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The Burden of Plastic Surgery Related Disease in Canada: A Perspective Based on the 2019 Global Burden of Disease Study

Morbidité des troubles liés à la chirurgie plastique au Canada : perspective basée sur l'étude mondiale 2019 de morbidité des maladies

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Abstract

Purpose: Identifying the burden of disease related to plastic and reconstructive surgery in Canada will provide timely population-based data, inform policy, and generate support for research funding. **Methods and Patients:** Data on the burden of disease (ie, prevalence, incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life years [DALYs]), were extracted from the Global Burden of Disease 2019 results tool for all available and relevant plastic surgery diseases. The economic burden of disease in Canadian dollars was calculated based on prior studies. Data are presented as either rates (per 100 000) or counts with the associated uncertainty interval. **Results:** In 2019, plastic surgery related conditions in Canada had an overall age-standardized DALY rate of 556 per 100 000 [463-664]. Of these conditions, breast cancer was responsible for approximately 50% of the overall burden of disease, with an age-standardized DALY rate of 268 per 100 000 [244-294] followed by squamous cell carcinoma (66 per 100 000 [45-94]) and thermal burns (61 per 100 000 [46-82]). Age-standardized incidence rates were highest for cellulitis (2654 per 100 000 [2502-2812]). Breast cancer had the highest age-standardized cost of care of all plastic surgery related diseases, at $5.1 billion, approximately half of the total age-standardized cost of $10.6 billion for included plastic surgery diseases. **Conclusion:** Plastic and reconstructive surgery related diseases, particularly breast cancer, thermal burns, and malignant melanoma, are responsible for a high burden of disease and significant cost to the Canadian healthcare system. These results will help guide national healthcare policy and should provide support to directing funding and research efforts toward impactful diseases facing the Canadian healthcare system.

Résumé

Objectif: L'identification de la morbidité des maladies liées à la chirurgie plastique et reconstructrice au Canada fournira des données en temps opportun reposant sur la population, permettra de renseigner les politiques et générer un soutien pour le financement de la recherche. **Méthodes et patients:** Des données sur la morbidité des maladies (c.-à-d. prévalence, incidence,

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mortalité, années de vie perdues [YLL], années vécues avec une invalidité [YLD], et années de vie corrigées pour l'invalidité [AVCI ou DALY]) ont été extraites de l'outil de résultats sur la morbidité mondiale des maladies 2019 pour toutes les affections disponibles et pertinentes pour la chirurgie plastique. Le poids économique de la maladie en dollars canadiens (CAD) a été calculé sur la base d'études antérieures. Les données sont présentées sous forme de taux (pour 100 000) ou de nombres avec les intervalles d'incertitude (Idl) associés. **Résultats:** En 2019, les troubles liés à la chirurgie plastique au Canada avaient un taux d'AVCI global standardisé pour l'âge de 556 pour 100 000 (463-664). Parmi ces affections, le cancer du sein était responsable d'environ 50% du fardeau global de la maladie avec un taux d'AVCI standardisé pour l'âge de 268 pour 100 000 (244-294) suivi du cancer épidermoïde (carcinome à cellules squameuses) (66 pour 100 000 [45-94]) et des brûlures thermiques (61 pour 100 000 [46-82]). Les incidences standardisées pour l'âge étaient les plus élevées pour la cellulite (2 654 pour 100 000 [2 502-2 812]). Le cancer du sein avait le coût des traitements standardisé pour l'âge le plus élevé de toutes les maladies liées à la chirurgie plastique, avec 5,1 milliards de dollars, soit environ la moitié des dépenses totales standardisées pour l'âge de 10,6 milliards de dollars pour les maladies incluses liées à la chirurgie plastique. **Conclusion:** Les maladies liées à la chirurgie plastique et reconstructrive, et plus particulièrement le cancer du sein, les brûlures thermiques et le mélanome malin, sont responsables d'une importante morbidité et de coûts significatifs pour le système de santé canadien. Ces résultats aideront à guider la politique nationale de soins de santé et devraient fournir un soutien pour orienter le financement et les efforts de recherche vers des maladies ayant les plus grandes répercussions sur le système de soins de santé canadien. **Mots-clés**: chirurgie plastique, morbidité, années de vie corrigées pour l'invalidité, fardeau global de la maladie, coût des soins, morbidité de la maladie.

Keywords
plastic surgery burden, disability-adjusted life years, global burden of disease, cost of care, burden of disease

Introduction

Access to accurate population-level burden of disease data is important for understanding causes of morbidity and mortality. To date, there has not yet been a comprehensive cross-sectional analysis of the morbidity and mortality of plastic and reconstructive surgery related diseases in Canada. Given that disease burden can inform public health policy and direct research funding, understanding the burden of plastic surgery related diseases in Canada is a critical step in advancing patient care.

The Global Burden of Disease Study (GBD) is an international collaboration through the Institute for Health Metrics and Evaluation (IHME) that generates a systematic and internally consistent source of health information.[1-4] This effort enables quantification of comparative health loss categorized by disease pathology, demographics, geographic region, and time.[3-5] The goal of the IHME is to provide an impartial, evidence-based picture of global health trends to inform the work of policymakers, researchers, funding agencies, and to guide population-level health initiatives.

For the Global Burden of Disease Study 2019 (GBD 2019) 369 diseases, including 13 relevant to plastic surgery, were estimated.[3,4,6] In this paper, we present a cross-sectional analysis of the Canadian GBD 2019 results on mortality, morbidity, incidence, prevalence, and economic cost for all 13 diseases related to plastic and reconstructive surgery.

Methods

The goal of the GBD study is to produce the highest quality epidemiologic data by ensuring transparent analytic strategies that include uncertainty distribution. Each update incorporates new studies and methodologies to further refine the available data thereby generating a "living database." The GBD 2019 methodology has been extensively described in the original study publications.[4,6-9]

We used GBD 2019 results to assess the morbidity, mortality, incidence, and prevalence of plastic and reconstructive surgery related diseases in Canada. Rates and numbers of deaths, incident cases and prevalence, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs) are generated for each disease and injury, with each metric reported by year, location, age group, and sex.[4,10] The GBD world standard population is used as a reference for calculating age-standardized YLD, YLL, and DALY rates.[4,11,12] The data is analyzed using a Bayesian meta-regression modelling tool to provide epidemiological estimates of YLLs, YLDs, and DALYs by combining other available parameters.[2,4,10] The width of the uncertainty interval (UI) is calculated through Bayesian estimation methods to reflect data availability, sample size, and consistency of data across multiple sources.[3,4,10]

In this paper, incidence, prevalence, YLLs, YLDs, and DALYs, are reported here for both sexes combined and for all age groups in Canada, as rates per 100 000 and as counts. 95% UI are reported in square brackets for all estimates (except for totals) and includes all sources of uncertainty (ie, systematic biases, measurement error). GBD is conducted in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting.[3,13,14]

Data Sources

The GBD 2019 estimates cover the years 1990 to 2019 and are drawn from more than 90 000 data sources. Data collected for the GBD 2019 is collected from multiple relevant data sources for each disease including vital statistics, disease registries, health service use, and disease notifications—identified from a systematic and thorough review of published studies, searches of government and international organization

websites, published reports, and primary data sources such as surveys and population-based registries.[3,4,12,15-17] For each iteration of GBD, the estimates for the whole time series are updated from the addition of new data and change in methods and based on an analytical framework. The GBD uses the International Classification of Diseases (ICD) for maximum comparability between diseases worldwide. For Canada, disease registries maintained by each province and data from the national census account for the majority of available data. Further information on Canadian data sources can be found online at the Global Health Data Exchange: http://ghdx.healthdata.org/geography/canada.

Classification of Plastic and Reconstructive Surgery Diseases

Data for 13 plastic surgery associated conditions were selected from the GBD 2019. These conditions were defined by the ninth and tenth revision codes of the ICD.[18] The conditions included were as follows: (1) breast cancer, (2) cellulitis, (3) decubitus ulcer, (4) pyoderma, (5) fire, heat and hot substances, (6) malignant skin melanoma, (7) squamous cell carcinoma, (8) basal cell carcinoma, (9) neoplasms of the lip and oral cavity, (10) neoplasms of the nasopharynx, (11) larynx cancer, (12) other pharynx cancer, and (13) orofacial clefts. The treatment of these conditions (especially breast cancer and melanoma) is not solely in the domain of plastic and reconstructive surgery, however, Canadian plastic surgeons contribute significantly to their management. Due to the limitations of the GBD classification it was not possible to select for traumas or upper extremity injuries/diseases—conditions for which plastic surgeons contribute significantly.

Definitions

The IHME defines incidence as the number of new cases of a given disease during a given period in a specific population whereas prevalence is the total number of cases of a given disease in a specific population at a designated time. Outcomes are reported here as both all-age and age-standardized values. Age-standardizing is a statistical technique which transforms the age characteristics of a specific population to match a reference population (ie, GBD 2019 World Standard Population), to allow comparisons with different age structures. All-age rates or counts do not have this correction done and so there are limitations to comparing these results to other populations or other points in time.

Cause of Death

The GBD study attributes cause of death to a single disease that initiated the ultimate cause of death with coding following ICD-10 principles. The GBD cause of death hierarchy is divided into 4 levels: Level 1 represents all-cause mortality, Level 2 represents cause-group mortality (ie renal disease), Level 3 represents cause-specific mortality, and Level 4 represents further specified diseases such as drug-resistant tuberculosis.[19] In this paper, we used Levels 3 and 4 to assess YLLs and mortality for applicable diseases.

Mortality and YLLs

All applicable diseases have age-specific mortality data. The GBD uses the Cause of Death Ensemble model[19] to predict age- and sex-specific mortality estimates by cause. Mortality-to-incidence ratios are used to transform registry incidence data to mortality estimates, in order to maximize data availability in locations with scarce mortality information. YLLs are calculated as a measure of cause-specific premature mortality. Given that the GBD attributes cause of death to a single disease, basal cell carcinoma does not have an attributable mortality rate.

Years Lived With Disability

GBD 2019 uses the Disease Modeling Meta-Regression 2.1 (DisMod-MR 2.1) to calculate prevalence for each disease while considering data on incidence, remission, mortality, and disease duration.[4,9,20] Prevalence estimates gathered by the GBD are multiplied by disability weights to calculate cause-specific YLDs.[4,9]

Disability-Adjusted Life Years

Morbidity is assessed using DALYs which represents the sum of YLLs and YLDs; one DALY is equivalent to 1 year of healthy life lost due to premature mortality or disability.[3,21] In the GBD, DALYs are the preferred metric used to compare disease burden across time and geography and between age and sex groups.

Economic Analysis

Given that the economic health of a nation is correlated to the overall disease burden,[22-24] we assessed the economic cost of disease using DALY rates as described in prior publications.[25,26] With increasing DALYs rates, a country's Gross National Income per capita decreases in a logarithmic fashion.[22] As such, the economic burden of disease can be approximated by accounting for the loss in Gross Domestic Product per capita due to disease-specific DALYs.[27,28]To quantify and compare the costs of adverse health end points, the monetary value of a DALY can be ascertained based on previous analysis.[27,28] While no official consensus of the appropriate value of a DALY has been established, a conversion based on the Value of Life Year has also been suggested.[29] Different economic values of DALYs have been allocated per income country group level, as defined by the World Bank.[30] A cost per DALY was recently estimated as $50,000 for Canada as a whole and is likely to be similar across most provinces.[30] This value can be used to approximate total cost of a disease by multiplying age standardized DALY rates by the Canadian population of 38 million in 2019 according to census data.[31]

Results

Prevalence and Incidence

In 2019, plastic surgery related conditions in Canada had an overall age-standardized incidence rate of 5412 per 100 000 [95% UI 4966-5907] (Table 1), and an overall all-age standardized prevalence rate of 3972 per 100 000 [3258-4823] (Table 2). Cellulitis had the highest incidence with an age standardized rate of 2654 per 100 000 [2502-2812] followed by pyoderma (1525 per 100 000 [1479-1577]). Fire, heat, and other hot substances had the highest age-standardized prevalence rate (1742 per 100 000 [1478-2054]) with a relatively low age-standardized incidence rate of 191 per 100 000 [146-241]. Breast cancer had an age-standardized incidence rate of 47 per 100 000 [37-61] and an age-standardized prevalence rate of 499 per 100 000 [410-607]. The age-standardized incidence rates of non-melanoma skin cancers combined (basal cell carcinoma: 32 per 100 000 [25-40] and squamous cell carcinoma: 828 per 100 000 [662-1019]) had approximately 60 times greater incidence than malignant melanoma (14 per 100 000 [10-18]).

Mortality and YLLs

In 2019, plastic surgery related conditions in Canada had an overall all-age death count of 11,411 [95% UI 9568-12,827] and an age-standardized death rate of 17 per 100 000 [14-19] (Table 3). All-age YLL count was 238,731 [206,951-266,194] and age-standardized YLL rate was 409 per 100 000 [357-457] (Table 4). Breast cancer overwhelmingly contributed to mortality with an age-standardized death rate of 10 per 100 000 [9-11]) and an age-standardized YLL rate of 233 per 100 000 [215-250]. Melanoma was the second largest contributor to mortality with an age-standardized death rate of 2 per 100 000 [1-2] and an age-standardized YLL rate of 53 per 100 000 [38-67]. Of note, melanoma and breast cancer are not solely treated by plastic surgery. Fire, heat, and hot substances, lip and oral cavity cancer, larynx cancer, and cutaneous squamous cell carcinoma also significantly contributed to mortality and YLL in 2019 (Tables 3 and 4). Orofacial clefts had the lowest age-standardized death rate (0 per 100 000 [0-0]) and YLL rate (0 per 100 000 [0-0]).

Years Lived with Disability

In 2019 in Canada, plastic surgery related conditions were responsible for an overall all-age YLD count of 89,397 [95% UI 56,089-134,521] with an age-standardized YLD rate of 147 per 100 000 [92-224] (Table 5). Squamous cell carcinoma had the highest age-standardized YLD rate (54 per 100 000 [33-83]) followed by fire, heat, and hot substances (35 per 100 000 [21-56]) and breast cancer (35 per 100 000 [23-51]).

Disability-Adjusted Life Years

In 2019 in Canada, plastic surgery related conditions were responsible for an overall all-age DALY count of 328 128

Table 1. All-age and Age-standardized Incidence Rates Per 100 000 for Plastic Surgery Related Disease in CANADA From GBD 2019.

	All-age incidence rate [95% UI]	Age-standardized incidence rate [95% UI]
Breast cancer	78 [61-99]	47 [37-61]
Cellulitis	3156 [2973-3326]	2654 [2502-2812]
Decubitus ulcer	204 [181-232]	110 [98-123]
Fire, heat, and hot substances	173 [133-216]	191 [146-241]
Pyoderma	1460 [1419-1506]	1525 [1479-1577]
Malignant skin melanoma	22 [15-29]	14 [10-18]
Basal cell carcinoma	58 [45-74]	32 [25-40]
Squamous cell carcinoma	1600 [1271-1971]	828 [662-1019]
Larynx cancer	4 [3-5]	2 [2-3]
Lip and oral cavity cancer	7 [5-9]	4 [3-5]
Nasopharynx cancer	2 [1-2]	1 [1-2]
Orofacial clefts	1 [1-2]	2 [1-3]
Other pharynx cancer	3 [2-4]	2 [1-2]
Total	**6767 [6111-7475]**	**5412 [4966-5907]**

Table 2. All-age and Age-standardized Prevalence Rates Per 100 000 for Plastic Surgery Related Disease in Canada From GBD 2019.

	All-age prevalence rate [95% UI]	Age-standardized prevalence rate [95% UI]
Breast cancer	847 [703-1018]	499 [410-607]
Cellulitis	120 [113-127]	101 [95-106]
Decubitus ulcer	55 [48-62]	30 [26-33]
Fire, heat, and hot substances	2307 [1945-2732]	1742 [1478-2054]
Pyoderma	79 [77-81]	83 [80-86]
Malignant skin melanoma	173 [119-233]	112 [79-152]
Basal cell carcinoma	8 [6-10]	4 [4-6]
Squamous cell carcinoma	2638 [2038-3337]	1342 [1040-1702]
Larynx cancer	30 [23-36]	17 [13-21]
Lip and oral cavity cancer	29 [22-38]	17 [13-22]
Nasopharynx cancer	12 [8-15]	8 [6-11]
Orofacial clefts	11 [9-14]	13 [10-16]
Other pharynx cancer	8 [6-10]	5 [3-6]
Total	**6316 [5120-7714]**	**3972 [3258-4823]**

Table 3. All-age Death Count and Age-standardized Death Rate Per 100 000 for Plastic Surgery Related Disease in Canada From GBD 2019.

	All-age deaths (count) [95% UI]	Age-standardized death rate [95% UI]
Breast cancer	6565 [5890-7168]	10 [9-11]
Cellulitis	313 [104-418]	0.4 [0.1-0.6]
Decubitus ulcer	54 [20-82]	0.1 [0.0-0.1]
Fire, heat, and hot substances	303 [278-325]	1 [1-1]
Pyoderma	238 [112-364]	0.3 [0.2-0.5]
Malignant skin melanoma	1295 [894-1564]	2 [1-2]
Basal cell carcinoma	-	-
Squamous cell carcinoma	528 [368-584]	1 [1-1]
Larynx cancer	508 [459-556]	1 [1-1]
Lip and oral cavity cancer	1072 [974-1165]	2 [1-2]
Nasopharynx cancer	136 [121-153]	0.2 [0.2-0.3]
Orofacial clefts	0.1 [0.1-0.2]	0.0 [0.0-0.0]
Other pharynx cancer	399 [349-449]	1 [1-1]
Total	**11,411 [9568-12,827]**	**17 [14-19]**

[-]: data not available.

Table 4. All-age YLL Count and Age-standardized YLL Rate per 100 000 for Plastic Surgery Related Disease in Canada From GBD 2019.

	All-age YLLs (count) [95% UI]	Age-standardized YLL rate [95% UI]
Breast cancer	138,252 [127,187-148,865]	233 [215-250]
Cellulitis	4948 [1831-6651]	8 [3-11]
Decubitus ulcer	605 [242-959]	0.8 [0.3-1.3]
Fire, heat, and hot substances	9290 [8662-9954]	26 [23-28]
Pyoderma	3287 [1623-5309]	5 [3-8]
Malignant skin melanoma	29,558 [20,610-36,483]	53 [38-67]
Basal cell carcinoma	-	-
Squamous cell carcinoma	7682 [6121-8340]	11 [9-12]
Larynx cancer	10,278 [9272-11,290]	16 [14-17]
Lip and oral cavity cancer	21,900 [20,069-23,740]	35 [32-38]
Nasopharynx cancer	3672 [3246-4121]	7 [6-8]
Orofacial clefts	11 [6-20]	0.1 [0.0-0.1]
Other pharynx cancer	9246 [8081-10,461]	15 [13-17]
Total	**238,731 [206,951-266,193]**	**409 [357-457]**

[-]: data not available.

[95% UI 270,881-392,439] with an age-standardized DALY rate of 556 per 100 000 [463-664] (Table 6). Breast cancer was responsible for the highest age-standardized DALY rate (268 per 100 000 [244-294]), followed by squamous cell carcinoma (66 per 100 000 [45-94]), fire, heat, and hot substances (61 per 100 000 [46-82]) and malignant skin melanoma (60 per 100 000 [42-75]). Diseases with lower age-standardized DALY rates include basal cell carcinoma (0.02 per 100 000 [0.01-0.04]), orofacial clefts (1 per 100 000 [1-1]), pyoderma (6 per 100 000 [3-9]), and decubitus ulcer (5 per 100 000 [4-7]). Figure 1 illustrates age-separated DALY rates per 100 000, illustrating the relatively higher proportion of DALY's due to the burden from fire, heat, and hot substances injury in ages 0-24, and the subsequent increase in DALY rate of other diseases including breast cancer, skin cancers, and fire, heat, and hot substances injuries.

Economic Analysis

In Canada in 2019, the age-standardized economic burden of included plastic surgery related diseases was $10.6 billion (**Table 7**). Breast cancer was responsible for the largest age standardized cost of $5.1 billion, representing approximately half of the total economic burden for plastic surgery associated diseases. Squamous cell carcinoma was the second largest contributors to age-standardized cost ($1.3 billion) followed by fire, heat, and hot substances ($1.2 billion) and malignant skin melanoma ($1.1 billion).

Discussion

This study presents a comprehensive, cross-sectional analysis on the burden and economic cost of 13 plastic and reconstructive surgery related diseases in Canada for the year 2019. In Canada as of 2019, plastic surgery related diseases are responsible for an overall age-standardized cost of greater than $10 billion Canadian dollars (CAD) and represent 3% of all-age DALYs in Canada. This places plastic surgery related diseases 14th among all-cause, all-age DALYs in Canada, behind disease groups such as neoplasms, cardiovascular disease, and substance use disorders, and ahead of disease groups such as transport injuries, maternal and neonatal disorders, and respiratory infections and tuberculosis. Plastic surgery related diseases are the 16th leading cause of age-standardized DALY rates in Canada in 2019, behind transport injuries and digestive diseases and ahead of sense organ diseases and respiratory infections and tuberculosis. Of the plastic surgery related diseases included in this analysis, breast cancer was responsible for the largest burden of disease and had the highest mortality rates, with an associated cost of $5.1 billion CAD—representing

Table 5. All-age YLD Count and Age-standardized YLD Rate per 100 000 for Plastic Surgery Related Disease in Canada From GBD 2019.

	All-age YLDs (count) [95% UI]	Age-standardized YLD rate [95% UI]
Breast cancer	21,600 [14,425-31,314]	35 [23-51]
Cellulitis	2401 [1606-3406]	6 [4-8]
Decubitus ulcer	3009 [2074-4129]	5 [3-6]
Fire, heat, and hot substances	16,574 [9843-26,572]	35 [21-56]
Pyoderma	161 [64-338]	0.5 [0.2-1.0]
Malignant skin melanoma	3746 [2219-5648]	7 [4-10]
Basal cell carcinoma	12 [5-24]	0.02 [0.01-0.04]
Squamous cell carcinoma	38,797 [23,864-58,573]	54 [33-83]
Larynx cancer	1013 [664-1456]	2 [1-2]
Lip and oral cavity cancer	1043 [675-1519]	2 [1-2]
Nasopharynx cancer	416 [260-620]	0.8 [0.5-1.1]
Orofacial clefts	265 [160-397	1 [1-1]
Other pharynx cancer	359 [230-527]	0.6 [0.4-0.8]
Total	**89,397 [56,089-134,521]**	**147 [92-224]**

Table 6. All-age DALY Count and Age-standardized DALY Rate Per 100 000 for Plastic Surgery Related Disease in Canada From GBD 2019.

	All-age DALYs (count) [95% UI]	Age-standardized DALY rate [95% UI]
Breast cancer	159,852 [144,867-175,827]	268 [244-294]
Cellulitis	7349 [4124-9579]	13 [8-17]
Decubitus ulcer	3614 [2636-4778]	5 [4-7]
Fire, heat, and hot substances	25,864 [19,015-35,990]	61 [46-82]
Pyoderma	3448 [1747-5483]	6 [3-9]
Malignant skin melanoma	33,304 [23,609-41,243]	60 [42-75]
Basal cell carcinoma	12 [5-24]	0.02 [0.01-0.04]
Squamous cell carcinoma	46,479 [31,701-66,222]	66 [45-94]
Larynx cancer	11,291 [10,082-12,476]	17 [15-19]
Lip and oral cavity cancer	22,944 [20,957-24,860]	37 [34-40]
Nasopharynx cancer	4088 [3576-4671]	8 [7-9]
Orofacial clefts	276 [170-409]	1 [1-1]
Other pharynx cancer	9605 [8393-10,879]	15 [13-17]
Total	**328 128 [270,881-392,439]**	**556 [463-664]**

approximately half of the $10.6 billion CAD total cost of plastic surgery related diseases in Canada in 2019.

With regards to YLLs, Canadians lost a cumulative 238,731 years of life due to plastic surgery conditions; equivalent to 409 years of life per 100 000 people in 2019. In terms of years spent in disability, plastic surgery conditions resulted in 89,397 years spent in disability (147 years lived in disability per 100 000 Canadians). When totaled together in cumulative as DALYs, there were 328 128 years were lost to disability or to mortality, or 556 years per 100 000 Canadians, due to plastic surgery related conditions in 2019.

Cellulitis has the highest disease incidence, representing a significant source of morbidity with an aging population. Skin and soft tissue infections occurring in the setting of trauma, peripheral vascular disease, and immunocompromised states such as diabetes which are highly incident likely explains this. Increasingly refractory infections due to antibiotic resistance (MRSA infections for example) and the healthcare systems difficulty in addressing more chronic condition could contribute to the higher incidence.

Non-melanoma skin cancers combined had 60 times greater incidence than melanoma, likely due to a combination of sun exposure and Canada's aging population. Sun exposure is a greater risk factor for keratinocyte carcinoma than it is for melanoma. Even though melanoma occurred less frequently, it was the second largest contributor to mortality behind to breast cancer.

Fire, heat, and other substances were the most prevalent diseases, explained by good survivability and presence throughout an individual's life. Burns most commonly occur in younger individuals, with the highest incidence of burns being in males aged 45-54.[32] Burn survivors can live long lives with reduced disability as shown by highest YLDs but relatively small contribution to overall DALYs in plastic surgery related conditions.

The Canadian Institute for Health Information reported that healthcare spending was expected to reach $242 billion, or 11.5% of Canada's gross domestic in 2017.[33] Physicians accounted for approximately 15% of Canadian health care spending, with a total cost of approximately $36 billion.[34]There were a total of 627 practicing plastic surgeons in Canada who billed a minimum of $60 000 in provincial billing fees in 2017-2018.[35] Their average yearly billing was $391 425, equating to a total annual billing of $245 million compared the $10.6 billion CAD total cost of plastic surgery related diseases in Canada in 2019.[35] Therefore, every dollar that plastic surgeons bill the government addresses $43 of the burden of disease for the conditions assessed in this paper. It is difficult to make generalizable conclusions from this analysis, as there are many other conditions that plastic surgeons treat that are not discussed in this paper, and many other health disciplines that contribute to treating these conditions. In

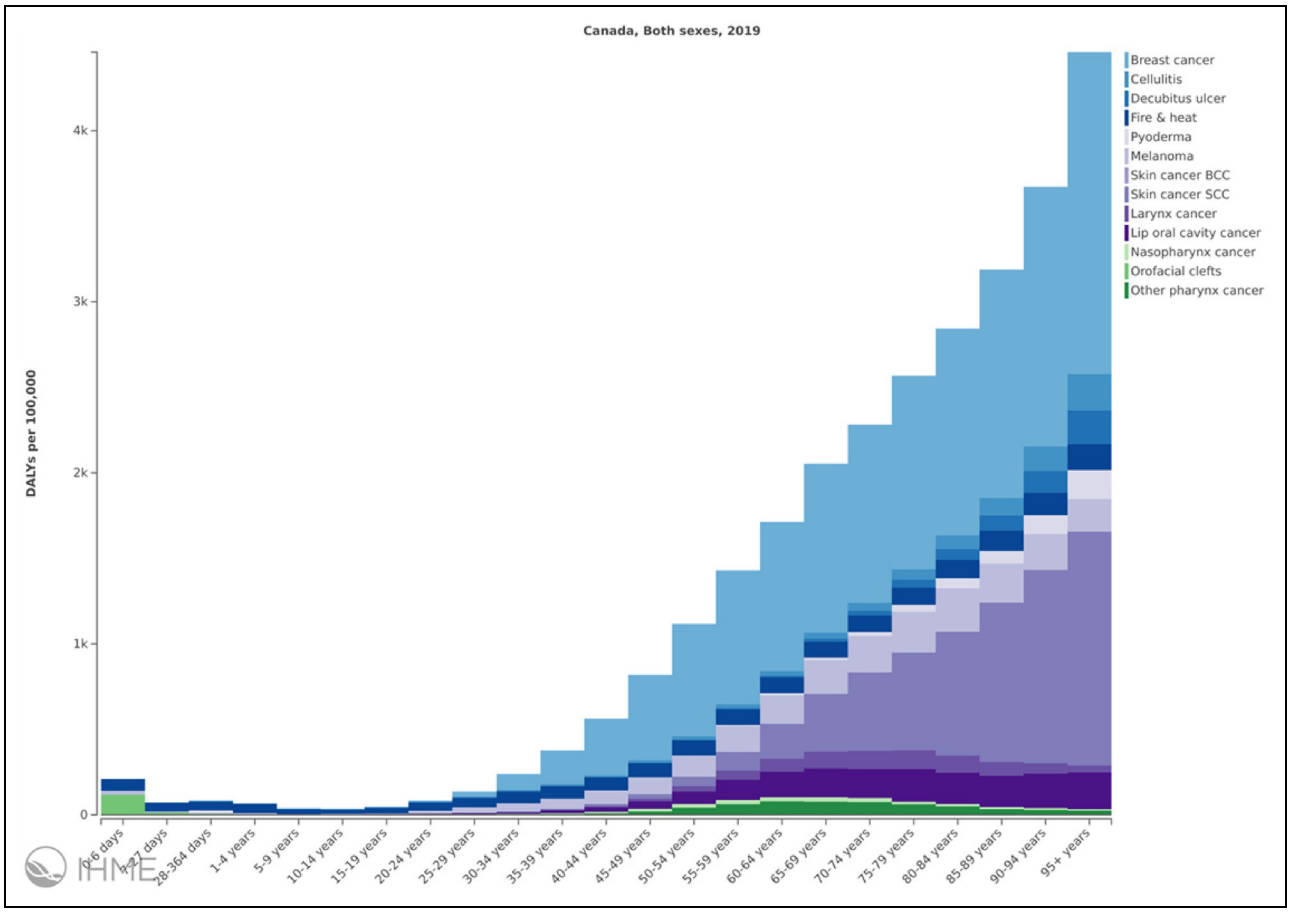

Figure 1. Age separated DALY rates per 100 000 for plastic surgery related disease in Canada from GBD 2019.

particular, the inability to include traumatic injuries based on the limitations of the GBD codes, especially upper and lower extremity and facial trauma is an important limitation to the economic benefit that plastic surgeons provide. Conversely, cellulitis and pyoderma are included in our analysis, but may infrequently require surgical care. This study provides a preliminary analysis of the benefit in providing plastic surgery services in Canada that needs to be followed with a comprehensive economic analysis examining direct, indirect, and future costs.

Government-funded plastic and reconstructive surgery is generally focused on treating hand injuries and diseases, breast cancer deformity, craniofacial injuries and diseases, skin cancer, burn injuries, and a variety of other reconstructive problems. The current evidence from GBD 2019 indicates that breast cancer, skin cancer, and burn injuries are a large cause of morbidity and mortality, justifying the current focus on treating and investigating these highly morbid diseases. These findings can help make evidence-based decisions regarding which diseases would benefit from increased funding in order to reduce disability and social and economic burden of disease. Future in-depth economic analyses should be used to advocate for increased funding and greater access to operating room and minor procedure time for the highly burdensome diseases such as burns and breast, head and neck, and skin cancers.

This study fills a gap in the literature on the morbidity and mortality of Canadian-specific plastic surgery related diseases. The most important limitation for our study is that the total DALYs and costs for included diseases are not solely in the domain of plastic and reconstructive surgery. For example, management of breast cancer and melanoma are shared by surgical, medical, and radiation oncology, family medicine, nursing staff, and other allied health. Furthermore, GBD 2019 data did not include several common plastic surgery conditions such as hand conditions (carpal tunnel syndrome, Dupuytren's disease, traumatic injuries to the hand, upper extremity nerve palsies), traumatic craniofacial and lower extremity reconstruction, and breast reduction surgery.

In the economic analysis, a universal CAD$50,000 per DALY value was attributed regardless of provincial differences that exist. This was done as GBD 2019 does not subcategorize by province. The costs calculated for provision of care are not comprehensive in this study. The physician's payments do not consider hospital costs, ancillary providers fee, and equipment that should be included in a full economic analysis. Furthermore, better characterization of indirect costs faced by patients beyond DALYs should also be considered. As the GBD constantly evolves, there will be changes in data

Table 7. Total Cost (in CAD billions) Associated With Each Plastic Surgery Disease in Canada Based on a Population of 38 Million and Average Cost Per DALY of $50 000.

	Age-standardized DALY rate (per 100 000)	Cost in CAD billions
Breast cancer	268	5.1
Cellulitis	13	0.2
Decubitus ulcer	5	0.1
Fire, heat, and hot substances	61	1.2
Pyoderma	6	0.1
Malignant skin melanoma	60	1.1
Basal cell carcinoma	0	0.0
Squamous cell carcinoma	66	1.3
Larynx cancer	17	0.3
Lip and oral cavity cancer	37	0.7
Nasopharynx cancer	8	0.2
Orofacial clefts	1	0.0
Other pharynx cancer	15	0.3
Total	557	10.6

collection and data analytical methods may come to influence the present results.[36,37]

Conclusion

Plastic surgeons address a large morbidity and cost of disease faced by patients in Canada. The major contributors to the burden of disease include breast cancer, melanoma, and traumatic injury due to thermal burns. Plastic surgeon payments in Canada totaled $245 million in 2016 while the GBD data shows an all-age burden of disease cost of approximately $10.6 billion for the 13 conditions examined by this study in 2019. These findings when combined with total healthcare spending per sector could provide evidence for deciding which conditions may benefit from increased spending to leverage economic gain from reducing disability. These results can be used to direct primary and secondary prevention strategies, healthcare expenditure, resource allocation and to advocate for improved funding for plastic surgery related diseases in the context of increasing healthcare demands.

Authors' Note

This article does not contain any studies with human or animal subjects and did therefore not require REB approval.

Declaration of Conflicting Interests

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