Journal of Cancer Policy xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Cancer Policy

journal homepage: www.elsevier.com/locate/jcpo

Original Research

# The health and economic implications of the use of tanning devices

Hugh R. Waters[a,*], Adewole Adamson[b]

[a] School of Nursing, The University of North Carolina at Chapel Hill, United States
[b] School of Medicine, The University of North Carolina at Chapel Hill, United States

ARTICLE INFO

*Article history:*
Received 30 July 2016
Accepted 12 December 2016
Available online xxx

*Keywords:*
Tanning devices
Tanning machines
Health care costs
Basal Cell Carcinoma
Squamous Cell Carcinoma
Melanoma

ABSTRACT

*Objectives:* We estimated the numbers of cases of health care conditions that are causally associated with exposure to tanning devices in the United States, and calculated the costs of medical care for treating these cases.
*Methods:* The principal unit of analysis for this study is the number of individuals living in the United States who sought treatment for basal cell carcinomas (BCC), squamous cell carcinomas (SCC), or melanomas. To estimate the percentage of these cases that are attributable to exposure to tanning devices, we calculated the Population Attributable Risk (PAR) for each disease. We calculated annual medical costs on a per-case basis as well as indirect productivity costs, using Years of Potential Life Lost.
*Results:* There were nearly 9000 incident cases of melanoma, and more than 86,600 cases of SCC and 168,000 cases of BCC, attributable to exposure to tanning devices in the U.S. in 2015. The cost of direct medical care for these cases is $343.1 million annually, and they will lead to a total economic loss of $127.3 billion over the lifetime of the individuals affected.
*Conclusions:* The use of tanning devices is a significant contributor to illness and premature mortality in the U.S., and also represents a major economic burden in terms of the costs of medical care and lost productivity.



## 1. Introduction

Indoor tanning continues to be a public health hazard in the United States. Approximately 30 million people use tanning devices at least once per year in the U.S. [1–3], where there are an estimated 25,000 tanning salons [4]. The proportion of the U.S. population using tanning devices has increased substantially in the last two decades [5]. An estimated 35.4% of adults in the U.S. have used indoor tanning devices [6].

*Healthy People 2020*, published by the U.S. Department of Health and Human Services, includes two specific goals related to indoor tanning for the year 2020. The first is reducing the proportion of adolescents in grades 9–12 who report using artificial sources of ultraviolet light for tanning – from 15.6% in 2009 to 14.0% by 2020. The second goal is to reduce the proportion of adults aged 18 and over who report using artificial sources of ultraviolet light for tanning – from 5.6% in 2010 to 3.6% in 2020 [7].

Indoor tanners are disproportionately female and young – an estimated 24% are teenagers [2,8,9]. The 1996 National Longitudinal Study of Adolescent Health found that 36.8% of white female adolescents, and 11.2% of white male adolescents, had used a tanning booth at least once [10]. The 2011 Youth Risk Factor Surveillance Survey (YRBSS), from the Centers for Disease Control and Prevention (CDC), found that 13.3% of students in 9th through 12th grades had used an indoor tanning device at least one time in the 12 month period prior to the survey. Females reported a higher utilization rate (20.9%) than males (6.2%) [11].

There is clear evidence that the use of tanning devices is a significant health risk [12–15]. Tanning devices primarily emit UV-A radiation, which has been linked to cellular damage – including DNA mutations, impaired immune surveillance, damaged cell integrity, and skin cancer [16–18]. The devices can also emit UV-B radiation, which causes tanning, burning and contributes to skin cancer [19,20]. There is sufficient epidemiologic data to determine that the use of these devices is causally associated with cutaneous melanoma (invasive and *in situ*), [21,22] and two non-melanoma skin cancers – basal cell carcinoma and squamous cell carcinoma [6].

Skin cancers are the most commonly diagnosed type of cancer in the United States, and their prevalence continues to grow. The average annual number of adults treated for skin cancer increased from 3.4 million in the 2002–2006 time period to 4.9 million in

* Corresponding author.
*E-mail addresses:* waters@unc.edu (H.R. Waters), adewole_adamson@med.unc.edu (A. Adamson).

http://dx.doi.org/10.1016/j.jcpo.2016.12.003
2213-5383/

2007–2011. During this period, the average annual total cost for skin cancer in the U.S. increased grew from $3.6 billion to $8.1 billion – or 126.2% – while the average annual total cost for all other cancers increased by 25.1% [23]. Given the direct relationship between indoor tanning and skin cancer, some of the excess cases can be attributed to tanning behavior. In this paper, we calculate the excess epidemiologic burden and economic costs attributable to tanning devices leading to melanoma and non-melanoma skin cancers.

## 2. Methods

This study uses several data sources to comprehensively establish the prevalence of skin cancers related to exposure to tanning devices in the United States, and the associated medical costs. There are important differences among health-related costing studies in terms of the perspective from which costs are calculated. This study uses a societal perspective – in other words, all costs are included whether they accrue to the individual, a third-party payer, or society at large. The principal unit of analysis for this study is the number of individuals living in the United States who sought treatment for basal cell carcinomas, squamous cell carcinomas or melanomas in 2015 that have been found to be causally related to exposure to tanning devices.

Although there are several medical conditions associated with indoor tanning such as keratitis, photodermatoses, dermatitis, and porokeratosis, there is limited data on their prevalence and proportion caused by tanning devices. We have therefore limited our analysis to the most common types of skin cancer, melanoma and non-melanoma skin cancer, specifically basal cell carcinoma and squamous cell carcinoma.

### 2.1. Prevalence

Table 1 applies available skin cancer incidence and prevalence information to the 2015 U.S. population – estimated by the Census Bureau to be 322.3 million in December 2015 [24]. There were approximately 78,281 cases of invasive melanoma treated in the U.S. in 2015, as well as an estimated 57,040 cases of melanoma *in situ* (Table 1). In addition, an estimated 2.26 million individuals were treated for NMSCs – including 1.81 million for Basal Cell Carcinoma and 452,087 for Squamous Cell Carcinoma.

### 2.2. Relative risk

We estimated the numbers of individuals with episodes of skin cancers related to exposure to tanning devices – using the scientific literature to establish the most recent valid estimates of the Relative Risk (RR). The Relative Risk is the probability that individuals exposed to tanning devices will develop the disease, divided by the probability for individuals not exposed. For melanoma, the calculations are based on the meta-analysis estimate of 18 cohort and population-based studies – 1.20 published in the journal *BMJ in* 2012, 95% confidence interval 1.09–1.43 [16]. For basal and squamous cell carcinomas, a separate *BMJ* meta-analysis, also published in 2012, calculated Relative Risks of 1.29 and 1.67 respectively [6]. Relative Risk estimates for each condition are summarized in Table 2.

### 2.3. Population attributable risk

To estimate the percentage of these cases that are attributable to exposure to tanning devices, we calculated the Population Attributable Risk (PAR) for each disease. The PAR is equivalent to the proportion of a disease burden that can be attributed to a specific causal factor; it is calculated as:

$$\frac{(Incidence\ \ in\ \ total\ \ population) - (Incidence\ \ in\ un\exp osed\ \ group)}{(Incidence\ \ in\ \ total\ \ population)}$$

Which is mathematically equivalent to:

$$\frac{(Prevalence) * (RR - 1)}{(Prevalence) * (RR - 1) + 1}$$

Prevalence in this equation refers to the percentage of the population exposed to the risk factor, and RR is the Relative Risk of having the condition in question for those exposed compared to those who are not. A 2010 study in the *New England Journal of Medicine* estimated that 30 million people in the U.S. and Canada use indoor tanning facilities [33]. Also in 2010, the U.S. Centers for Disease Control and Prevention (CDC) published a study reporting that the prevalence of tanning bed use in the previous year was 31.8% and 29.6% for Caucasian American women aged 18–21 years and 22–25 years, respectively [34]. A recently published systematic review and meta-analysis calculated that 35.7% of adults in the U.S. have used tanning devices [6].

The resulting Population Attributable Risks for exposure to tanning devices are 6.61% for melanoma, 9.31% for basal cell carcinoma, and 19.17% for squamous cell carcinoma. With these PAR estimates, it is then possible to calculate the numbers of cases attributable to each of the conditions causally linked to exposure to tanning devices. These estimates are consistent with estimates of Population Attributable Risks from the literature, which range from 2.6 to 9.4% for melanoma; and from 3.0 to 21.8% for NMSCs [6].

**Table 1**
Estimated Prevalence, 2015.

| Condition | Prevalence (per 100,000 population) | Cases in 2015 |
|---|---|---|
| **Melanoma**, of which: | **42.0** | **135,321** |
| Invasive | 24.3 | 78,281 |
| In situ | 17.7 | 57,040 |
| **NMSCs**, of which: | **701.4** | **2,260,437** |
| Basal Cell Carcinoma | 1.1 | 1,808,349 |
| Squamous Cell Carcinoma | 140.3 | 452,087 |

Sources for Table 1:
Prevalence of melanoma and melanoma *in situ* [25].
Prevalence of non-melanoma skin cancers 13 [26].
The U.S. Population in 2015 is estimated to be 322,275,000 [26].

### 2.4. Costs

Having established the conditions and the numbers of cases that are causally linked to exposure to tanning devices, we next established the cost of treating these cases. To do this, we used the results of the *Burden of Skin Diseases Study*, a comprehensive study of the costs of treatment associated with different skin diseases [35]. We calculated annual medical costs associated with melanoma, BCC and SCC on a per-case basis, and adjusted these for inflation to 2015 dollars. We also reviewed a wide range of published estimates of the costs of treating these conditions, finding that these estimates are compatible with the results of the Burden of Skin Diseases Study. We also estimate indirect costs – related to the opportunity cost of time lost due to illness. To do this, we calculated the Years of Potential Life Lost (YPLL) that can be attributable to diseases that are causally related to exposure to tanning devices in 2015. Indirect economic costs – related to lost productivity and premature mortality – are calculated per year of life lost.

Despite the fact that there is well-established literature quantifying the value of premature mortality, assigning a monetary value to human life is a controversial task [36–38]. Among studies that

Please cite this article in press as: H.R. Waters, A. Adamson, The health and economic implications of the use of tanning devices, J Cancer Policy (2016), http://dx.doi.org/10.1016/j.jcpo.2016.12.003