinics, surgical services, and oncology programs all provide opportunities to identify tobacco use and deliver evidence-based cessation support. Continued smoking after diagnosis is associated with treatment complications and worse outcomes in several head and neck cancer settings, so cessation should be part of comprehensive care rather than an optional preventive message.

Alcohol data were not analyzed, and Indonesia's national consumption patterns differ from those in many Western studies. Individual-level exposure information would be necessary to estimate independent and joint effects. Future Indonesian analytic studies should therefore measure exposures with dose, duration, product type, and cessation history rather than using a binary ever/never variable. They should also capture smokeless tobacco, kretek cigarettes, secondhand smoke, areca nut, and locally relevant products.

Oral cavity cancer, areca nut, and early detection

Lip and oral cavity cancer was the second-largest group, with approximately 4,745 cases and 2,872 deaths. Oral lesions are potentially visible or palpable, offering an opportunity for earlier recognition. Yet anatomic accessibility does not guarantee early diagnosis. Lack of awareness, normalization of symptoms, fear, travel constraints, fragmented referral, limited biopsy access, and pathology turnaround can all prolong the diagnostic interval.

Areca nut and betel-quid chewing deserve specific attention. A recent global attributable-burden analysis estimated a substantial oral-cancer contribution from smokeless tobacco and areca nut.[4] Indonesia's cultural diversity means exposure is unlikely to be uniform across provinces, sex, age, or ethnic group. A single national prevalence estimate may obscure high-risk communities. Risk-factor surveillance should document product composition, tobacco inclusion, frequency, duration, age at initiation, and co-use with smoking or alcohol.

Population-wide visual oral screening is not automatically beneficial in every setting, because effectiveness depends on examiner training, target-population risk, referral completion, diagnostic confirmation, and treatment access. A more defensible near-term strategy is risk-based early detection embedded in primary and dental care, supported by standardized referral criteria and audit of diagnostic intervals. Community interventions should be designed with cultural competence and avoid stigmatizing traditional practices. Prevention messages must explain that areca nut itself is carcinogenic, not only mixtures that contain tobacco.

Oral potentially malignant disorders create an additional service need. Detecting leukoplakia, erythroplakia, oral submucous fibrosis, or other concerning lesions is useful only if systems can provide biopsy, pathology, risk stratification, longitudinal surveillance, behavior-change support, and definitive management when indicated. Training without a functioning referral network can produce anxiety without benefit. The estimated burden therefore supports an integrated pathway rather than a stand-alone awareness campaign.

Oropharyngeal cancer and HPV-related prevention

Oropharyngeal cancer contributed a smaller estimated burden than nasopharyngeal, oral cavity, laryngeal, or salivary gland cancers. International analyses show increasing HPV-associated oropharyngeal cancer in several populations, while tumor-characterized cohorts demonstrate geographic heterogeneity.[6,7] Discordance between p16 and HPV-specific testing can alter prognostic classification, and recent population-based studies show that trends and survival differ across settings.[18–20] The Indonesian proportion attributable to HPV cannot be inferred from the GLOBOCAN site category because the database does not contain tumor HPV or p16 status. It would be inappropriate to label all C09–C10 cancers as HPV-driven.

Indonesia's HPV vaccination program is a major platform for infection-related cancer prevention. Any future statement about preventing oropharyngeal cancer should distinguish direct evidence, potential herd effects, sex-neutral vaccination policy, coverage,

and the long latency to adult malignancy. Surveillance of HPV-associated oropharyngeal cancer will require high-quality tumor-site classification and validated biomarker testing. Pathology studies should avoid p16-only assumptions where confirmatory viral testing is required for the research question.[18]

Public communication must also distinguish nasopharyngeal and oropharyngeal cancers. Their names are similar, but their dominant viral associations, anatomy, epidemiology, and prevention strategies differ. Conflation risks misdirecting policy—HPV vaccination is not a prevention strategy for EBV-associated nasopharyngeal carcinoma, and EBV biomarker research does not address HPV-positive oropharyngeal disease.

Salivary gland, laryngeal, and hypopharyngeal cancers

The C07–C08 salivary-gland group represented 2,355 cases and 1,278 deaths. It should not be interpreted as all salivary malignancies: tumors arising in minor salivary tissue are generally coded to their anatomical site and may fall within another category. Population-based epidemiology and translational studies show that major salivary-gland cancer comprises uncommon but biologically diverse diseases.[21,22] The aggregate group cannot distinguish mucoepidermoid, adenoid cystic, acinic cell, salivary duct, or fusion-defined tumors. This limitation reinforces the need for morphology-resolved registry and pathology data rather than permitting histologic conclusions from anatomical counts.

Laryngeal cancer generated 3,179 cases and 2,020 deaths and showed the largest male–female disparity. Recent population-based analyses document changing laryngeal incidence and persistent geographic survival disparities across laryngeal and hypopharyngeal disease.[23,24] Laryngeal cancer prevention is closely aligned with tobacco control, while early recognition of persistent hoarseness can permit evaluation at a more treatable stage. Management requires balancing oncologic control with airway safety, voice, swallowing, and quality of life. Depending on stage and resources, treatment may involve endoscopic surgery, partial or total laryngectomy, radiotherapy, chemoradiotherapy, rehabilitation, and long-term airway or stoma care. Counts alone do not capture this functional burden.

Hypopharyngeal cancer was least common but remains clinically important because symptoms may emerge late and treatment can be complex. Its high male predominance is compatible with established exposure patterns. A low absolute count should not be interpreted as low service intensity: advanced tumors may require airway management, extensive surgery or chemoradiotherapy, enteral nutrition, and rehabilitation. For rare or lower-volume subsites, referral concentration may improve expertise, but centralization must be balanced against geographic equity and timely access.

Interpreting the international benchmarks

Indonesia's combined ASIR was below the WHO South-East Asia and lower-middle-income aggregates but above the high-HDI estimate. Its ASMR was above the high-HDI and world estimates. These comparisons should be read as contextual, not evaluative rankings. Contemporary nationwide and multi-registry studies demonstrate how site definition, population structure, and registration coverage influence reported head and neck cancer burden.[13,14] The South-East Asia aggregate includes populations with high oral cancer rates associated with smoked and smokeless tobacco and areca nut; high-HDI countries include heterogeneous patterns of HPV-associated oropharyngeal cancer, declining tobacco-related disease in some populations, and more complete registration. Differences in estimation inputs also influence the comparison.

The apparently lower Indonesian ASIR than the regional aggregate must not be taken to mean that the country has adequate control or complete ascertainment. Indonesia's incidence estimate depends on selected subnational registries and scaling. If registry areas differ from the national population in exposures, ethnicity, urbanization, healthcare access, or diagnostic intensity, the national estimate may be biased in either direction. Conversely, the prominence of nasopharyngeal cancer may be robust even if the exact magnitude changes because multiple Indonesian clinical and registry studies have reported its importance.

Capacity implications of demographic growth

The constant-rate scenario asks what happens if rates do not change. Even under that assumption, Indonesia would have approximately 18,700 more incident cases and 11,900 more deaths annually by 2050. These epidemiological counts signal potential pressure across diagnosis and care but cannot be converted directly into procedure volumes: stage, performance status, treatment indications, contraindications, access, preference, and completion are unknown.

Capacity scenarios should be site-aware and linked to observed stage and treatment data. Indonesian studies of linear-accelerator downtime and barriers encountered during radiotherapy delivery demonstrate that installed equipment counts alone do not describe usable capacity.[25,26] Nasopharyngeal cancer frequently involves radiotherapy-based pathways; oral cavity disease may involve ablative surgery and reconstruction; laryngeal and hypopharyngeal cancers require airway and functional expertise; and salivary malignancies require specialist pathology. Trial evidence also shows that treatment selection depends on patient fitness and available radiosensitization options rather than diagnosis counts alone.[27] These are clinical pathway considerations, not treatment-need estimates derived from GLOBOCAN. A future needs assessment should combine population incidence with stage-specific

guidelines, current utilization, waiting times, capacity, and patient flows.

A 2025 IAEA imPACT review provides contemporary service context: Indonesia reported 57 radiotherapy centers and 96 external-beam machines in 2023, approximately 30,000 patients receiving radiotherapy against more than 200,000 estimated to require it, and waits longer than one month at 22% of centers.[28] These system-level figures were not linked to the present cancer estimates and should not be treated as head-and-neck-specific utilization. They nevertheless show why validated service audits should measure equipment uptime, staffing, planning capability, maintenance, waiting times, geographic catchments, indicated treatment, and completion before translating projected cases into investment targets.

Workforce planning is equally important. Equipment without trained radiation oncologists, medical physicists, radiation therapists, dosimetrists, oncology nurses, engineers, and quality systems cannot deliver safe treatment. Surgical expansion requires teams capable of complex resection, reconstruction, anesthesia, critical care, pathology, and rehabilitation. Telemedicine can support case discussion and follow-up, but it cannot replace procedures, imaging, pathology, or radiotherapy. Hub-and-spoke networks should be evaluated on timely completion of care, not merely on referral volume.

Alignment with Indonesia's cancer-control strategy

Indonesia's National Cancer Control Plan 2024–2034 provides a policy opportunity to integrate head and neck cancer needs into cross-cutting system reforms.[11] Although the plan's named priority cancers do not encompass the full group analyzed here, several proposed capabilities are shared: stronger registration, prevention, early detection, diagnostic quality, referral, treatment access, financing protection, workforce development, and monitoring. Head and neck oncology should be incorporated into these platforms rather than built as an isolated vertical program.

The first priority is prevention. Tobacco control will influence multiple cancer and non-cancer outcomes and offers broader benefit than any site-specific screening program. Areca-nut risk communication and cessation support should be tailored to exposed communities. HPV vaccination should achieve high and equitable coverage for its established benefits, while research clarifies the local HPV-attributable oropharyngeal burden. Occupational exposure control, oral health promotion, and reduction of harmful alcohol use where relevant complement these measures.

The second priority is earlier diagnosis linked to treatment. Public awareness should focus on persistent, high-value symptoms rather than indiscriminate fear: a neck mass, non-healing oral ulcer, progressive swallowing difficulty, persistent hoarseness, unilateral nasal or ear symptoms, and unexplained cranial nerve signs. Referral targets should be accompanied by access to endoscopy, imaging, biopsy, and pathology. Monitoring should measure intervals from first presentation to diagnosis and from diagnosis to treatment, stratified by geography, insurance, and subsite.

The third priority is data. Population-based cancer registration is infrastructure, not a one-time research project. Registries need stable funding, trained personnel, legal and governance frameworks, standardized coding, active case finding, linkage with pathology and mortality sources, deduplication, quality indicators, and timely publication. Hospital-based registries remain valuable for stage, treatment, and outcomes but cannot estimate population incidence without a defined catchment. Linking—not conflating—population, hospital, pathology, vital-statistics, and administrative data would create a more complete evidence system.

Research priorities

The analysis identifies several priorities for Indonesian head and neck cancer research. First, contemporary population-based registries should quantify incidence by province, age, sex, ethnicity where appropriate and ethical, and tumor subsite. Second, standardized hospital registries should capture stage, histology, biomarkers, treatment, timeliness, completion, toxicity, recurrence, functional outcomes, and survival. Third, linkage with national health-insurance claims could measure utilization and direct reimbursed expenditure, but claims-based studies would require validated algorithms for patient identification, incident episodes, procedures, and censoring.

Fourth, etiologic studies should examine locally relevant exposure combinations, including tobacco product type, areca nut, betel-quid composition, alcohol, diet, occupational agents, EBV markers, and HPV tumor status. Recent consortium research illustrates the value of individual exposure histories and confounder adjustment for questions that aggregate datasets cannot answer.[29] Genetic and genomic studies may clarify susceptibility and tumor biology, but they should be designed with adequate sample size, ancestry-aware methods, replication, consent, data governance, and equitable benefit sharing. A genomic association is not automatically a screening test, and tumor sequencing should be connected to a clinically actionable question.

Fifth, implementation research should test interventions across the care continuum. Feasibility research in dental settings illustrates that screening cannot be separated from utilization, referral, and follow-up pathways.[30] Other candidates include primary-care referral tools, EBV-based nasopharyngeal screening in high-risk groups, decentralized biopsy pathways, digital pathology, multidisciplinary teleconferencing, navigation, radiotherapy workflow redesign, nutrition programs, speech and swallowing rehabilitation, and

survivorship care. Outcomes should include equity, timeliness, completion, patient-reported function, survival, costs, and unintended consequences.

Finally, clinical registries should preserve stage detail rather than infer it from anatomical site. Contemporary work refining TNM classification for EBV-related nasopharyngeal carcinoma illustrates how outcome-linked clinical data can improve prognostic grouping beyond population counts.[31] Economic evaluation should likewise be undertaken with appropriate data rather than inferred from cancer counts. A burden-of-illness study requires direct medical costs, nonmedical costs, productivity effects, household spending, and a defined perspective and time horizon. Cost-effectiveness analysis additionally requires comparative interventions, health outcomes, uncertainty, and opportunity costs. GLOBOCAN can provide epidemiologic inputs to such analyses, but it cannot independently estimate Indonesia's healthcare utilization or economic burden.

Strengths

This study uses GLOBOCAN 2024 data version 08 July 2026 and an explicit source-code-to-ICD map. It preserves site detail, reports counts and standardized rates, emphasizes absolute sex differences, labels projections as a constant-rate demographic scenario, and adds site-specific projections and definitional sensitivity analyses. The workflow retains raw inputs, checksums, processed outputs, an executed notebook, 21 hard-stop validation checks, and a completed GATHER checklist. It avoids inferential statistics that the source uncertainty structure cannot support.

The study's multidisciplinary interpretation is another strength. The epidemiology is connected to subsite-specific biology, risk factors, clinical pathways, and health-system capacity without claiming that the aggregate data directly measured those mechanisms. This approach is particularly important for a cancer group in which EBV-associated nasopharyngeal disease, tobacco-associated laryngeal disease, HPV-associated oropharyngeal disease, areca-related oral disease, and histologically diverse salivary tumors coexist.

Limitations

The principal limitation is that GLOBOCAN values are estimates, not a census of all cancers diagnosed and deaths observed in Indonesia. National incidence was constructed from selected subnational registry data from different years, scaled with external all-site rates, and applied to the 2024 population. Registry areas may not represent Indonesia's geographic, ethnic, socioeconomic, exposure, and healthcare diversity. National mortality was modeled from incidence using survival-based mortality-to-incidence ratios rather than derived from complete cause-specific vital registration. The apparent numerical precision of the estimates should therefore not be confused with certainty.

Second, the six-site definition is intentionally incomplete relative to the clinical field. It excludes C14, sinonasal, thyroid, cutaneous, and other tumors, while C07–C08 does not capture every minor salivary-gland malignancy. Comparisons using different definitions may be invalid. Summing mutually exclusive site ASRs is arithmetically justified under a shared population and standard, but published two-decimal inputs create ±0.03 worst-case rounding bounds. The mucosal-only and non-nasopharyngeal analyses address definition dependence but do not replace alternative full case definitions.

Third, the analysis is ecological and cross-sectional. It cannot identify causal determinants of sex or international differences, measure inequalities within Indonesia, or distinguish true risk from ascertainment. No individual exposure, stage, histology, HPV or EBV status, comorbidity, treatment, recurrence, function, quality of life, or survival data were available. Anatomical site counts therefore cannot be converted to histologic or viral-attributable burden.

Fourth, the projections assume constant 2024 rates and APC=0. Real rates may change with prevention, exposures, ascertainment, diagnosis, and care. Public source outputs did not provide a propagatable uncertainty distribution, so the scenario has no statistical interval and must not be read as a deterministic forecast. Fifth, reference aggregates overlap and inherit heterogeneous estimation methods. Finally, no utilization or economic data were analyzed; the study cannot estimate procedures, insurance expenditure, out-of-pocket costs, productivity loss, or cost-effectiveness.

5. Conclusion

Six selected anatomical site groups accounted for an estimated 28,226 incident cases and 16,025 deaths in Indonesia in 2024. Nasopharyngeal cancer contributed more than half of this operational definition, while age-standardized rates were higher in males. Under constant 2024 rates, demographic change increased annual cases by 66.1% and deaths by 74.1% by 2050.

The findings support prevention priorities and justify collection of the stage, treatment, utilization, capacity, cost, and outcome data required for precise planning. They do not demonstrate treatment need, prognosis, causal attribution, or economic burden. Stronger population-based registration linked—without conflation—to hospital, pathology, mortality, and insurance data is needed to transform this modeled national burden map into equitable service policy.

Declarations

Ethics approval and consent to participate

The study used publicly accessible, aggregate, deidentified estimates and no individual participant data. No ethics approval or informed consent was sought.

Consent for publication

Not applicable; the manuscript contains no identifiable individual information.

Availability of data and materials

The source estimates are publicly accessible through the IARC Global Cancer Observatory. The analytical package contains retained source responses, a file-level provenance manifest with public routes and SHA-256 hashes, processed datasets, executable Python code, an executed notebook, validation results, tables, figures, and the GATHER checklist, subject to IARC terms of use. Authors should deposit this package in a persistent repository and insert its DOI before journal submission.

Competing interests

No competing interests are declared in this blinded manuscript.

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Author contributions

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