ORIGINAL ARTICLE

Epidemiology and histological spectrum of cutaneous melanoma in Sri Lanka: a population-based analysis, 2015–2022

Abarana Atchuthan[1]

[1]National Cancer Institute, Apeksha Hospital, Maharagama, Sri Lanka.

Correspondence: Abarana Atchuthan, abarana2001@gmail.com

Abstract

Background: Cutaneous melanoma is a biologically aggressive malignancy demonstrating substantial geographic, ethnic, and environmental heterogeneity. Although melanoma incidence remains markedly lower in South Asia than in Western populations, demographic aging, improved cancer surveillance, and evolving dermatopathology infrastructure may progressively alter melanoma burden in low- and middle-income countries (LMICs). Population-level melanoma epidemiology from Sri Lanka remains limited.

Methods: A retrospective population-based epidemiological study was conducted using Sri Lanka National Cancer Registry data from 2015 to 2022. All cutaneous melanoma cases (ICD-10 C43) were included. Comparative analyses incorporated non-melanoma skin cancers (NMSC; ICD-10 C44) and overall malignant neoplasm incidence. Crude incidence rates, age-specific incidence rates, mortality rates, and age-standardised incidence rates (ASIRs) per 100,000 population were calculated using the WHO standard population methodology. Temporal trends were evaluated using annual percentage change (APC) analysis through log-linear regression. Mortality-to-incidence ratios (MIRs) were calculated as survival proxies. Histological subtype distributions and sex-specific differences were evaluated descriptively and analytically.

Results: Between 2015 and 2022, 760 melanoma cases were recorded nationally, including 396 males (52.1%) and 364 females (47.9%), producing a male: female ratio of 1.09:1. Annual melanoma incidence increased from 74 cases in 2015 to 117 cases in 2022, representing a 58.1% relative increase in crude case burden. Crude incidence ranged from 0.35–0.53 per 100,000 population, whereas ASIR remained relatively stable between 0.33–0.51 per 100,000 population. APC analysis demonstrated no statistically significant increase in ASIR (APC +0.41% annually; P=0.792). Incidence increased sharply after 50 years and peaked among individuals aged ≥75 years. Melanoma mortality demonstrated a gradual expansion with persistently elevated MIR values ranging approximately 0.36–0.44. Melanoma not otherwise specified (NOS) represented 81.9% of classified cases. Among specified subtypes, acral lentiginous melanoma and nodular melanoma predominated. NMSC incidence exceeded melanoma approximately sixfold and demonstrated statistically significant incidence acceleration (APC +5.31%; P=0.028).

Conclusion: Melanoma incidence in Sri Lanka remains substantially lower than in Western populations but demonstrates progressive absolute expansion associated predominantly with demographic ageing rather than substantial increase in melanoma risk. Persistent high MIR values and extensive NOS histological classification indicate ongoing diagnostic and pathological limitations. These findings support the emergence of an early melanoma epidemiological transition in Sri Lanka within the broader framework of LMIC cancer evolution.

Keywords: melanoma; Sri Lanka; epidemiology; mortality-to-incidence ratio; histology; skin cancer; cancer registry

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Introduction

Cutaneous melanoma represents one of the most biologically aggressive human malignancies and contributes disproportionately to skin cancer mortality despite accounting for a relatively smaller proportion of total skin cancer incidence.[1] Global melanoma epidemiology demonstrates marked geographic heterogeneity, with the highest incidence rates reported in Australia, New Zealand, North America, and Northern Europe.[2,3] In contrast, South Asian populations continue to demonstrate substantially lower melanoma incidence rates, likely reflecting darker skin phototypes, greater melanin-mediated ultraviolet protection, differing occupational and recreational ultraviolet exposure patterns, and ethnic biological variation.[4]

Historically, melanoma has been conceptualized predominantly as a malignancy affecting fair-skinned populations. However, cancer epidemiology in low- and middle-income countries (LMICs) is increasingly influenced by demographic ageing, urbanization, environmental transition, and improving healthcare surveillance systems.[5] Consequently, low-incidence populations cannot be regarded as epidemiologically static.

Sri Lanka is currently undergoing a major demographic and epidemiological transition characterized by rapid population ageing and increasing national cancer burden.[6] Simultaneously, the Sri Lankan National Cancer Registry represents one of the more mature cancer surveillance systems within South Asia, permitting longitudinal population-level oncology analyses.

Despite this, melanoma epidemiology in Sri Lanka remains inadequately characterized. Existing regional literature largely comprises institutional series and small observational studies.[7] Comprehensive analyses integrating incidence trends, mortality patterns, age-specific burden, histological subtype distribution, mortality-to-incidence ratios, and comparative epidemiology with non-melanoma skin cancers remain scarce.

Melanoma epidemiology is strongly influenced by age, sex, ethnicity, and histological subtype.[8] Superficial spreading melanoma predominates in Western populations and is strongly associated with intermittent ultraviolet exposure.[9] In contrast, acral lentiginous melanoma and nodular melanoma occur proportionally more frequently in darker-skinned populations and may demonstrate distinct biological behaviour.[10]

Histological subtype distribution possesses major clinical and epidemiological relevance because melanoma subtype influences metastatic potential, Breslow thickness, treatment responsiveness, and survival outcomes.[11] Furthermore, histological patterns may provide insight into ultraviolet-associated versus non-ultraviolet carcinogenic pathways.

This study, therefore, aimed to conduct a comprehensive population-based epidemiological analysis of cutaneous melanoma in Sri Lanka between 2015 and 2022. Specifically, the study evaluated:

1. Temporal incidence trends
2. Sex-specific and age-specific incidence patterns
3. Mortality patterns and mortality-to-incidence ratios

4. Histological subtype distributions
5. Comparative epidemiology with non-melanoma skin cancers
6. Regional and global epidemiological context

Methods

Study Design: A retrospective population-based epidemiological study was conducted using Sri Lanka National Cancer Registry data between 2015 and 2022.

Data Source: Data were obtained from the Sri Lanka National Cancer Registry maintained by the National Cancer Control Programme (NCCP). The registry compiles nationwide cancer incidence data through pathology laboratories, oncology treatment centres, hospital notifications, and death certification systems.

Case Definition: All cutaneous melanoma cases coded under ICD-10 C43 were included. Comparative analyses included non-melanoma skin cancers coded under ICD-10 C44.

Variables: The following variables were analyzed:

- Year of diagnosis
- Sex
- Age group
- Annual incidence
- Population denominators
- Histological subtype
- Melanoma mortality
- Overall malignant neoplasm mortality

Statistical Analysis: Crude incidence rates were calculated per 100,000 population using annual national population estimates. Age-specific incidence rates were calculated separately for males and females across all registry age categories. Age-standardised incidence rates (ASIRs) per 100,000 population were calculated using direct standardization according to the WHO world standard population methodology.

Temporal trends were evaluated using annual percentage change (APC) calculations through log-linear regression modelling.

Mortality-to-incidence ratio (MIR) was calculated as: MIR = {Melanoma mortality} / {Melanoma incidence}. MIR was used as a population-level survival proxy and healthcare effectiveness indicator.

Histological subtype frequencies were summarized descriptively. Chi-square analysis was used to evaluate subtype proportional variation and sex differences.

Histological Classification: Histological subtypes were grouped into:

- Melanoma NOS
- Acral lentiginous melanoma
- Nodular melanoma
- Superficial spreading melanoma
- Lentigo maligna melanoma
- Amelanotic melanoma
- Spindle cell melanoma
- Other variants

Ethical Considerations: This study utilized anonymized secondary registry data without individual patient identifiers.

Results

Overall Melanoma Burden: Between 2015 and 2022, a total of 760 melanoma cases were recorded nationally, including 396 males (52.1%) and 364 females (47.9%), yielding a male:female ratio of 1.09:1. Annual melanoma incidence increased from 74 cases in 2015 to 117 cases in 2022, representing an absolute increase of 43 annual cases and a relative increase of 58.1%. Crude melanoma incidence ranged from 0.35 to 0.53 per 100,000 population. The overall ASIR ranged between 0.33 and 0.51 per 100,000 population throughout the study period. Melanoma contributed less than 0.3% of all registered malignancies nationally during all study years, confirming its rarity relative to the broader Sri Lankan cancer burden (Figure 1).

Temporal Trends: Absolute melanoma burden increased progressively across the study period. However, APC analysis demonstrated no statistically significant increase in age-standardised incidence, with APC +0.41% annually and *P*=0.792. This divergence between increasing crude burden and relatively stable ASIR strongly suggests demographic ageing rather than rapid increase in melanoma risk as the primary driver of increasing melanoma cases. In contrast, NMSC incidence demonstrated statistically significant expansion as APC +5.31% and *P*=0.028. The melanoma: NMSC incidence ratio remained approximately 1:5.8 during the study period (Figure 2).

Age-Specific Epidemiology: Melanoma incidence demonstrated a strong age gradient. Only 25 cases (3.3%) occurred below 30 years of age. Incidence increased progressively after 40 years and accelerated sharply after 50 years. The highest incidence rates occurred among individuals aged ≥75 years. Age-specific incidence curves demonstrated minimal burden in younger populations and steep late-life escalation with strong elderly concentration. The median diagnostic age category was 65–69 years. Male incidence exceeded female incidence predominantly after 60 years of age (Figure 3,4).

Sex Distribution: The overall male:female ratio was 1.09:1. Male predominance became progressively greater with advancing age. Several mechanisms may contribute to cumulative occupational ultraviolet exposure, delayed healthcare-seeking behaviour, reduced sun-protective practices, and differential environmental exposure burden. Female incidence remained substantial but consistently lower overall.

Melanoma Mortality and MIR: Melanoma mortality demonstrated a gradual numerical expansion during the study period. The overall MIR remained persistently elevated, ranging approximately between 0.36 and 0.44 across multiple study years. Compared with high-income countries where MIR frequently remains below 0.15, Sri Lankan MIR values may suggest possible survival disparities and healthcare access limitations.12 Persistently elevated MIR values may reflect delayed diagnosis, reduced public awareness, restricted specialized melanoma care, limited access to advanced systemic therapy, and pathology and diagnostic delays (Figure 5).

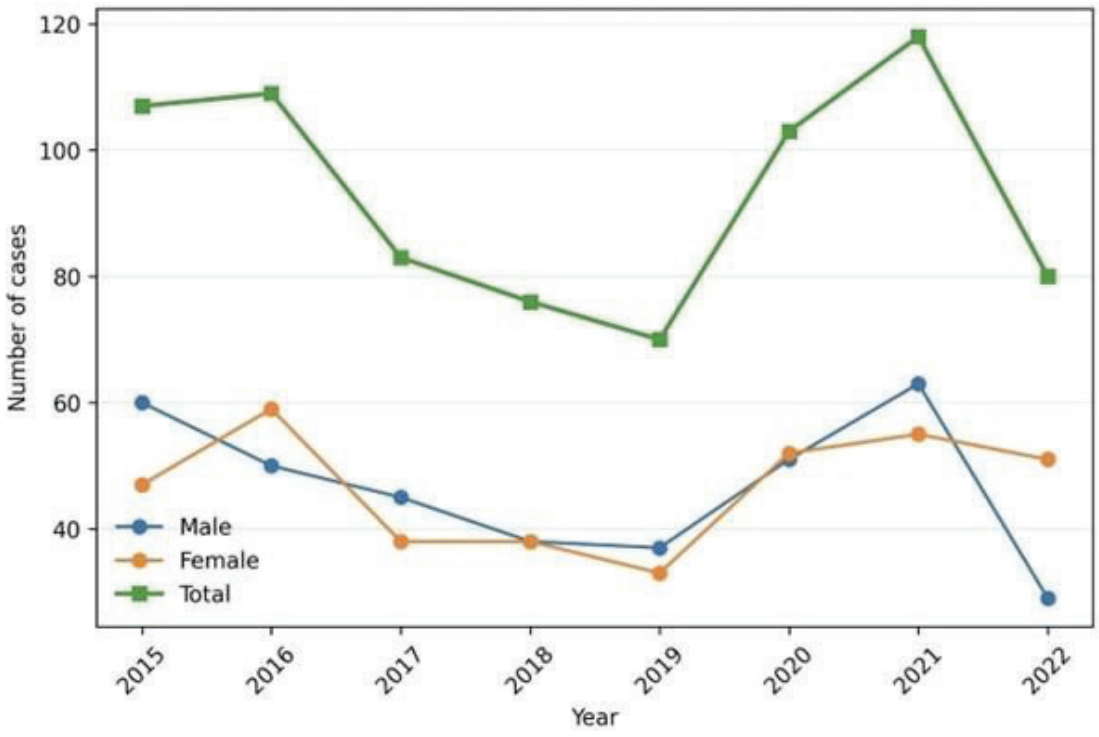

Figure 1. Annual melanoma incidence counts by sex, Sri Lanka, 2015–2022. Annual number of newly diagnosed cutaneous melanoma cases among males and females in Sri Lanka between 2015 and 2022. The graph demonstrates a gradual increase in melanoma case numbers over time in both sexes, with a mild male predominance throughout most study years. This suggests increasing absolute melanoma burden despite low national incidence rates.

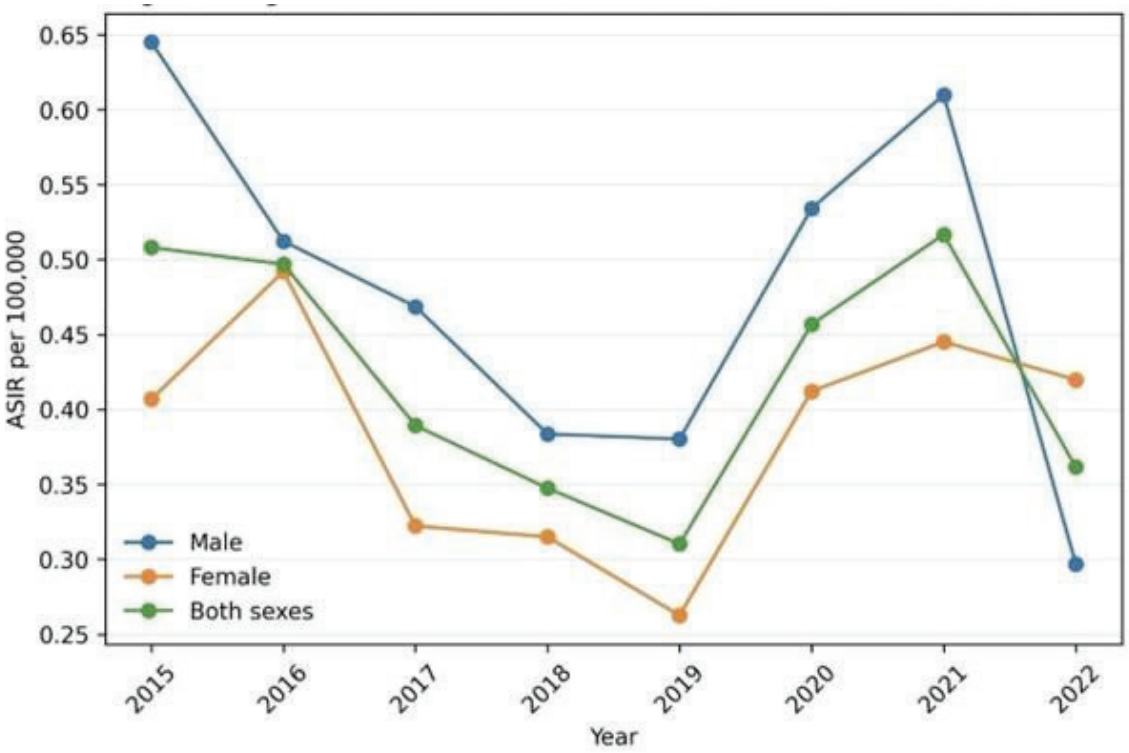

Figure 2. Age-standardised melanoma incidence rate (ASIR) trends, Sri Lanka, 2015–2022. Age-standardised incidence rates (ASIRs) per 100,000 population for melanoma by sex and overall population using WHO standard population methods. ASIR remained relatively stable across the study period with only minor fluctuations. This indicates that the increasing number of melanoma cases is more likely related to demographic ageing rather than a major increase in age-adjusted melanoma risk.

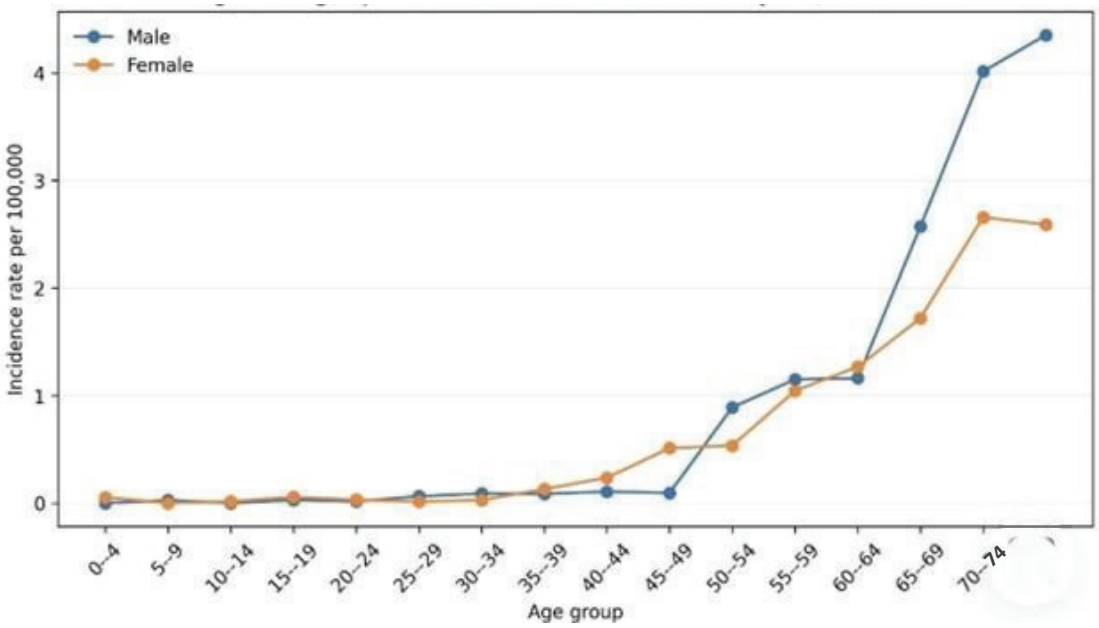

Figure 3. Age-specific melanoma incidence rates by sex, Sri Lanka, 2015–2022. Age-specific melanoma incidence rates per 100,000 population among males and females across different age groups. Melanoma incidence was very low in younger populations but increased sharply after middle age, peaking in elderly age groups. Male incidence exceeded female incidence, particularly in older adults.

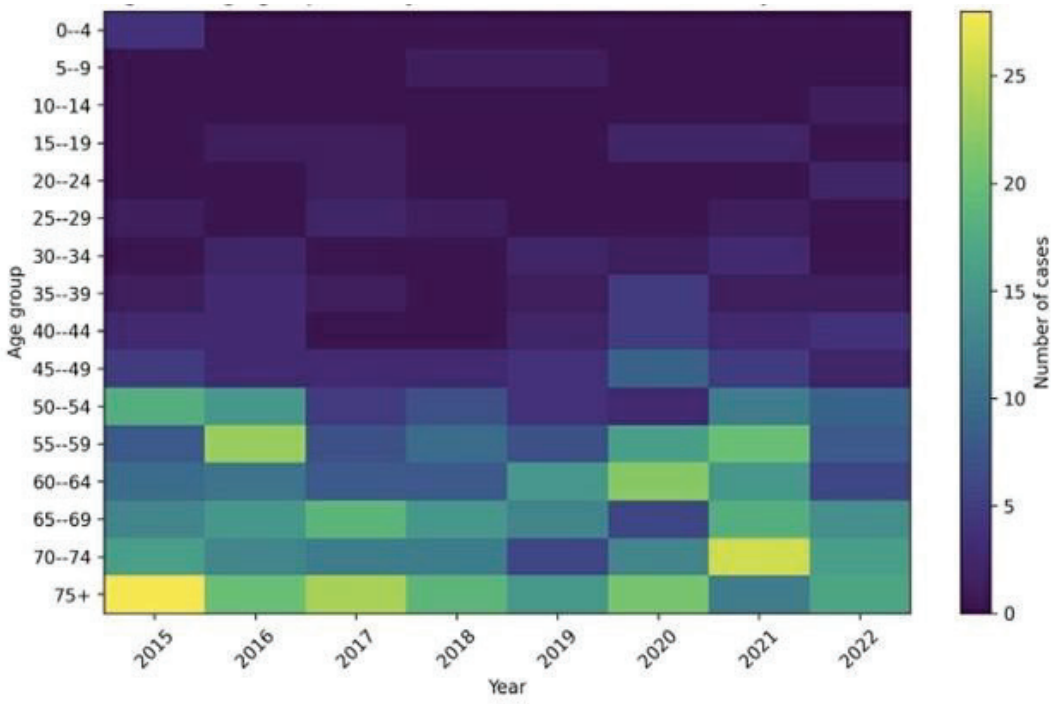

Figure 4. Heatmap of age-group versus year melanoma incidence density, Sri Lanka, 2015–2022. Heatmap illustrating melanoma case density across age groups and study years. Darker intensity indicates higher case concentration. The heatmap demonstrates the concentration of melanoma burden in older age groups, particularly above 60 years. Younger age groups consistently showed very low incidence density.

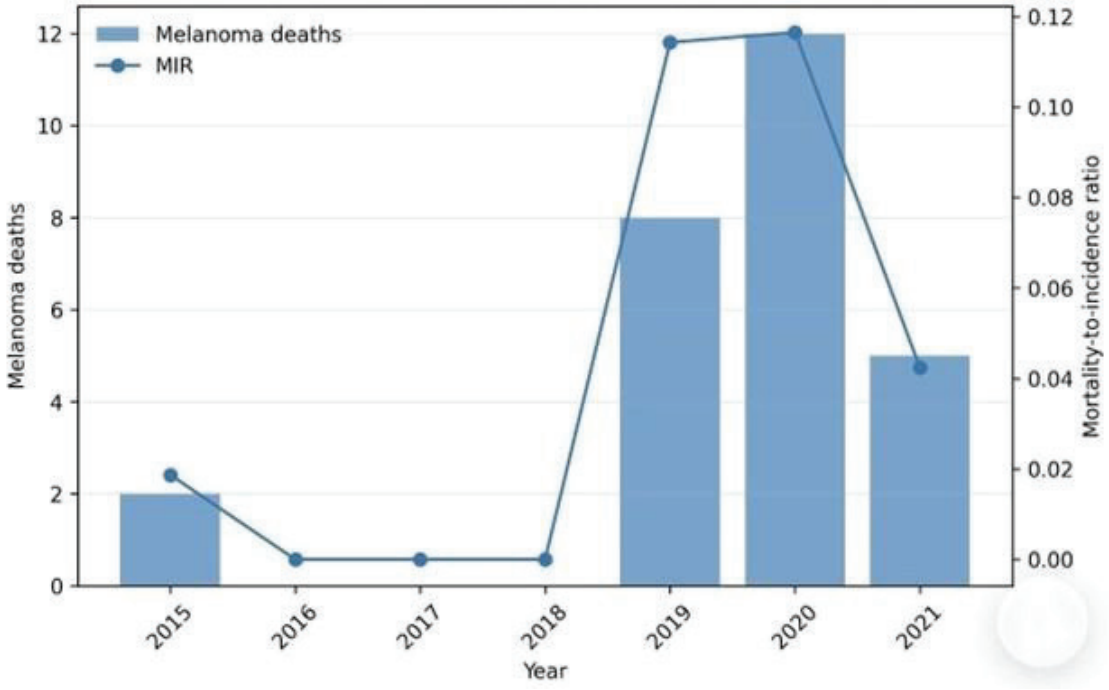

Figure 5. Melanoma mortality trends and mortality-to-incidence ratio (MIR), Sri Lanka, 2015–2022. Annual melanoma mortality counts and mortality-to-incidence ratios (MIRs) during the study period. MIR was calculated as melanoma mortality divided by melanoma incidence. Although melanoma mortality remained numerically low, MIR values stayed relatively elevated. This suggests possible delays in diagnosis, survival disparities, or limitations in specialized melanoma management compared with high-income countries.

Histological Spectrum: Histological analysis demonstrated substantial subtype heterogeneity. Melanoma NOS accounted for 81.9% of classified cases, indicating major limitations in pathological subclassification and registry precision (Figure 6).

Among specifically classified melanomas:

- Acral lentiginous melanoma: 31 cases (4.1%);
- Nodular melanoma: 30 cases (3.9%);
- Regressing melanoma: 14 cases (1.8%);
- Amelanotic melanoma: 11 cases (1.4%);
- Spindle cell melanoma: 8 cases (1.1%);
- Lentigo maligna melanoma: 6 cases (0.8%).

Acral lentiginous melanoma and nodular melanoma represented the dominant specified subtypes. Temporal analysis suggested a modest reduction in NOS classification frequency during later years, potentially reflecting gradual pathology maturation.

Distribution of melanoma histological subtypes across study years, including melanoma NOS, acral lentiginous melanoma, nodular melanoma, and other variants. Melanoma NOS represented the dominant histological category throughout the study period, indicating limited pathological subclassification. Among specified subtypes, acral lentiginous and nodular melanoma were the most frequent.

Comparison with Non-Melanoma Skin Cancer: NMSC burden substantially exceeded melanoma burden nationally. Between 2015 and 2022, 4,526 NMSC cases were recorded. Annual NMSC incidence ranged from 382 to 707 cases annually. Crude NMSC incidence ranged from 1.82 to 3.30 per 100,000 population. Unlike melanoma, NMSC demonstrated statistically significant incidence acceleration. Despite a substantially lower incidence, melanoma likely contributed disproportionately to skin cancer mortality because of markedly greater metastatic potential and biological aggressiveness (Figure 7).

Regional and Global Comparison: Sri Lankan melanoma incidence remained dramatically lower than rates reported in Western populations (Figure 8).

Approximate ASIR comparisons included:

- Sri Lanka: 0.3–0.5 per 100,000;
- India: 0.5–0.8 per 100,000;
- Japan: 1–2 per 100,000;
- United Kingdom: 20–25 per 100,000;
- Australia: 35–40 per 100,000.[13–16]

However, histological patterns in Sri Lanka more closely resembled Asian populations, with proportionally greater acral melanoma representation.

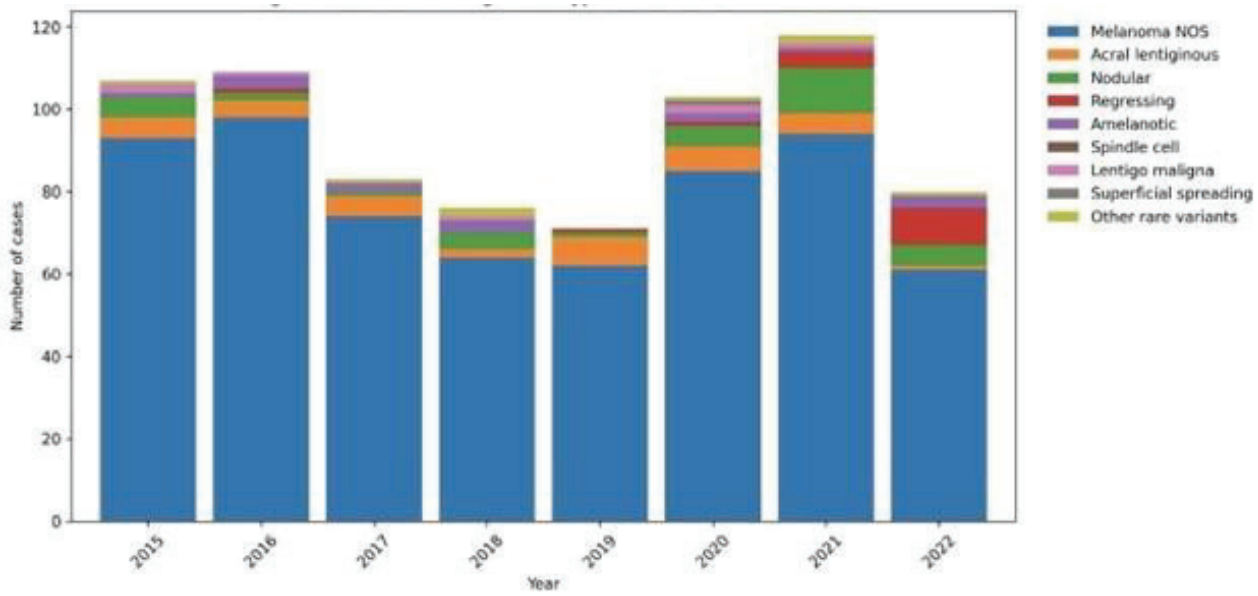

Figure 6. Stacked histological subtype distribution of melanoma, Sri Lanka, 2015–2022.

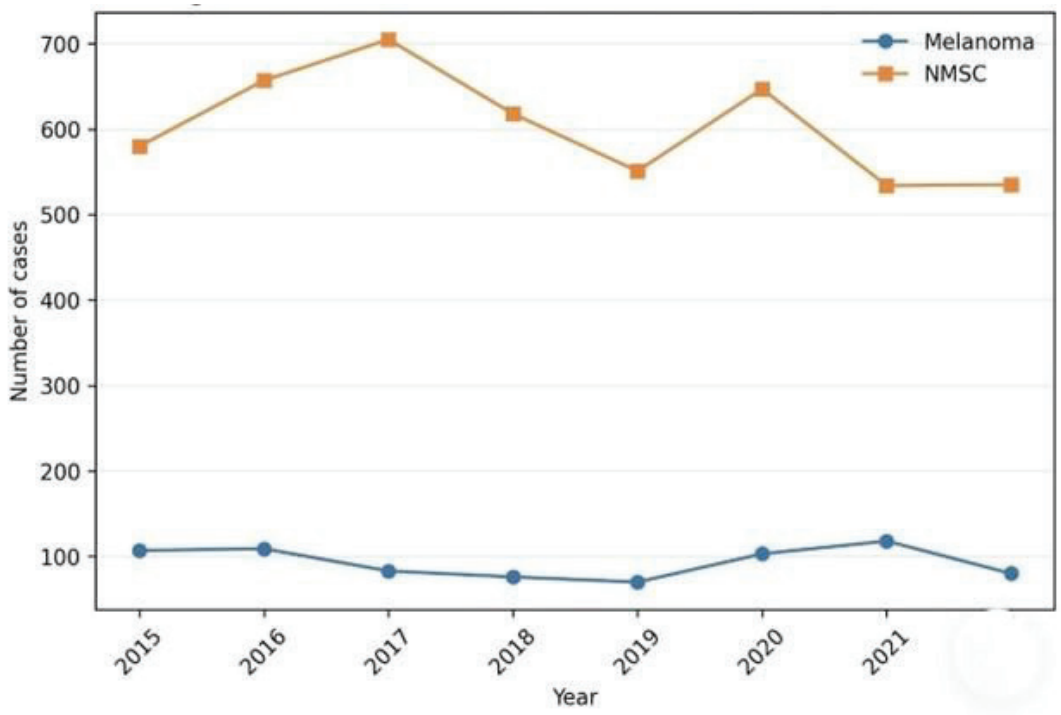

Figure 7. Melanoma versus non-melanoma skin cancer (NMSC) incidence trends, Sri Lanka, 2015–2022. Comparative annual incidence trends of melanoma and non-melanoma skin cancers in Sri Lanka. NMSC incidence substantially exceeded melanoma incidence throughout the study period and demonstrated a stronger temporal increase. However, melanoma remains biologically more aggressive despite a lower incidence.

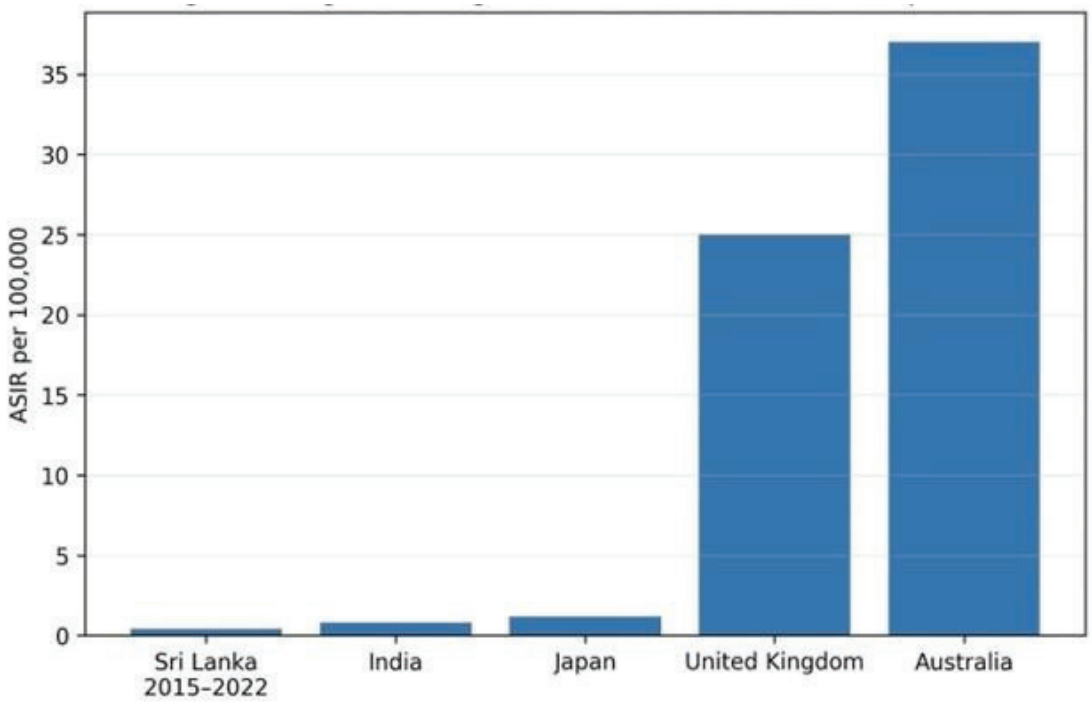

Figure 8. Regional and global comparison of melanoma incidence rates. Comparison of melanoma age-standardised incidence rates (ASIRs) between Sri Lanka and selected regional and global populations. Sri Lanka demonstrated markedly lower melanoma incidence rates compared with Western countries such as Australia and the United Kingdom. The pattern more closely resembled other Asian populations with low overall melanoma burden.

Discussion

This study provides one of the most comprehensive population-based analyses of melanoma epidemiology in Sri Lanka to date. Several major epidemiological observations emerge.

First, melanoma incidence in Sri Lanka remains extremely low compared with Western populations. Second, absolute melanoma burden is gradually increasing despite relatively stable age-adjusted incidence. Third, melanoma demonstrates profound age dependence. Fourth, histological classification remains substantially constrained by NOS coding. Finally, melanoma mortality remains disproportionately high relative to incidence burden.

Low Incidence but Emerging Epidemiological Transition: The low ASIR observed in Sri Lanka aligns with broader South Asian epidemiology.[17] Melanin-mediated ultraviolet protection, darker skin phototypes, and differing recreational ultraviolet exposure patterns likely contribute substantially. However, epidemiological stability should not be interpreted as the absence of transition. Absolute melanoma cases increased progressively during the study period despite stable ASIR. This phenomenon strongly suggests demographic ageing as the principal driver of increasing melanoma burden. This pattern parallels broader LMIC cancer transitions described globally.[18]

Silent Expansion Through Population Ageing: One of the most important findings was the striking age concentration of melanoma burden. Incidence escalated sharply beyond 50 years and peaked among elderly populations. Sri Lanka is currently experiencing rapid demographic ageing with increasing proportions of older adults nationally. Consequently, even stable age-specific incidence rates may generate progressively increasing absolute melanoma burden. This phenomenon may be conceptualized as "silent cancer expansion," whereby demographic restructuring drives increasing oncology workload despite stable standardized incidence. This conceptual framework may become increasingly relevant across multiple malignancies in ageing LMIC populations.

Sex Differences: Male predominance observed in this study parallels international melanoma epidemiology.[19] Potential contributors include cumulative occupational exposure, reduced sunscreen utilization, delayed clinical presentation, and behavioural risk variation. The stronger male predominance observed in older age groups suggests cumulative lifetime exposure effects rather than purely early biological divergence.

Histological Implications: Histological interpretation requires caution because NOS classifications exceeded 80%. This likely reflects limited dermatopathology infrastructure, incomplete immunohistochemistry access, registry coding limitations, and incomplete pathological subclassification. Nevertheless, among specified subtypes, acral lentiginous melanoma and nodular melanoma predominated. This pattern aligns with melanoma epidemiology observed in Asian and African populations.[20]

Acral Lentiginous Melanoma: Acral melanoma demonstrates a weaker ultraviolet association and is proportionally more frequent among darker-skinned populations.[21] Its relative prominence in Sri Lanka, therefore, supports ethnicity-associated biological variation.

Nodular Melanoma: Nodular melanoma is clinically important because it demonstrates rapid vertical growth, greater Breslow thickness, and worse prognosis. Its substantial representation may indicate delayed diagnosis and advanced disease presentation.

Mortality and MIR: The persistently elevated MIR observed in Sri Lanka represents one of the most clinically important findings. MIR serves as a useful population-level proxy for survival, diagnostic effectiveness, healthcare access, and treatment availability. The MIR observed in Sri Lanka remained substantially higher than values reported in Australia and Western Europe.[22] Potential explanations include delayed diagnosis, lower public awareness, restricted dermatopathology access, and limited immunotherapy availability. Thus, despite low incidence, melanoma may still produce a substantial mortality burden relative to case numbers.

Melanoma Versus NMSC: NMSC incidence exceeded melanoma nearly sixfold. However, incidence alone does not fully reflect the oncological burden. Melanoma possesses substantially greater metastatic potential and lethality compared with keratinocyte malignancies. The statistically significant increase in NMSC incidence likely reflects aging, cumulative ultraviolet exposure, improving dermatological diagnosis, and enhanced pathology recognition.

Diagnostic Awareness: Several public health implications emerge. Melanoma may remain under-recognized clinically in darker-skinned populations. Educational initiatives should emphasize acral lesions, nodular lesions, amelanotic melanoma, and elderly skin lesions.

Pathology Infrastructure: Improving dermatopathology services is critically important. Enhanced histological subclassification would improve epidemiological interpretation, treatment planning, registry precision, and research quality.

Future Burden: Population ageing suggests melanoma burden may continue increasing in the coming decades despite low standardized incidence. Sri Lankan healthcare systems should therefore anticipate increasing demand for dermatological oncology, pathology services, and systemic therapy.

Strengths: Major strengths of the study include its nationwide population-based design, longitudinal 8-year analysis, integration of incidence, mortality, histology, and comparative oncology, inclusion of MIR analysis, and its regional and global contextualization.

Limitations

Several limitations should be acknowledged, including the dependency of registry studies on reporting completeness, the high proportion of "not otherwise specified" (NOS) cases limiting histological precision, and the omission of stage, survival, and anatomical lesion-site data; however, despite these constraints, this study provides important national epidemiological insight into melanoma evolution in an LMIC setting.

Conclusion

Cutaneous melanoma in Sri Lanka remains a low-incidence malignancy compared with Western populations but demonstrates progressive absolute expansion characterized by strong age dependence, male predominance, elevated MIR, and evolving histological recognition. The divergence between increasing crude burden and stable ASIR suggests demographic ageing rather than a substantial increase in melanoma risk as the principal driver of melanoma transition. Persistent high MIR values and substantial NOS histological classification indicate ongoing healthcare and pathological limitations. These findings suggest Sri Lanka may be entering an early epidemiological transition in melanoma burden within the broader framework of LMIC cancer evolution.

Ethics Statement

Publicly available aggregated data is used without individual patient identifiers.

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