Global Burden of Cutaneous Melanoma in 2020 and Projections to 2040

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**IMPORTANCE** Despite many cases being preventable, cutaneous melanoma remains the most serious skin cancer worldwide. Understanding the scale and profile of the disease is vital to concentrate and reinforce global prevention efforts.

**OBJECTIVE** To examine global patterns of cutaneous melanoma in 2020 and to provide projected estimates of cases and deaths by 2040.

**DESIGN, SETTING, AND PARTICIPANTS** This population-based study used the GLOBOCAN 2020 database for global epidemiological assessment of new cases and deaths due to invasive melanoma.

**MAIN OUTCOMES AND MEASURES** Age-standardized incidence and mortality rates were calculated per 100 000 person-years by country, world region, and 4-tier level of human development. Estimated numbers of cases and deaths were calculated for the year 2040.

**RESULTS** A worldwide total of 325 000 new melanoma cases (174 000 males, 151 000 females) and 57 000 deaths (32 000 males, 25 000 females) was estimated for 2020. Large geographic variations existed across countries and world regions, with the highest incidence rates among males (42 per 100 000 person-years) and females (31 per 100 000 person-years) observed in Australia/New Zealand, followed by Western Europe (19 per 100 000 person-years for males and females), North America (18 per 100 000 person-years for males, 14 per 100 000 person-years for females), and Northern Europe (17 per 100 000 person-years for males, 18 per 100 000 person-years for females). Melanoma continued to be rare in most African and Asian countries, with incidence rates commonly less than 1 per 100 000 person-years. Mortality rates peaked at 5 per 100 000 person-years in New Zealand, and geographic variations were less pronounced than for incidence. Melanoma was more frequent among males than females in most world regions. If 2020 rates continue, the burden from melanoma is estimated to increase to 510 000 new cases (a roughly 50% increase) and to 96 000 deaths (a 68% increase) by 2040.

**CONCLUSIONS AND RELEVANCE** This epidemiological assessment suggests that melanoma remains an important challenge to cancer control and public health globally, especially in fair-skinned populations of European descent.

With more than 1.5 million new cases estimated in 2020, skin cancers are the most commonly diagnosed group of cancers worldwide. Malignant melanomas (hereafter melanoma) account for approximately 1 in 5 of these cancers, with approximately 325 000 cases estimated globally in 2020. Historically a rare disease, melanoma incidence rates have been increasing during the last 50 years in fair-skinned populations of European ancestry. Much of this increase is likely due to increased exposure of vulnerable populations to UV radiation, a strong and ubiquitous risk factor for melanoma, emitted naturally by the sun but also from artificial sources. According to recent global estimates, more than three-quarters of all newly diagnosed melanoma cases can be attributed to UV radiation.

Although the risk of melanoma generally increases with age and incidence is greater among older populations, melanoma is among the most common cancers in young adults. Incidence rates have stabilized or decreased among recent birth cohorts in a few countries, such as Australia and the US. The reasons for these decreases in incidence are still debated and are likely associated with a combination of changes in lifestyle and social behavior, ethnic heterogeneity, and population admixture (ie, in which previously diverged or isolated genetic lineages mix). Yet with generational increases in...
melanoma incidence reported in most other high-risk populations and uniform increases observed in older age groups, the rates and number of melanoma diagnoses are projected to increase in the coming decades,\(^8,^9\) emphasizing the urgent need for targeted melanoma control measures.\(^7\) In parallel, mortality rates have continued increasing in high-incidence populations, with case fatality depending greatly on melanoma thickness at diagnosis.\(^8,^10\)

Herein, we examine the global burden of cutaneous melanoma in 2020 based on the GLOBOCAN estimates of cancer incidence and mortality produced by the International Agency for Research on Cancer (IARC). We describe the variations in the magnitude and distribution of the disease geographically for the year 2020 and estimate the future burden in 2040.

**Methods**

The numbers of new cases and deaths from invasive melanoma of the skin (International Statistical Classification of Diseases, Tenth Revision code C43) were extracted from the IARC GLOBOCAN 2020 database for 185 countries or territories by sex and 18 age groups (0-4, 5-9, . . . , 80-84, and ≥85 years).\(^11-13\) Corresponding population data for 2020 were extracted from the United Nations website.\(^14\) The data sources and hierarchy of methods used in compiling the cancer estimates have been described in detail elsewhere.\(^11\) In brief, the GLOBOCAN estimates were assembled at the national level using the best available sources of cancer incidence and mortality data within a given country. The methods used to derive the 2020 estimates corresponded to those used for previous years\(^15-17\); where applicable, priority was given to short-term projections and ratios of modeled mortality to incidence, whereas validity was dependent on the degree of representativeness and quality of the source information.\(^14\) Specific details on the data sources and methods used to estimate incidence and mortality in a given country are provided at the IARC Global Cancer Observatory.\(^13\) Data on race and ethnicity were not available. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline. Because the GLOBOCAN project exclusively uses secondary and publicly available data, the IARC Ethics Committee deemed that no ethical approval was required for this study.

We present a table and figures showing the estimated numbers of new cases and deaths, crude incidence and mortality rates, and 2 summary measures using direct standardization, namely, the age-standardized (incidence or mortality) rate per 100 000 person-years based on the 1966 Segi World standard population\(^18\) adapted by Doll et al\(^19\) and the cumulative risk of developing or dying of cancer before 75 years of age expressed as a percentage, assuming the absence of competing causes of death.\(^20\) These measures allow for comparisons between populations adjusted for differences in age structures. We also provided a simple estimate of the future number of melanoma cases and deaths worldwide for the year 2040, based on demographic projections and scenarios of uniformly increasing, stable, or decreasing rates annually from the baseline year of 2020.

The results are presented by country, and aggregated, across 20 world regions as defined by the United Nations\(^14\) and according to the 4-tier Human Development Index (HDI) put forth by the United Nations in 2020.\(^21\) The latter is a means to assess the cancer burden at varying levels of development (low, medium, high, and very high HDIs). Throughout the article, we use the terms transitioning, emerging, and lower HDI countries/economies as synonyms for nations classified as low or medium HDI and the terms transitioned or higher HDI countries/economies for nations classified as high or very high HDI. All data were analyzed using R software, version 4.0.2 (R Foundation for Statistical Computing).

**Results**

In 2020, an estimated 325 000 persons (174 000 males, 151 000 females) worldwide were diagnosed as having melanoma, and approximately 57 000 persons (32 000 males, 25 000 females) died of the disease. Of all newly diagnosed cases in 2020, 259 000 (79.7%) were persons older than 50 years of age, and of all deaths in 2020, 50 000 persons (87.7%) were older than 50 years of age. The Table gives the number of newly diagnosed melanoma cases and deaths, the incidence and mortality age-standardized rate, and the cumulative risk of developing and dying of melanoma by world region and sex. The highest incidence rates for both males (42 per 100 000 person-years) and females (31 per 100 000 person-years) were observed in Australia/New Zealand, followed by Western Europe (19 per 100 000 person-years for males and females), North America (18 per 100 000 person-years for males, 14 per 100 000 persons for females) and Northern Europe (17 per 100 000 person-years for males, 18 per 100 000 person-years for females). The lowest incidence rates occurred in most regions of Africa and Asia, with rates less than 1 per 100 000 person-years (except for Middle and Southern Africa as well as Western Asia). The highest mortality rates (4 per 100 000 person-years for males, 2 per 100 000 person-years for females) were observed in Australia/New Zealand, whereas rates in most other world regions were much lower, ranging between 0.2-1.0 per 100 000 person-years.
Table. Melanoma Incidence and Mortality in 2020 by Sex, World Region, and HDI Level

<table>
<thead>
<tr>
<th>Region</th>
<th>Population No. (%), in thousands</th>
<th>Incidence Cases, No. (%)</th>
<th>Mortality Deaths, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern</td>
<td>445 406 (5.7)</td>
<td>2056 (0.6)</td>
<td>735 (0.6)</td>
</tr>
<tr>
<td></td>
<td>593 (0.7)</td>
<td>506 (0.6)</td>
<td>490 (0.4)</td>
</tr>
<tr>
<td>Middle</td>
<td>179 595 (3.3)</td>
<td>1099 (0.3)</td>
<td>478 (0.4)</td>
</tr>
<tr>
<td>Northern</td>
<td>246 233 (3.2)</td>
<td>968 (0.3)</td>
<td>968 (0.3)</td>
</tr>
<tr>
<td>Southern</td>
<td>67 504 (0.9)</td>
<td>1885 (0.6)</td>
<td>968 (0.3)</td>
</tr>
<tr>
<td>Western</td>
<td>401 861 (5.2)</td>
<td>955 (0.3)</td>
<td>337 (0.2)</td>
</tr>
<tr>
<td>Caribbean</td>
<td>43 532 (0.6)</td>
<td>414 (0.1)</td>
<td>232 (1.1)</td>
</tr>
<tr>
<td>America</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>179 670 (2.3)</td>
<td>2452 (0.8)</td>
<td>1199 (1.4)</td>
</tr>
<tr>
<td>South</td>
<td>430 760 (5.5)</td>
<td>16 015 (4.9)</td>
<td>7802 (3.7)</td>
</tr>
<tr>
<td>North</td>
<td>368 870 (4.7)</td>
<td>105 172 (32.4)</td>
<td>61 675 (33.8)</td>
</tr>
<tr>
<td>Eastern Asia</td>
<td>1 678 090 (21.5)</td>
<td>10 427 (3.2)</td>
<td>5414 (0.6)</td>
</tr>
<tr>
<td>All but China</td>
<td>230 620 (3.0)</td>
<td>2713 (0.8)</td>
<td>1329 (1.2)</td>
</tr>
<tr>
<td>China</td>
<td>1 447 470 (18.6)</td>
<td>7714 (2.4)</td>
<td>4085 (0.6)</td>
</tr>
<tr>
<td>South-Eastern Asia</td>
<td>668 620 (8.6)</td>
<td>3275 (1.0)</td>
<td>1742 (0.5)</td>
</tr>
<tr>
<td>South Central Asia</td>
<td>2 014 709 (25.8)</td>
<td>6232 (1.9)</td>
<td>3312 (0.3)</td>
</tr>
<tr>
<td>All but India</td>
<td>634 704 (8.1)</td>
<td>2316 (0.7)</td>
<td>1264 (0.4)</td>
</tr>
<tr>
<td>India</td>
<td>1 380 004 (17.7)</td>
<td>3916 (1.2)</td>
<td>2048 (0.3)</td>
</tr>
<tr>
<td>Western Asia</td>
<td>278 429 (3.6)</td>
<td>3819 (1.2)</td>
<td>1922 (1.3)</td>
</tr>
<tr>
<td>Europe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central-Eastern</td>
<td>293 013 (3.8)</td>
<td>27 993 (8.6)</td>
<td>12 191 (8.8)</td>
</tr>
<tr>
<td>Northern</td>
<td>106 261 (1.4)</td>
<td>33 551 (10.3)</td>
<td>16 937 (32.3)</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Region</th>
<th>Population No. (%), in thousands</th>
<th>Incidence Both sexes</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Mortality Both sexes</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern</td>
<td>1,514,23 (2.0)</td>
<td>23,915 (7.4)</td>
<td>12,436</td>
<td>16.6</td>
<td>9.2</td>
<td>0.99</td>
<td>11,479</td>
<td>14.6</td>
<td>8.9</td>
<td>0.88</td>
<td>4,926</td>
</tr>
<tr>
<td>Western</td>
<td>1,96,146 (2.5)</td>
<td>65,168 (20.1)</td>
<td>34,745</td>
<td>36.1</td>
<td>19.4</td>
<td>2.11</td>
<td>30,423</td>
<td>30.5</td>
<td>18.9</td>
<td>1.89</td>
<td>74,15 (13.0)</td>
</tr>
<tr>
<td>Australia/New Zealand</td>
<td>30,322 (0.4)</td>
<td>18,972 (5.8)</td>
<td>11,003</td>
<td>73.0</td>
<td>41.6</td>
<td>4.67</td>
<td>7,969</td>
<td>52.2</td>
<td>30.5</td>
<td>3.29</td>
<td>1,880 (3.3)</td>
</tr>
<tr>
<td>Melanesia</td>
<td>11,123 (0.1)</td>
<td>240 (0.1)</td>
<td>109</td>
<td>1.9</td>
<td>3.0</td>
<td>0.28</td>
<td>131</td>
<td>2.4</td>
<td>3.4</td>
<td>0.38</td>
<td>64 (0.1)</td>
</tr>
<tr>
<td>Micronesia/Polynesia</td>
<td>1233 (&lt;0.1)</td>
<td>27 (0.0)</td>
<td>14</td>
<td>2.2</td>
<td>2.2</td>
<td>0.26</td>
<td>13</td>
<td>2.1</td>
<td>2.0</td>
<td>0.21</td>
<td>5 (0.0)</td>
</tr>
<tr>
<td>HDI</td>
<td>Low</td>
<td>990,175 (12.7)</td>
<td>3728</td>
<td>1538</td>
<td>0.3</td>
<td>0.7</td>
<td>0.08</td>
<td>2,190</td>
<td>0.4</td>
<td>0.8</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>2,327,556 (29.9)</td>
<td>7,121</td>
<td>3,629</td>
<td>0.3</td>
<td>0.3</td>
<td>0.04</td>
<td>3,492</td>
<td>0.3</td>
<td>0.3</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>2,909,468 (37.3)</td>
<td>35,597</td>
<td>17,517</td>
<td>1.2</td>
<td>1.0</td>
<td>0.10</td>
<td>18,080</td>
<td>1.3</td>
<td>0.9</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Very high</td>
<td>1,564,286 (20.1)</td>
<td>277,993</td>
<td>151,055</td>
<td>19.5</td>
<td>11.2</td>
<td>1.25</td>
<td>126,938</td>
<td>16.1</td>
<td>9.7</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>World</td>
<td>7,794,799 (100)</td>
<td>324,635</td>
<td>173,844</td>
<td>4.4</td>
<td>3.8</td>
<td>0.42</td>
<td>150,791</td>
<td>3.9</td>
<td>3.0</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Abbreviations: ASR, age-standardized rate per 100,000 person-years; HDI, Human Development Index. Cumulative risk of developing or dying of melanoma until 74 years of age in 2020.
Figure 1 presents the distribution of incident melanoma cases and deaths in 2020 across world regions. With 150,672 cases, close to half the global melanoma cases occurred in Europe (46.4%), followed by North America (32.4%). Most melanoma deaths were observed in Central and Eastern Europe (16.3%), followed by North America (14.7%) and Western Europe (13.0%). Although 5.9% of all melanoma cases occurred in Oceania, the continent’s share of melanoma deaths was about half that (i.e., 3.4% of global deaths). This is in contrast to Asia, where 7.3% of all cases but 21.0% of all deaths occurred, and to Africa, which contributed 2.1% of cases yet had 4.7% of global melanoma deaths.

Worldwide, melanoma was more common in males (174,000 cases) than in females (151,000 cases). A male predominance in incidence was consistently observed across world regions, apart from Eastern and Western Africa as well as Northern Europe and Melanesia, where rates of melanoma in females exceeded those observed in males. The cumulative risk of developing melanoma was highest in Australia/New Zealand, with approximately 1 in 20 males and 1 in 30 females being affected by 75 years of age (Table). The corresponding cumulative risk of dying of melanoma before 75 years of age in Australia/New Zealand was 1 in 280 males and 1 in 555 females.

At the national level, estimated incidence varied by more than 36-fold (from 36 per 100,000 person-years in Australia to fewer than 1 per 100,000 person-years in many African and Asian countries), and mortality varied by more than 5-fold (from 5 per 100,000 person-years in New Zealand to less than 1 per 100,000 person-years in many African and Asian countries) (Figure 2). Variations in incidence were also marked across countries in high-risk world regions. For example, in Western Europe, incidence rates ranged from 14.2 per 100,000 person-years among females and 13.2 per 100,000 person-years among males in Austria, through to 27.4 per 100,000 person-years among females and 27.1 per 100,000 person-years among males in the Netherlands. In Northern Europe, they ranged from 5.9 per 100,000 person-years among females and 7.3 per 100,000 person-years among males in Latvia to 33.6 per 100,000 person-years among females and 26.2 per 100,000 person-years among males in Denmark (eFigure 1 and eFigure 2 in the Supplement). Mortality from melanoma was relatively more...
similar across world regions (eFigure 3 and eFigure 4 in the
Supplement).

In 2020, melanoma incidence rates were approximately 10
times as high in very high HDI countries than in low HDI
countries; however, this gap was only 3- to 5-fold for a similar
comparison of mortality rates. A strong gradient across human
development level was observed for melanoma incidence. In
terms of absolute cases and deaths, 85.6% of all melanoma
cases and 67.2% of all melanoma deaths worldwide occurred
in very high HDI countries (Table).

The number of newly diagnosed cases of melanoma was es-
timated to increase by more than 50% by 2040, to 510 000. Simi-
larly, melanoma deaths were estimated to increase by approxi-
ately 68%, from 57 000 in 2020 to 96 000 in 2040, assuming
rates in 2020 remained stable (Figure 3). These projections were
calculated solely by assuming changes in world population size
and age structure and did not account for possible changes in age-
specific incidence globally or within countries. Decreases in in-
cidence and mortality rates would need to be greater than 2% glob-
ally to ensure there would be fewer melanoma cases in 2040 than
there were in 2020.

Discussion
This population-based epidemiological study found that
melanoma constituted a considerable cancer burden in 2020 and
was largely concentrated in highly developed countries, predomi-
nantly inhabited by people of European origin, with lighter skin pigmentation and therefore higher
risk and higher susceptibility to the carcinogenic effects of
solar radiation. There were marked geographic variations in
incidence and mortality rates across countries and world
regions, with the highest incidence observed in the fair-
skinned populations of Australia/New Zealand, Western and
Northern Europe (such as Denmark, Norway, and the Neth-
erlands), and North America. By contrast, melanoma
remained rare in most parts of Africa, South and Central
America, and Asia. With mortality rates peaking at 5 per 100,000 person-years in New Zealand, geographic differences in mortality were similar, but with lower rates and less between- and within-region variability. Yet the global share of deaths relative to cases remained disproportionately high in Asia and Africa compared with other world regions.

Exposure to UV radiation is the most important risk factor for melanoma and nonmelanoma skin cancers, as it has been shown to lead to carcinogenic mutations and the suppression of certain aspects of the immune system. Evidence from both epidemiological and mechanistic studies support this evaluation, with continuous increases in skin cancer incidence reported over time and across populations. Historically a rare disease, the incidence of melanoma has been increasing progressively for several decades. The magnitude of incidence and the rate of increase varies considerably across populations, ethnic groups, and geographic locations, and even within populations across age and sex. Different patterns in incidence rates depending on latitude and north-south gradients have been observed in several countries and world regions. Although melanoma rates continue to increase in most European countries, rates in North America and Oceania appeared to have leveled off in recent years. Temporal variations in melanoma incidence in high-risk populations are associated with a strong cohort effect, with rates stabilizing or decreasing among recent generations in some countries. In Australia, the country with the highest melanoma incidence rates worldwide, more than 95% of all melanoma cases have been attributed to high ambient levels of UV radiation exposure. Melanoma incidence in Australia has been decreasing since 2005 (by ~0.7% per year), attributable to multiple converging forces, including secular changes in outdoor activity, nationwide changes, and targeted prevention activities (eg, mass media campaigns, sun-safe policies, supportive environments such as shade, and availability of sun-protection products). In addition, there is evidence that the proportion of people with fair pigmentation who are highly susceptible to melanoma is diminishing over time. Incidence rates in New Zealand increased until the early 2010s but are projected to decrease in the future. Although the incidence and mortality levels were much lower outside of Australia/New Zealand, North America, and Europe, important heterogeneity in patterns and trends were also observed across populations in low-incidence regions, such as in South and Central America. Even with such diverse temporal patterns by birth cohort and age in different populations in each world region, we noted that a global decrease in rates of greater than 2.0% annually would be needed to ensure that there are fewer melanoma cases in 2040 than there were in 2020.

The markedly lower incidence rates in darker-skinned populations have been associated with protective phenotypes related to UV radiation sensitivity, such as pigmented skin types and few freckles, as well as other associated factors, including number of atypical nevi or sunbathing behavior. People of European origin typically have a much higher risk of developing skin cancer, which is partly attributable to decreased photoprotection from lower levels of melanin in the epidermis and higher proportions of pheomelanin rather than eumelanin. With an estimated 10% of cutaneous melanomas occurring in familial settings, the risk of melanoma is also influenced by genetics. Substantial advances in molecular and genetic research in recent years have led to an improved characterization of gene mutations associated with melanoma. For example, an estimated 35% to 40% of familial melanomas have been linked to mutations in the 2 main highly penetrant genes associated with melanoma (CDKN2A/p16 and CDK4). Furthermore, common variants causing loss of function of the human melanocortin-1 receptor gene (MCIR), which plays a crucial role in human skin and hair pigmentation, have been found to increase the risk of developing melanoma as have numerous other genes involved in pigmentation, nevus, and telomere length pathways. The reason melanoma rarely affects fair-skinned individuals of East Asian descent remains largely unknown.

Melanoma is more common in men than in women in most parts of the world. This, however, differs by age, with rates in women exceeding those in men before 50 years of age. Sex differences also exist with respect to the anatomic localization of the
lesion; melanoma is more frequent on the trunk in men and on the lower limbs in women. The reasons for this are still poorly understood, and it remains to be uncovered how much of the melanoma development can be attributed to gender role-specific behaviors or to biologically intrinsic differences, notably the role of sex hormones. In addition, in terms of age-specific incidence patterns, melanoma is particular, following a bimodal distribution with a peak at younger ages for melanomas arising on less exposed sites (eg, trunk, limbs) and a peak at older ages for melanomas arising on more exposed sites (eg, ears, face, neck, and scalp in men). In fact, melanoma is not uncommon even among patients younger than 30 years and is one of the most common cancers in young adults, especially young women.

Despite being largely preventable, melanoma is the most serious skin cancer owing to its high potential for metastasis. Mortality rates were highest in New Zealand and Australia, reflecting the high burden and increasing incidence of melanoma in many high-income countries. Yet although most transitioning countries carry a relatively low burden of melanoma cases, their share of melanoma deaths is often disproportionate, for example, in most parts of Asia and Africa, most likely owing to higher case fatality. Surviving melanoma depends on the sex of the patient (superior female survival), subtype (eg, acral lentiginous melanomas—unrelated to UV radiation exposure and representing a higher proportion of melanomas diagnosed in darker-skinned populations—have a generally poor prognosis), tumor thickness, body site, and, most importantly, stage at diagnosis. Five-year survival estimates range between 60% and 90% in most parts of the world and exceed 90% in several high-income (and high-incidence) countries, such as the US, parts of Europe, Australia, and New Zealand, in which skin cancer awareness and clinical skin checks are more common. In line with this, a lower Breslow thickness at diagnosis and thus higher incidence of tumors with good prognosis have been reported in those countries. By contrast, outcomes are estimated to be poorer in low- and middle-income settings. A rapid decrease in mortality rates for melanoma has been documented in the US by 6.4% per year since 2013 through 2017 after the introduction of new therapies, including immune checkpoint inhibitors and targeted therapies for metastatic melanoma. Yet there are still a high number of deaths from thin melanomas in both Australia and the US, reinforcing the importance of prevention and early detection in high-income settings.

Limitations

There are important limitations in this study. The numbers and rates presented are estimates based on the best available data from population-based cancer registries that have been thoroughly reviewed. Yet some caution is warranted when interpreting the findings, especially for countries in which estimates were based on proxy data (eg, rates from neighboring countries). It is also likely that the incidence of melanoma was underreported in some parts of the world because of either lack of diagnostic facilities or a lack of reporting cases treated in outpatient settings. Given those prospects of underdiagnosis and incomplete registration, underestimation of cases and deaths in some populations therefore cannot be wholly discounted. These artifacts may be counterbalanced by overreporting and increasing detection of thin melanomas, as reported in high-income settings, as a result of increased diagnostic scrutiny. Supporting this hypothesis and despite stabilizing or decreasing incidence rates among recent birth cohorts in some populations at high risk, data from the US show melanoma incidence rates increasing by up to 6% per year for several decades, while mortality rates have remained constant or decreased, possibly due to overdiagnosis. The implementation of skin cancer screening programs and improved detection technologies as well as increasing awareness in the population have likely influenced these temporal patterns. Skin cancer screening programs in Germany and other countries have been shown to have inflated incidence, with only limited evidence of benefits resulting from screening or decreased mortality. Increasing incidence rates in the UK, which were steepest for stage I tumors, could be attributed to both a genuine increase in risk but also some degree of overdiagnosis. The extent to which melanoma current and future incidence and mortality trends might be associated with overdiagnosis warrants further study and should ideally be based on tumor thickness or stage at diagnosis.

The GLOBOCAN estimates did not reflect the effect of the COVID-19 pandemic because they were based on extrapolations of cancer data collected in earlier years. Although we found a positive association between melanoma incidence and HDI (as a proxy for affluence), it is important to reiterate that this association did not account for confounding by skin color and differing distributions of pigmentation in the populations of interest. In consequence, associations between melanoma mortality and HDI were attributable in part to higher background incidence levels in the same countries. Future analyses by race or ethnicity (or ideally skin color and type) are crucial to disentangle these associations.

We age-adjusted incidence and mortality rates to allow for fair comparisons across populations. As a relative measure, the world standard population was used for consistency and continuity, although some differences in the absolute ranking of age-adjusted melanoma rates may occur were another standard used, particularly in high-incidence countries, where the present age structures were quite different from that of the applied standard population. The crude rates (as provided in the Table) remain of relevance in measuring the “load” of the melanoma burden in a given population.

The future projections were estimated based on the assumption that incidence and mortality rates will remain unchanged between 2020 and 2040. The difference in the current and future burden of melanoma presented here was therefore solely attributable to projected national demographic changes (population growth and aging) and did not account for national or within-country temporal variations. More detailed and accurate prediction exercises, such as those based on age-period-cohort modeling, will require high-quality long-term data, ideally augmented with other information on risk factors, interventions, and population composition, which are lacking in many world regions at present. In addition, highly developed countries appear to be entering a transition phase with respect to deaths from melanoma; the advent of new immune therapies and targeted therapies since the mid-2010s is already leading to...
Global Burden of Cutaneous Melanoma in 2020 and Projections to 2040

Conclusions
Melanoma is the most lethal form of skin cancer; this epidemiological assessment found a heavy public health and economic burden, and our projections suggest that it will remain so in the coming decades. Although marked geographical variations remain, melanoma continues to mainly affect fair-skinned populations of European descent residing in high-income countries. In addition, the global share of melanoma deaths was disproportionally high in Asia and Africa compared to other world regions. Despite the increasing global melanoma burden, many cases and deaths may be averted through effective public health measures that target primary prevention and early detection combined with curative treatment.

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ARTICLE INFORMATION
Accepted for Publication: January 16, 2022.
Published Online: March 30, 2022.
doi:10.1002/ijd.27616

Author Contributions: Dr Arnold had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of Interest Disclosures: Dr Cust reported receiving a fellowship from the Australian National Health and Medical Research Council (NHMRC) outside the submitted work. Dr de Vries reported receiving personal fees from Angen outside the submitted work. Dr Whiteman reported receiving salary support and competitive grants from the Australian NHMRC during the conduct of the study. No other disclosures were reported.

Funding/Support: Dr Cust is supported by a Career Development Fellowship (1147843) from the Australian NHMRC.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; and the decision to submit the manuscript for publication.

Disclaimer: Where authors are identified as personnel of the International Agency for Research on Cancer/World Health Organization, the authors alone are responsible for the views expressed in this article, and they do not necessarily represent the decisions, policy, or views of the International Agency for Research on Cancer/World Health Organization.

Additional Information: All data are publicly available and accessible through the Global Cancer Observatory (https://gco.iarc.fr/today/home).

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Etiologic and other factors predicting high-risk melanoma susceptibility genes and melanoma across GenoMEL.


