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Original Contribution

A Melanoma Epidemic in Iceland: Possible Influence of Sunbed Use

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Since 1980, sunbed use and travel abroad have dramatically increased in Iceland (64°–66°N). The authors assessed temporal trends in melanoma incidence by body site in Iceland in relation to sunbed use and travel abroad. Using joinpoint analysis, they calculated estimated annual percent changes (EAPCs) and identified the years during which statistically significant changes in EAPC occurred. Between 1954 and 2006, the largest increase in incidence in men was observed on the trunk (EAPC = 4.6%, 95% confidence interval: 3.2, 6.0). In women, the slow increase in trunk melanoma incidence before 1995 was followed by a significantly sharper increase in incidence, mainly among women aged less than 50 years, resembling an epidemic incidence curve (1995–2002: EAPC = 20.4%, 95% confidence interval: 9.3, 32.8). In 2002, the melanoma incidence on the trunk was higher than the incidence on the lower limbs for women. Sunbed use in Iceland expanded rapidly after 1985, mainly among young women, and in 2000, it was approximately 2 and 3 times the levels recorded in Sweden and in the United Kingdom, respectively. Travels abroad were more prevalent among older Icelanders. The high prevalence of sunbed use probably contributed to the sharp increase in the incidence of melanoma in Iceland.

Iceland; melanoma; ultraviolet rays

Abbreviations: CI, confidence interval; EAPC, estimated annual percent change; UV, ultraviolet; UV-A, ultraviolet A; UV-B, ultraviolet B; UV-C, ultraviolet C.

Editor's note: *An invited commentary on this article appears on page* ***000****, and the authors' response is published on page* ***000****.*

Cutaneous malignant melanoma is a potentially deadly cancer that occurs predominantly in sun-sensitive subjects, that is, subjects with light skin and poor ability to tan (1). Intermittent exposure to ultraviolet (UV) radiation is the main environmental cause of cutaneous malignant melanoma (2). Intermittent sun exposure consists of intense exposure to UV radiation of skin areas normally sun protected, such as the trunk. UV radiation reaching the earth's surface contains ultraviolet A (UV-A) (>320–400 nm) and ultraviolet B (UV-B) (>280–320 nm) radiation. More recently, UV radiation (wavelength, 100–400 nm, encompassing ultraviolet C (UV-C), UV-B, and UV-A), as well as UV-emitting tanning devices, has been classified as carcinogenic to humans (group 1 carcinogens) by a Working Group of the International Agency for Research on Cancer (3).

Until about 1990, melanoma incidence in Iceland was below that of other Nordic countries (4), as expected from its northern latitude (between 64° and 66°N), frequent cloud cover, and consequent low natural UV radiation. However, melanoma incidence sharply increased in both genders during the 1990s and, in 2000, the incidence in Icelandic women was the highest of all Nordic countries (4). The indoor tanning fashion was suspected as a possible cause of this increase. A few years ago, we predicted that melanomas associated with solarium use would be preferentially localized to the trunk (5). We therefore performed a detailed analysis of temporal trends in melanoma incidence in

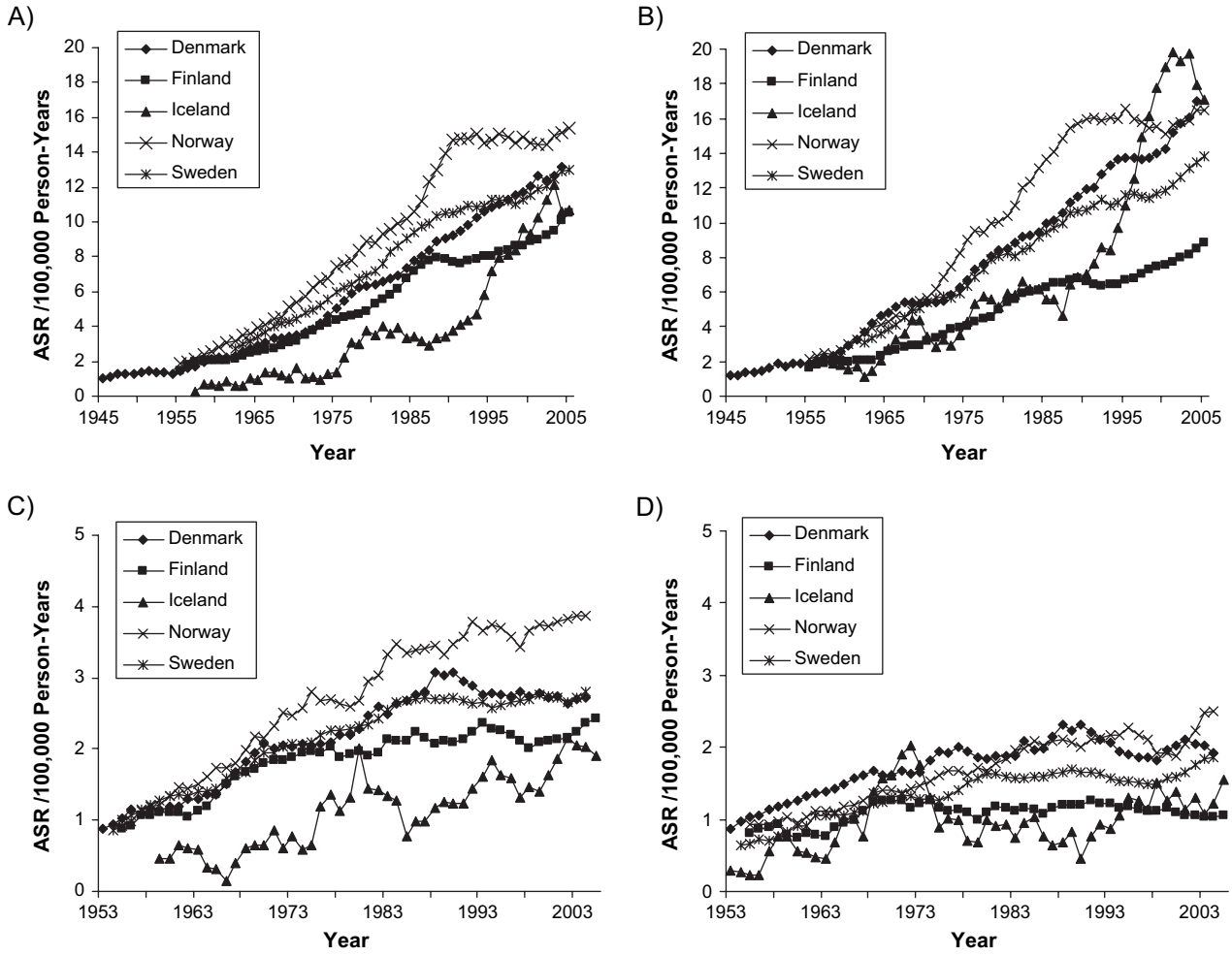

Figure 1. Trends in cutaneous melanoma incidence (1945–2007, men (A) and women (B)) and mortality (1953–2007, men (C) and women (D)) in Nordic countries. Incidence rates are 5-year moving averages with 2007 being the last possible year. The *y*-axis scale of mortality is approximately 4 times lower than that of incidence. ASR, age-standardized rate. Data source: NORDCAN (4), age adjusted on the World Standard Population.

Iceland and of changes in exposure to sources of UV radiation, mainly sunlight and artificial tanning devices.

MATERIALS AND METHODS

The population-based Icelandic Cancer Registry provided information on invasive melanoma incidence from 1955 to 2007 (6). Melanoma incidence rates for all body sites, by sex, were analyzed by using the Joinpoint Regression Program, version 2.7 (7), to identify periods with distinct trends between 1955 and 2007. The analysis was stratified by gender, by age (0–49 and $\geq$50 years of age), and by anatomic site. The NORDCAN online database provided Nordic incidence and mortality data on cancer from 1945 until 2006 (4). All rates were standardized to the World Standard Population.

Data on sunbed numbers were provided by the Icelandic Radiation Protection Institute (8). Further information on sunbed use came from surveys of melanoma risk factors in the Icelandic population conducted in 2001–2002 (8) and in 2002 (9). Information on travel abroad was provided by a survey done in 2001–2002 (10) and from the National Statistical Institute of Iceland (11).

RESULTS

Melanoma incidence

In 1955–2007, 861 melanoma cases (306 in men and 555 in women) were reported to the Icelandic Cancer Registry. In the period 1955–1959, the age-standardized incidence rate of melanoma in Iceland was less than 1/100,000 in men and 2.2/100,000 in women. Until around 1990, despite an annual increase of 4.1%, the melanoma incidence remained lower in Iceland than in the other Nordic countries (Figure 1), but during the period 1998–2002, the age-standardized incidence rate was 9.0/100,000 for men and 18.5/100,000 for women.

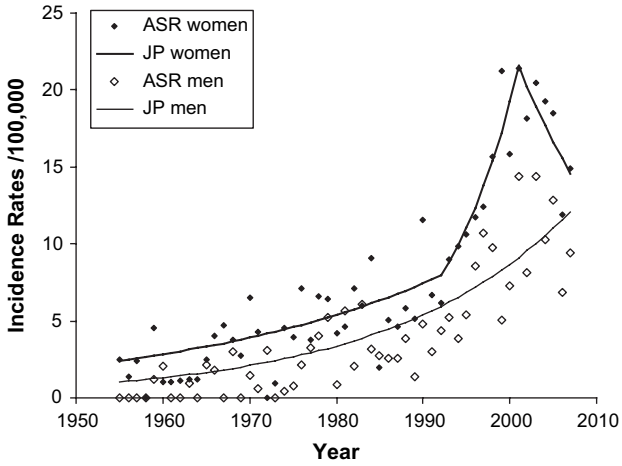

Figure 2. Joinpoint (JP) analysis of cutaneous melanoma incidence in Iceland (1955–2007) by sex. ASR, age-standardized rate.

Joinpoint analysis of incidence data from 1955 through 2007 for men showed a steady 4.8% estimated annual percent change (EAPC) (95% confidence interval (CI): 3.8, 5.9) without breakpoint, whereas for women a statistically significant breakpoint was observed in 1992 (Figure 2). Before 1992, the EAPC in incidence was 3.3% (95% CI: 1.9, 4.7) per year for women, but from 1992 until 2001, it was 11.8% (95% CI: 5.1, 18.8). A second breakpoint was observed in 2001, followed by a nonsignificant 6.3% (95% CI: −13.5, 1.4) decrease until 2007.

The age distribution of melanoma cases for men showed no significant change ($P = 0.85$) before and after 1992, with the number of cases tripling in men of both age groups (Table 1; Figure 3). In contrast, melanoma incidence rates increased by 3 times in women younger than 50 years and only slightly in women aged 50 or more years between 1955–1992 and 1993–2007 ($P < 0.001$) (Table 1; Figure 3). Moreover, using joinpoint analysis, we found that women younger than 50 years required 2 joinpoints ($P < 0.001$), with an EAPC of 2.3% (95% CI: 0.1, 4.6) from 1955 to 1991, an EAPC of 15.5% (95% CI: 6.8, 24.8) between 1991 and 2001, and an EAPC of −9.0% (95% CI: −18.1, 1.1) until 2007. For women 50 years of age or older, no joinpoint was required ($P = 0.63$), as the incidence increased steadily (EAPC = 2.6%, 95% CI: 1.7, 3.5).

The largest increase over the period was observed on the trunk in men (EAPC = 4.6%, 95% CI: 3.2, 6.0) and on the lower limbs in women (EAPC = 3.5%, 95% CI: 2.5, 4.6) (Figure 4). From the period 1955–1992 to the period 1993–2007, the frequency of melanoma on the trunk more than tripled in both sexes (Table 1). Although trunk melanoma increased steadily in men, in women the slow increase before 1995 was followed by a significantly sharper increase in incidence, resembling an epidemic incidence curve (1995–2002: EAPC = 20.4%, 95% CI: 9.3, 32.8) (Figure 4). As a consequence, in 2002 the incidence of trunk melanoma among women was higher than the incidence of melanoma on the lower limbs. The site with the largest percentage increase in incidence for women after 1992 was the trunk in younger women (Table 1).

Table 1. Numbers and Body Site Distribution of Cutaneous Melanomas Diagnosed in Iceland During the Time Period, 1955–2007

	Men				Women			
	1955–1992		1993–2007		1955–1992		1993–2007	
	No.	%	No.	%	No.	%	No.	%
All sites								
Age, <50 years	35	37.2	89	38.4	75	38.1	232	60.3
Age, ≥50 years	59	62.8	143	61.6	122	61.9	153	39.7
Age, <50 years								
Head and neck	5	14.3	8	9.0	8	10.7	10	4.3
Trunk	13	37.2	54	60.6	16	21.3	83	35.8
Upper limbs	6	17.1	7	7.9	12	16.0	26	11.2
Lower limbs	9	25.7	17	19.1	33	44.0	99	42.7
Others	2	5.7	3	3.4	6	8.0	14	6.0
Total		100		100		100		100
Age, ≥50 years								
Head and neck	17	28.8	45	31.5	33	27.0	30	19.6
Trunk	16	27.1	57	39.8	14	11.5	27	17.6
Upper limbs	8	13.6	16	11.2	22	18.0	29	19.0
Lower limbs	15	25.4	23	16.1	49	40.2	64	41.8
Others	3	5.1	2	1.4	4	3.3	3	2.0

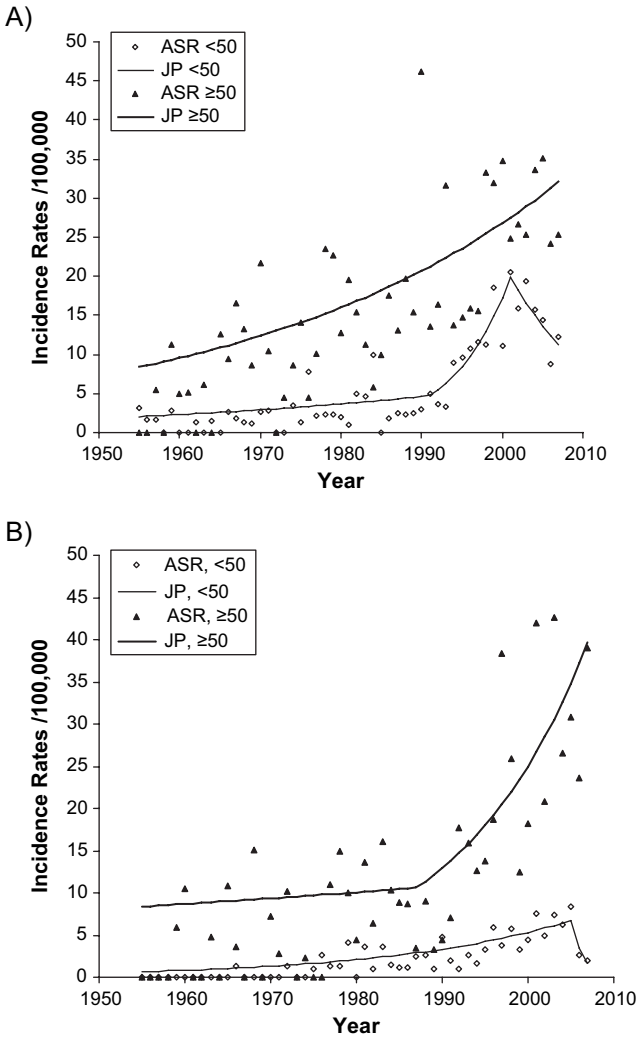

Figure 3. Joinpoint (JP) analysis of cutaneous melanoma incidence in Iceland (1955–2007) by age group for women (A) and for men (B). ASR, age-standardized rate.

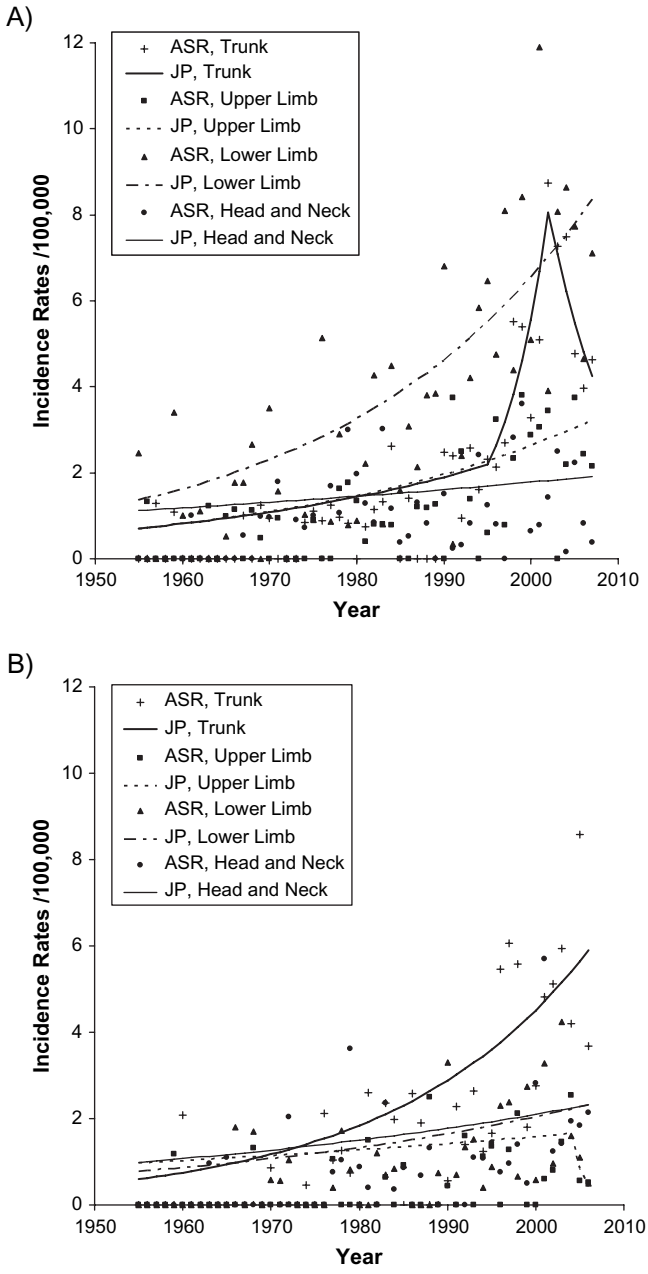

Figure 4. Joinpoint (JP) analysis of cutaneous melanoma incidence in Iceland (1955–2007) by morphologic site for women (A) and for men (B). ASR, age-standardized rate.

Melanoma mortality

Bearing in mind that, in Figure 1, the *y*-axis scale is 4 times lower than that of incidence, melanoma mortality from 1974 until 2007 did not parallel changes in incidence rates. Melanoma mortality in Iceland mostly stayed slightly below the rates observed in other Nordic countries and, from 1974 until 2007, remained quite stable around 1.0 and 1.4/100,000 in women and in men, respectively.

Sunbed use

In 1979, there were only 3 sunbed salons in Reykjavik, but their number increased rapidly and, in 1988, 56 facilities offered cosmetic tanning with 207 sunbeds (1.5 beds/1,000 inhabitants). In 2004, a campaign was launched by the Icelandic health authorities to discourage sunbed use, focusing particularly on teenage girls. In 2005, the number of publicly available sunbeds in the Reykjavik area decreased to 144 and further decreased to 97 in 2008 (T. Sigurdsson, personal communication, 2008).

The 2002 survey indicated that 70% of women and 35% of men had used a solarium (9). Among users, 42% of women and 30% of men reported a burn in a solarium. In the 2001–2002 survey (8), 16% of women and 12% of men aged 20–39 years had used a solarium more than 100 times during their lifetime. In contrast, these proportions were 2% and 1% among women and men aged 50 years or more.

Capacent-Gallup surveys done in the period 2004–2007 indicated that, on average, 26% of the Icelandic population had used a sunbed in the previous 12 months, representing 2.8 sessions per adult (16–75 years) per year (8). Among teenagers, each year about 50% of girls and 30% of boys used sunbeds in the last 12 months (T. Sigurdsson, B. Sigurgeirsson, and J. H. Olafsson, personal communication, 2008).

Sun exposure

Travel abroad to more southern areas represents an important source of sun exposure for Icelanders. In 1970, 65,941 voyages abroad by Icelanders were recorded, and this number steadily increased to 937,315 in 2006 (11). This increase went uninterrupted without slowing in recent years. In 2001–2002, 6% of women and 5% of men aged 20–39 years had travelled abroad 10 times or more during their lifetime (10). In contrast, these proportions were 17% among women and men aged 50 years or more.

DISCUSSION

This study had an ecologic design in which data were compared at the population level rather than at the individual level. The number of cases is relatively low, owing to the small population of Iceland. Ecologic correlation does not imply causation, but we found that sunbed use likely played an important role in affecting the melanoma incidence trends observed in Iceland. This hypothesis is supported by the sharp increase in incidence on the trunk in younger women who also had the highest records of sunbed use, which allows women to expose the trunk to UV radiation without protection. It is further supported by the decline in incidence in women observed after 2001, following the decline in sunbed use. Sunbed use in Iceland often started during the teen years, and the sharp increases in melanoma incidence are in agreement with the estimates of increased risk when sunbed use starts before approximately 35 years of age (risk = 1.75, 95% CI: 1.35, 2.26) (12, 13). As young Icelanders have fewer cumulative trips abroad but higher cumulative sunbed use than older Icelanders do, intermittent sun exposure in more southern latitudes alone is a less plausible explanation for increases in young men and women after 1994.

Compared with midday sunlight on the Mediterranean Sea, the UV radiation spectrum of sunbeds contains a greater proportion of UV-A, and the UV radiation intensity of powerful tanning units may be 10–15 times higher than that of the midday sun (14, 15), leading to UV-A doses per unit of time received by the skin during a typical tanning session well above those experienced during daily life or even during sunbathing. Such levels of repeated exposures to high UV-A doses constitute a new phenomenon for human beings. The whole UV radiation spectrum (including UV-A) and UV-emitting tanning devices are now considered as carcinogenic to humans (3). The Icelandic data also suggest that the time lag between exposure and melanoma occurrence may be relatively short, in the order of a few years. One possible hypothesis underlying a short lag time would be the stimulation, by repeated high UV-A doses, of melanocytes in preexisting nevi that developed earlier during life.

The average of 2.8 sunbed sessions per year in 2004–2007 in Iceland (8) is around 3 times higher than that estimated for the United Kingdom in 1996 (16) and around 2 times higher than that estimated for Sweden in 2005–2006 (17, 18). Before 2000, in most light-skinned communities, the increase in melanoma incidence in men was apparent mainly on the trunk, followed by the head and neck. In women, it was apparent mainly on the lower limbs (19). As in Iceland, the increase in melanoma incidence in Swedish women has been most pronounced on the trunk, and in 1996 the melanoma incidence on the trunk became equal to the incidence on the lower limbs (20). In Northern Ireland, incidence increases in men and women are more pronounced for trunk melanoma (21). In the United Kingdom, a rebound increase of melanoma incidence from 1998 onward has been reported for women 20–39 years of age (16).

Other reasons for the increases in incidence have been sought. No modification in cancer registration modalities has occurred that can explain changes in incidence. A fraction of the rising incidence may be due to markedly increased awareness and screening for melanoma in Iceland, initiated around 1990 by activities of the Icelandic Dermatological Association and the Icelandic Cancer Society. However, a screening effect is not likely to be specific to the female trunk.

The melanoma epidemic that occurred in 1987–1992 in the Hunter district of New South Wales, Australia, did not affect melanoma mortality, and it was concluded that the epidemic consisted mainly of a nonmetastasizing form of melanoma (22, 23). Likewise, because there is no efficient treatment for metastatic melanoma, the absence of change in melanoma death rates after 1974 in Iceland suggests that most of the epidemic was due to a non–life-threatening form of melanoma.

There is the possibility of synergistic effects between early detection and sunbed use: Intense exposure to UV radiation is known to induce changes in nevi appearance (24, 25) that could lead to more visits to dermatologists and to more excisions of suspicious pigmented skin lesions.

The low-background UV radiation and the high use of sunbeds make Iceland an interesting place for studying the effects of sunbed use on melanoma risk. A case-control study investigating the relations between melanoma and past sunbed use in Iceland has been envisioned, but the population has been well informed about the dangers of sun exposure and of indoor tanning (26, 27), which raises issues of selection and recall bias. A follow-up study is desirable, but several years will be needed before results become available.

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