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Indoor Tanning in Norway

Regulations and inspections

Statens strålevern
Norwegian Radiation Protection Authority

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Key words:
Indoor tanning. Sunbed. Solarium. UV irradiance. Regulations. Compliance. Inspection.

Abstract:
The report presents Norwegian regulations regarding indoor tanning, compliance with these and UV irradiance from the sunbeds. Inspections revealed low compliance and too high short wave UV irradiance. The long wave UV irradiance was more than three times higher than for summer sun in South Norway in approved as well as in inspected sunbeds.

Referanse:
Nilsen LTN, Aalerud TN, Johnsen B, Friberg EG, Hannevik M. Indoor Tanning in Norway. Regulations and inspections. StrålevernRapport 2008:9. Østerås: Statens strålevern, 2008. Språk: Engelsk.

Emneord:
Solarium. Kosmetisk bruk. UV irradians. Forskrift. Regelverk. Tilsyn.

Resymé:
Rapporten presenterer regelverk for kosmetiske solarier i Norge, hvordan dette er overholdt og UV stråling fra tilgjengelige solarier i Norge. Tilsyn avslørte mange brudd på regelverket og alt for høy kortbølget UV stråling i solariene. Langbølget UV stråling i både de godkjente og de inspiserte solariene var omtrent tre ganger høyere enn for sommersol i Sør-Norge.

Head of project: Lill Tove N. Nilsen.
Approved:

Gunnar Saxebøl, director, Department for Radiation Protection and Nuclear Safety

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Østerås, 2008

Foreword

The main results of this report are presented in a publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen, Merete Hannevik, Tommy N. Aalerud, Bjørn Johnsen, Eva G. Friberg and Marit B. Veierød, DOI: 10.1111/j.1751-1097.2008.00330.x, Published article online: 9. April 2008). It is stated in the figure and table legends when figures and tables from this publication are used.

We would like to acknowledge operators and owners of the many inspected tanning establishments. We would also like to thank Mrs. Kirsti Bredholt (NRPA), Mr. Christer Jensen (former NRPA) and others that have participated in measuring the devices. Furthermore, we would like to thank Director Gunnar Saxebøl at NRPA for his excellent memory and written notes from the early start of the tanning regulation history in Norway, Nemko AS for access to their approval lists, retired Nemko employee Mr. Tom Randlev for providing his notes and Dr. Tore Tynes (former NRPA) for valuable discussions. Last, but not least, we would like to thank Dr. Marit B. Veierød, UiO, for asking for UV irradiance data from sunbeds and thereby initiating our common work resulting in the publication in Photochemistry and Photobiology.

Content

Summary

This report presents regulations of indoor tanning in Norway from the first regulation in 1983 and the impact this has had on the tanning market, with respect to available tanning devices, compliance with the regulations and on the UV irradiance. The results are based on two inspection surveys, in 1998-1999 and in 2003, and on measurements of UV irradiance as part of the approvals for new tanning models.

The years after the first regulation came in force in 1983 most tanning devices had only fluorescent body lamps and low erythemal or CIE-weighted short wave UV irradiance. As the UV type 3 requirements were introduced in 1992/1993 the mean short wave irradiance doubled to 0.101 W/m² in the approved devices, i.e. comparable to summer sun in South Norway. The mean long wave UV irradiances differed less, but were more than 3 times higher than for summer sun in South Norway. More devices combined fluorescent body lamps with facial fluorescent or high-pressure lamps. Despite strict Norwegian regulations, inspections in 1998 revealed low compliance with these. Only one out of 130 establishments complied with all requirements, 28 % of the sunbeds were equipped with correct lamps and 43 % of the establishments provided exposure schedules to the customers. The inspections in 2003 showed improvements, and in particular, 59 % of the sunbeds had correct lamps and 71 % of the establishments provided exposure schedules. UV irradiance estimates revealed mean short wave irradiance in the inspected sunbeds much higher than when they were approved. The mean long wave irradiance varied less for the approved and inspected devices as well as between the different time periods.

This report shows that regulations are necessary, but insufficient if not followed by inspections. The results are important for assessing changes in time with respect to UV irradiance and compliance with regulations. Thus, it will be important basis for future changes in indoor tanning regulations and management. The results also provide important knowledge of UV irradiance and spectral distribution of tanning devices. This can be useful for planning and interpretation of studies on sunbed use in relation to adverse health effects and potential health benefits.

Norwegian summary

Rapporten presenterer regelverk for bruk av kosmetiske solarier i Norge, fra den første forskriften trådte i kraft i 1983. Den viser hvilken påvirkning dette har hatt på det norske solariemarkedet i forhold til hvilke solarier som er tilgjengelig, hvordan krav i forskriften er overholdt og nivå av UV stråling fra solariene. Resultatene er basert på to tilsynsrunder, i 1998-1999 og i 2003, og på UV målinger tatt som del av godkjenningsprosessen for nye modeller til det norske markedet.

Etter at den norske forskriften trådte i kraft i 1983 var de fleste solariene utstyrt kun med fluorescerende lamper beregnet for eksponering av hele kroppen. Erytemvektet eller CIE-vektet UV irradians i den kortbølgede delen av spekteret var lav. Da UV type 3 krav ble innført i det norske regelverket i 1992/1993 økte den midlere kortbølgende UV irradiansen til det dobbelte, 0.101 W/m², i de godkjente modellene. Dette er på nivå med kortbølget UV om sommeren i Sør-Norge. Midlere langbølget UV irradians var mer lik i de to periodene, men var mer en tre ganer så høy som for sommersol i Sør-Norge. I siste periode hadde flere solarier kombinasjoner av fluorescerende kroppsrør og enten rør eller høytrykkslamper for ansiktseksponering. På tross av streng regulering av solarier i Norge, avslørte tilsynene i 1998 at forskriften i liten grad ble overholdt. Bare en av 130 virksomheter overholdt alle krav, 28 % av solariene hadde korrekte rør og lamper og 43 % av solstudioene hadde solingstidsplaner tilgjengelig for kundene. Tilsynene i 2003 viste forbedringer siden 59 % av solariene hadde korrekte rør og lamper og 71 % av virksomhetene hadde solingstidsplaner tilgjengelig. Estimat av UV irradians viste at midlere kortbølget UV irradians i de inspiserte solariene var mye høyere enn da de ble godkjent. Midlere langbølget UV irradians var ikke så forskjellig for de godkjente og inspiserte solariene.

Rapporten konkluderer med at regulering av kosmetiske solarier er nødvendig, men ikke tilstrekkelig dersom det ikke følges av tilsyn. Resultatene i rapporten er viktig for å følge endringer over tid i UV nivå og hvordan krav i forskriften er overholdt. Dette er viktig ved eventuelle endringer i regelverket og forvaltning av det. Resultatene gir også viktig kunnskap om UV nivå og spektralfordeling for solarier i Norge i ulike tidsperioder. Dette kan være essensielle data for andre solariestudier som ser på negative helseeffekter og også mulige positive effekter.

1 Indoor tanning

Indoor tanning has become widely used in many countries during the recent two decades. A register of tanning facilities were established in 2004 in Norway, and so far more than 1100 facilities (tanning saloons, fitness centres, hotels, hair dressers and at workplaces) and several thousand sunbeds have been reported. In addition, an unknown number of sunbeds exist in private homes. Regulations and recommendations regarding indoor tanning exist in a dozen countries in addition to Norway, as described in a recent expert report on exposure to artificial UV (ultraviolet) radiation and skin cancer from IARC (1). Use of indoor tanning is more common among women, particularly among younger age groups and in the Northern countries. Indoor tanning is also frequently used by those with a poor tanning ability, i.e. skin types I and II. This is in contrast to conclusions from international authorities like World Health Organization (WHO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), EUROSKIN and the Scientific Committee on Consumer Products (SCCP) that have advised against use of sunbeds for adolescents and those with a low ability to tan (3-6). SCCP has also suggested stringent European regulations regarding use of tanning devices and with strict UV irradiance limits.

Estimates from a Swedish study (26) show that on a population level, UV exposure to the skin from artificial UV sources could be of the same order of magnitude as from the sun. Excessive tanning is associated with adverse health effects. Immediate effects include sunburn, phototoxic and photoallergic reactions and eye damage, while late effects include skin aging and skin cancer (1, 2, 20). Exposure to sunbeds, and in particular, first exposure to sunbeds before 35 year of age significantly has been shown to increase the risk of cutaneous malignant melanoma (1, 2, 21-23). On the positive side, exposure to the sun initiates the synthesis of vitamin D in the skin (11, 25).

Over time, the spectral characteristics from indoor tanning devices have shifted from predominantly UVB (280-315 nm) to UVA (315-400 nm), and then to UVA combined with increasing amounts of UVB (1-2, 7-19). As regards skin cancer, UVB is important for squamous cell carcinoma development, but both UVB and UVA may play a role for cutaneous malignant melanoma and basal cell carcinoma. More knowledge is needed concerning the action spectrum (1, 2, 24). Experimental models mimicking the induction of skin cancer are still not satisfactory, therefore epidemiological studies are important. In particular, it is important to consider the time periods when these devices have been used with respect to UVB and UVA irradiances and the ratio between them.

Norway, together with Sweden, was among the first countries to implement national regulations for indoor tanning devices (28, 31). The first regulation appeared in 1983, and the irradiance limits changed to comply with the European Standard (36) in the autumn 1992. The European Standard sets technical requirements for the tanning devices, but only a few countries regulate the use of these devices.

This report presents regulations of indoor tanning in Norway from 1983 to 2005, including approval of tanning devices and results from two inspection surveys (1998 and 2003). Approval and inspection data provides a unique opportunity to assess UV irradiance due to indoor tanning devices in use during this period. Comparisons with irradiance of natural sun are also performed. The report also forms the basis to assess changes in compliance with regulations over time.

UV wavelength regions

UVC	100 - 280 nm
UVB	280 - 315 nm
UVA	315 - 400 nm

UV wavelength regions according to the European Standard

Short wave UV	250 - 320 nm
Long wave UV	320 - 400 nm

1.1 History of indoor tanning

The first commercial tanning devices were single mercury arc lamps, often causing severe sunburn and acute eye damage due to very high UVB irradiation. In Norway, Nemko AS has performed mandatory safety testing and national approval of electrical equipment to be marketed in Norway from 1933 until 1992. The safety testing did not include radiation safety. According to their register, mercury arc sunlamps were sold in Norway from 1937 (30). On the tanning market world wide, small devices with fluorescent tubes were commercially available in the 1960s, with spectral UVB representing up to 5 % of the output (1).

The first tanning devices in Norway were the mercury arc sunlamps, sold from 1937.

The first whole body tanning model appeared in Norway in 1972, and since 1982 most tanning models were equipped with fluorescent lamps.

A whole body tanning device common in Norway from the late 1980s.

Due to a growing concern world wide about the carcinogenic potential of UVB in the 1980s and 1990s, the UV output of low-pressure fluorescent lamps was shifted towards UVA (1). Indoor tanning was therefore often called "UVA tanning". Though, they still emitted some UVB, which is crucial for induction of a deep, persistent tan. Also high-pressure lamps producing large quantities of long-wave UVA (>335 nm) were marketed, often in combination with low-pressure fluorescent lamps. The high-pressure lamps can emit up to 10 times more UVA than natural sun. In Norway it was restricted to a lower level by the national regulations.

From the late 1990s fluorescent lamps emitting UV that mimic tropical sun with a higher level of UVB, around 4 %, has become more common world wide.

A modern tanning device approved for cosmetic use in Norway in 2003.

2 Regulations

The Norwegian Radiation Protection Authority initiated a process for regulating indoor tanning devices in the late 1970s due to the high incidence of skin cancers in Norway and the many cases of acute sunburn after using the mercury arc sunlamps. It was also desired to exclude the high-pressure lamps with extreme UVA radiance. The process was in parallel with Swedish sunbed regulations.

2.1 First regulation, 1983

The first Norwegian regulations were issued 1 July 1983 with a two year transition time (28).

From this date all tanning models needed an approval from NRPA before being sold, used or advertised in Norway. In addition to irradiance limits, the regulations included requirements for user instructions and labeling. Approval was based on UV measurements from accepted laboratories and was valid for the tanning device with specified sunlamps.

2.1.1 Irradiance limits, 1983-1992

From 1983 the UV irradiance limits were based on ACGIH-weighted UVC and UVB in addition to spectral or unweighted UVA. Irradiances were integrated over the respective wave bands. The Norwegian and Swedish authorities agreed upon these limits being respectively around 4 and 2-2.5 times the UVA and ACGIH-weighted UVB in natural summer sun at 60°N. The new limits excluded the extremely UVC- and UVB-rich sunlamps, as well as extreme UVA-rich lamps, so intens that sunburn easily could happen in only a few minutes in case of a defective or misused timer.

Sunbed irradiance limits in Norway

1983 - 1992		
UVC, ACGIH-weighted	0.002	W/m²
UVB, ACGIH-weighted	0.05	W/m²
UVA, unweighted	200	W/m²
1993 -		
Short wave, CIE-weighted	0.15	W/m²
Long wave, CIE-weighted	0.15	W/m²

See Appendix C for explanation of weighting functions and wavelength regions.

2.1.2 Irradiance limits, 1993-

In 1989 the European Committee for Electrotechnical Standardization (CENELEC) published harmonized European regulations based on an international standard. Tanning models are classified into UV types 1 to 4 according to the CIE-weighted UV irradiance (see Appendix C). Conflicting national regulations had to be withdrawn within a three-year period (34-36).

The Norwegian regulations were revised late 1992 to implement the European Standard, EN 60335-2-27. However, only UV type 3 tanning devices were allowed for cosmetic purposes, i.e. with limited short and long wave UV irradiance. Tanning models approved prior to the revision were still accepted in use. The European Standard also included recommendations regarding exposure times, i.e. the first exposure should not exceed a dose corresponding to 100 J/m² and maximum yearly exposure should not exceed a dose of 15 kJ/m².

2.1.3 Converting 1983-1992 data

To be able to compare the spectral irradiances from different time periods, all results are converted to CIE-weighted values based on conversion functions found from measuring 69 different fluorescent lamp types (10). Thus the 1983-1992 limits is converted to 0.19 and 0.15 W/m² CIE-weighted short and long wave irradiances, respectively. In other words, the limit for short wave irradiance was reduced from 0.19 to 0.15 W/m² in the autumn 1992.

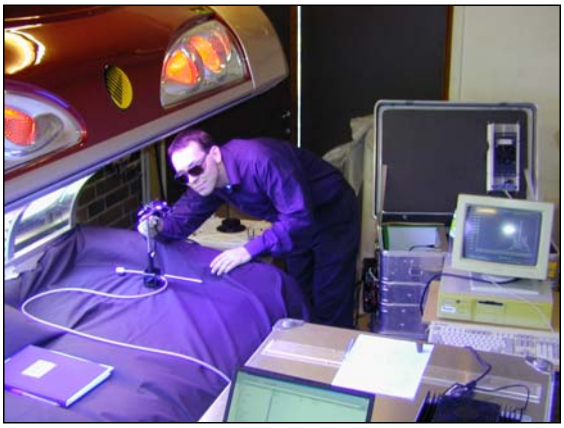
2.2 New regulations, 2004

New regulations regarding radiation protection and use of radiation in Norway took effect from 1 January 2004 (29). With respect to indoor tanning, there is still a restriction to UV type 3 tanning models. Models approved according to the previous regulations, but not classified as UV type 3, were only allowed for a two year transition period until 1 January 2006. Regulations still include requirements for user instructions and labeling. The authority for inspecting tanning facilities and tanning units is now delegated to local authorities.

3 Approval of indoor tanning devices

A total of 496 models of indoor tanning devices from 53 manufacturers were approved in 1983-2005. Irradiance data was available for all except 50 models where acceptances were based on Swedish approvals. The 446 models with available irradiance data include 41 models approved with several lamp types and thereby different spectral output. All approvals are based on type testing performed by

European laboratories, including NRPA's laboratory from 1995. Since 1997, the approval was based on the maximum UV irradiance measured anywhere in the device according to the European Standard (37). Previously, the mean irradiance was usually recorded, i.e. the mean irradiance measured over the surface of the device or at a distance stated in the instructions for use.



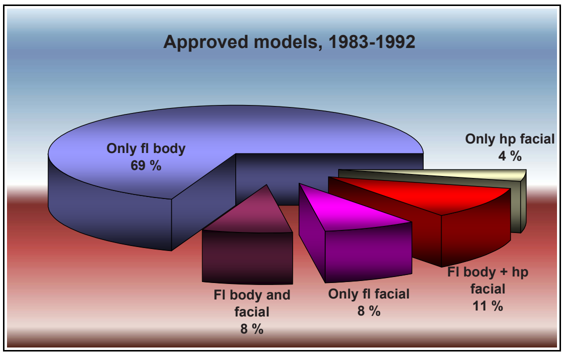
Type testing at the Norwegian Radiation Protection Authority.

Lamp combinations in tanning devices

- Only facial high-pressure lamps
- Only facial fluorescent lamps
- Only fluorescent body lamps
- Fluorescent body lamps + facial high-pressure lamps
- Fluorescent body lamps + facial fluorescent lamps

3.1 Type of models approved

Figure 1 shows that the majority of the approved models in 1983-1992 were equipped with only fluorescent body lamps, and a combination of body and facial lamps from 1993.



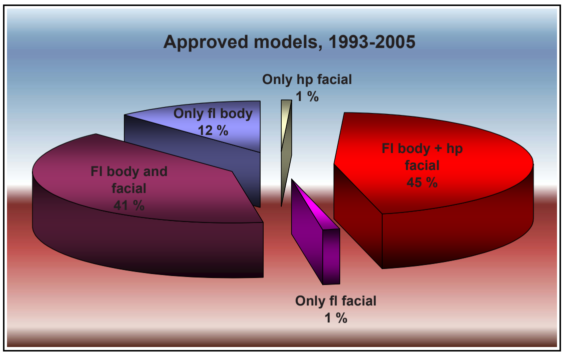


Figure 1. Distribution of the approved tanning models in Norway with respect to type and combination of fluorescent (fl) and high-pressure (hp) lamps.

3.2 Irradiance of approved models

Figure 2 shows the CIE-weighted short wave, long wave and total UV irradiances, before and after 1993 (see also table A1). Values slightly above the limits in 1993-2005 were accepted because of rounding. Two high-pressure lamps with UVA irradiances below the 200 W/m² limit valid in 1983-1992, have CIE-weighted long wave irradiances above 0.15 W/m².

The CIE-weighted short wave irradiance limit was higher in 1983-1992 than in 1993-2005 (0.19 vs. 0.15 W/m²), but the mean short wave values of many approved models were much lower in the first period (Fig. 2). Accordingly, the variation in short wave irradiances was larger in the first than the second period. There was no clear trend in the association between irradiances and calendar year within the two periods.

The average of the approved models' mean and maximum short wave irradiances were doubled in 1993-2005 compared to 1983-1992 (Table A1). Moreover, the percentage of short wave irradiance increased by more than 30 % and the UV index by more than 50 %. Similar results were found for canopy and bench, but not for the facial position (Table A1) or for devices with fluorescent lamps in both body and facial positions (data not shown). Note that there were only six facial units measured in 1983-1992.

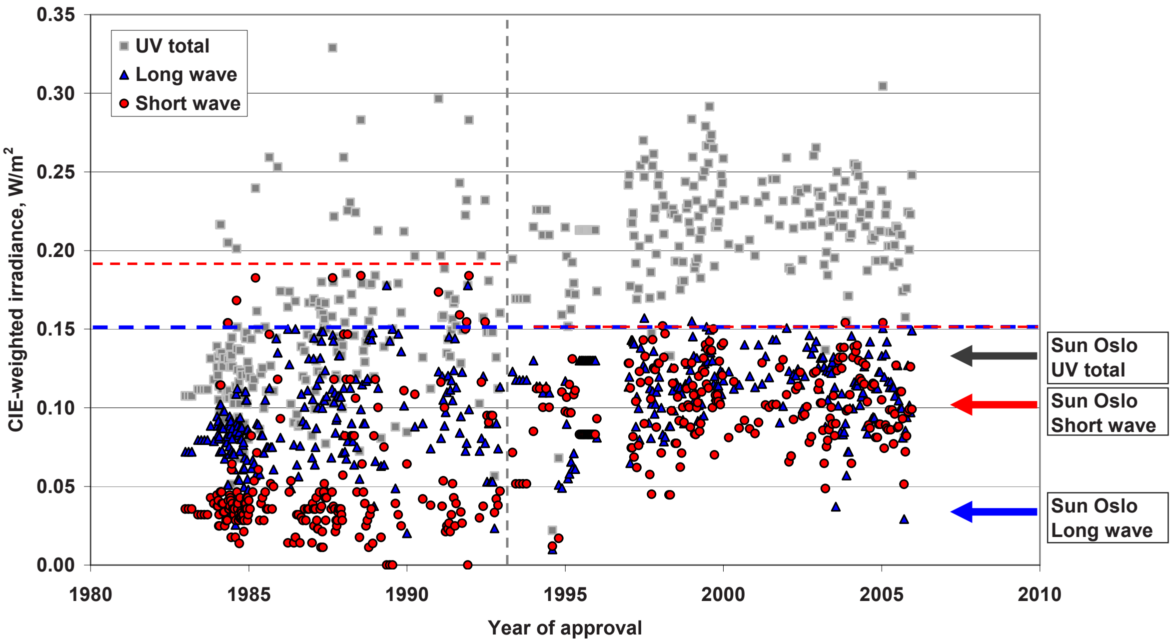


Figure 2. Mean CIE-weighted short wave, long wave and total UV irradiances for tanning models approved for cosmetic use in Norway in 1983-2005. The horizontal lines show the irradiance limits and the vertical line when the new limits were introduced. Yearly number of approved models is given in Appendix A. Corresponding irradiance levels for summer sun in Oslo is indicated to the right. This figure is modified from the publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen et al., DOI: 10.1111 / j.1751-1097.2008.00330.x, Published article online: 9. April 2008).

3.3 Discussion of approved models

The majority of the tanning models approved for cosmetic use in Norway in the 1980s had only body lamps and the short wave irradiance was low. This was in agreement with the general European opinion, i.e. lower UVB to UVA ratio compared to that of natural sun was considered less hazardous, and such lamps dominated the European market in the mid 1980s (40, 41). In 1993-2005, the majority of approved models had fluorescent body lamps combined with either high-pressure or fluorescent lamps in the facial position. Particularly the short wave irradiances were higher, even though the limit became stricter in late 1992. It might be that the regulation process has led to production of new and more UVB-rich sunlamps resulting in an increase in total UV.

There is some uncertainty in converting the spectral data for the most UVA-rich lamps approved in 1983-1992 to CIE-weighted irradiances, since these differ spectrally from the majority of the fluorescent lamps that the conversion factors were based on (10). The ACGIH- and CIE-weighting functions are spectrally comparable for UVB (280-315 nm) and short wave (250-320 nm) wavelengths. The CIE action spectrum, however, has low weighting of the longer UVA wavelengths. Lamps with high UVA irradiance could not be approved with the old spectral limit of 200 W/m², but can be approved with the new limits, e.g. high-pressure lamps (Table A5).

The output variation within the same lamp type can be large. NRPA has found a 20 % variation for some lamp types (data not shown). One should therefore expect the same order of variation in irradiance for the tanning models.

4 Inspections

Two large inspection surveys have been carried out by the NRPA. The inspection survey starting in 1998 included 130 establishments along the coastal road from Bergen (western Norway) via the southern coast to Drammen (southeast Norway). After this first inspection, all establishments received a report presenting the observed violations together with a request for improvements mandatory for further operation. Fifty-six tanning studios were re-inspected in 1999 to check whether the requirements had been implemented.

Inspection survey facts

1998-1999

130 establishments, 1034 sunbeds
77 % unattended establishments
49 different sunbed models
72 % of the sunbeds had incorrect lamps

2003

52 establishments, 307 sunbeds
81 % unattended establishments
67 different sunbed models
41 % of the sunbeds had incorrect lamps

The survey in 2003 included 52 establishments in five municipalities on the east side of the lake Mjøsa (eastern Norway) and the cities Trondheim (central Norway) and Tromsø (northern Norway). All establishments that were identified in the selected regions were inspected, including tanning salons, fitness centres, hairdressing or beauty salons, kiosks, hotels and even a gas station. Most of them were identified from the regional phone catalogues in advance. A few were identified by information from rival establishments throughout the inspections. No announcements were made in advance. We included all tanning devices found in the inspected establishments, 1034 in 1998 and 307 in 2003. Compliance was recorded according to the following criteria and with respect to attendance level of the tanning establishment:

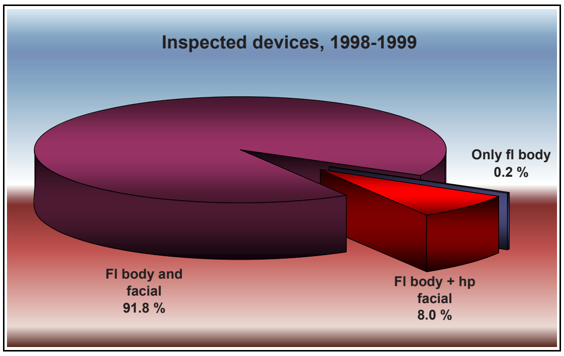
Compliance criteria

- Tanning model approved
- Sunlamps allowed in model
- User instruction and exposure schedule present
- Warning and approval labels present

4.1 Type of inspected tanning facilities and devices

Most tanning establishments were of the unattended or partially attended type in both surveys (Table A2).

The majority of the inspected devices were equipped with fluorescent body and facial lamps (Fig. 3). The 1341 inspected devices constitute 89 different tanning models from 16 different manufacturers.



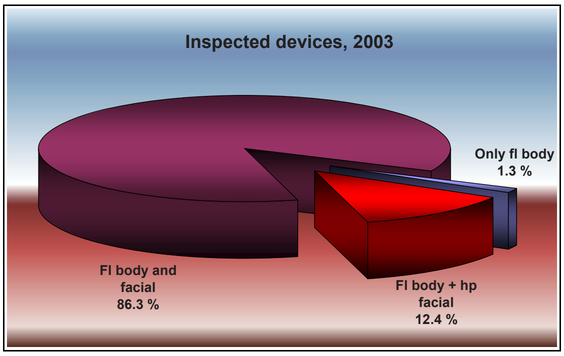


Figure 3. Distribution of inspected tanning devices with respect to type and combination of fluorescent (fl) and high-pressure (hp) lamps.

The most frequently observed model in 1998 was the Miami Sun Suveren 53 IG, followed by Wolff Universal IG and UWE Starflight 38 UPP N. In 2003, the top three list included Wolff Ideal/Perfect, UWE Starflight 38 UPP N and Miami Sun Suvern 53 IG.

4.2 Compliance with regulation

In 1998 only one of the 130 inspected establishments fulfilled all requirements (Fig. 4 and Table A2) and 28 % of the tanning devices were equipped with correct sunlamps, i.e. the type of sunlamps as approved. The follow-up inspections in 1999 revealed improvements for 93 % of the establishments, 36 % of them had carried out all improvements. 48 % had correct sunlamps in all sunbeds. Surprisingly, 13 % of the establishments had installed new lamps that were not according to the approval.

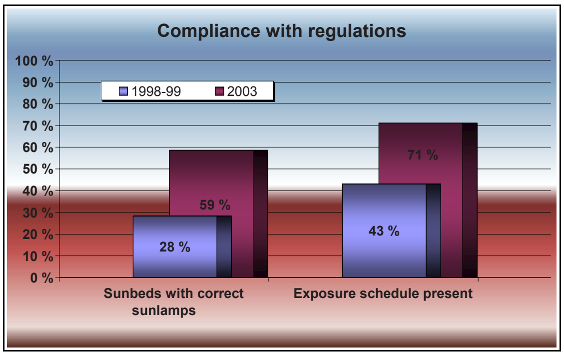


Figure 4. Percentage of sunbeds with correct sunlamps and percentage of establishments providing exposure schedule in the two inspection surveys.

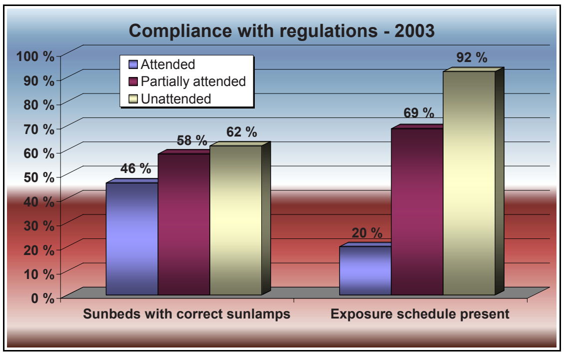


Figure 5. Percentage of sunbeds with correct sunlamps and percentage of establishments providing exposure schedule in the 2003 inspection survey, with respect to attendance level.

In 2003, two out of the 52 inspected establishments fulfilled all requirements and 59 % of the 307 tanning devices were equipped with correct sunlamps.

In both surveys more unattended establishments provided user instruction and exposure schedule than attended ones. The opposite was the case for using correct sunlamps in all sunbeds. However, unattended studios had more sunbeds per studio than the attended ones and therefore more often had at least one sunbed with incorrect lamps. Only looking at the sunbeds, the 2003 survey showed that sunbeds in unattended studios more often had correct sunlamps (Table A2).

The spectroradiometer and the broadband radiometer with UVA and UVB sensors used during the inspection surveys.

4.3 Irradiance of inspected devices

Irradiance measurements were performed according to the European Standard in a representative selection of tanning devices in both inspection surveys. Two different radiometers were used; a high-precision, but large, double monochromator scanning spectroradiometer from Macam Photometrics LTD fitted with a quartz optical light guide, and a handheld broadband radiometer from Solar Light Co with sensors for spectral UVA and CIE-weighted UVB. Based on these measurements, the irradiances were estimated in the remaining sunbeds. Details are found in Appendix A and B.

The mean and percentage of short wave irradiance were in general higher in 1998 than in 2003, while the long wave irradiances were generally slightly lower (Table A3).

Mean and percentage of short wave irradiances and UV indexes were also markedly higher in the inspected tanning devices than the approved models (Tables A1 and A3). The long wave irradiances differed less.

Figure 6 shows the sum of short and long wave irradiances and the UV indexes for the inspected sunbeds as well as for the approval data for the same sunbeds, i.e. when the approval irradiances are weighted according to the number of each model observed during inspection. In both surveys the short wave irradiance of the inspected sunbeds was much higher than when the models were approved (Table A3 and A4). For both surveys the total UV irradiance represented by the UV index was therefore markedly higher for the inspected devices.

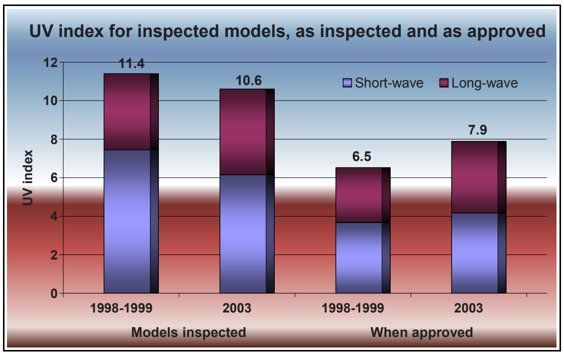


Figure 6. Contribution from short and long wave UV irradiances and UV indexes for the two inspection surveys in 1998-1999 and in 2003 compared to the corresponding values when these devices were approved.

4.4 Discussion of inspected sunbeds

The inspection surveys clearly demonstrated that neither the number and type of approved models nor the irradiances did map those being used most frequently. By the end of 2002, 392 models had been approved (Fig. 2), whereas the 1341 inspected tanning devices represent only 89 different models. The mean short wave irradiance in the first inspection survey was much higher than for the approved models.

The short and long wave irradiances varied within the same range as found in other European studies (8, 12, 16, 27), but the sum (the total UV irradiance) was lower in our surveys. An exception is lower total UV irradiance in a Scottish study in 1997 (14, 15) and on the other hand, an American study from 1999 showed mean UVB irradiance almost twice as high (9). This demonstrates a strong influence from other European countries on the Norwegian market. These studies also showed large variation in UV output between different tanning devices and across the device surface.

A limitation of our inspection surveys is that we did not measure all tanning devices. The output from UV fluorescent sunlamps declines with hours in use (12), and type testing is performed with fluorescent lamps aged for 50 hours (test requirement up to 1997) or 5 hours (after 1997) (36, 37). Acceptance of these uncertainties illustrates our priority; to map UV output for many devices with a simple instrument, rather than only a few devices with a high quality, but less mobile, spectroradiometer.

The main reason for too high short wave irradiances in the inspected devices in 1998 was use of other sunlamps than specified in the approvals. Only 28 % of the devices had correct lamps and thereby complied with the UV type 3 irradiance requirements. It is easy to replace the lamps in a tanning device.

Our surveys reveal the effect of carrying out inspections. The short wave and total UV irradiance decreased from the first to the second survey in Norway. Correspondingly, the number of tanning devices complying with UV type 3 requirements increased from 28% to 59 %. Also Sweden and Finland have national regulations regarding use of indoor tanning, since 1982 and 1987, respectively (31-33). The Radiation and Nuclear Safety Authority in Finland, STUK, performed pre-marketing type inspections of sunbeds in 1989-1993 and market surveillance and inspections (spot checks) of tanning establishments since 1994 (personal correspondence with Reijo Visuri, STUK). An inspection study in Finland in 1998-1999 showed that 90 % of the devices complied with the UV type 3 requirements (18, 19). In Gothenburg in Sweden the corresponding number was 75 % in 2001 (17). The Gothenburg Environment Administration had conducted a campaign in 1999 to supervise tanning facilities according to the regulations. France have national regulations since 1997, and the proportion compliant with technical requirements increased from 51 % when controls started in 1999 to 72 % in 2003 (1).

The IARC Working Group Report from 2006 points out that few countries regulate indoor tanning, and compliance studies show in general poor agreement with regulations (1, 7). In Scotland there has been no national regulations regarding use of tanning devices. Two studies from Scotland in 1997 and 2004-2005 (14-16) showed increased short wave and total UV irradiances, i.e. the opposite trend from what was found in Norway. There is no restriction with respect to UV type in Scotland. For comparison, the number of tanning devices complying with UV type 3 requirements was 17 % in Scotland in 2004-2005.

The improvements seen in Norway for all requirements in the follow up inspections in 1999 and in the inspections in 2003 (Table A2, Fig. 4 and 5) demonstrates the importance of inspections. Much publicity after the first survey may have caused attention to the existence of regulations and motivated for better compliance in Norway.

WHO, ICNIRP and EUROSKIN recommend that indoor tanning facilities have qualified personnel that can guide the customers regarding length and interval of their tanning sessions (3-5). The results of our more technical compliance surveys do not favour any choice of attendance level (Table A2). Note that all Norwegian tanning facilities may be considered unattended since there has been no training requirements for the staff until 2004. Lack of qualified personnel will probably be the case in all countries without national tanning regulations with training requirements. In any case, the debate is essential also with respect to restricting admission to indoor tanning for those with low tanning ability and for minors.

5 Irradiance of indoor tanning compared to natural sun

UV spectra for natural summer sun at noon were simulated for selected locations: the cities Tromsø (northern Norway) and Oslo (southeast Norway), Nice (southern France), Crete (Greece), Gran Canaria (Canary Islands) and Brisbane (Australia). A radiation transfer model, FastRT, was used for the conditions cloudless sky, sand environments, sea level, local noon and midsummer (43-45). Average ozone values for the years 2005 to 2007 at midsummer was used (Table A5). Simulated UV spectra for Oslo were in good agreement with measured spectra.

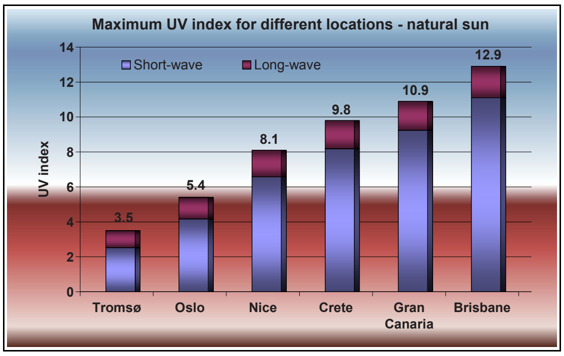


Figure 7. Maximum UV index for different locations at midsummer with the contribution from short and long wave irradiance.

UV irradiances and UV indexes increase with decreasing latitude (Fig. 7 and Table A5). Due to larger increase for UVB and short wave irradiances, the percentage UVB and short wave also increase.

The UV index at Gran Canaria is comparable to the average UV index of the inspected sunbeds in 2003 (Fig. 6 and 7). However, the contribution from long wave irradiance is much higher for the sunbeds.

The spectra for natural sun are further compared to those from three tanning devices with lamps frequently observed during the inspections (Table A5 and Fig. A1). These fluorescent lamps had high either short or long wave irradiance. For comparison, an old mercury arc sunlamp is included. The spectrum for this lamp was measured with a Bentham DTM 300 spectroradiometer (see Appendix B for measurement procedure). The ratio of short and long wave irradiances of these devices compared to that of summer sun in Oslo is:

Ratio of CIE-weighted UV irradiance of tanning devices compared to summer sun in Oslo

Device with lamp type	Short wave	Long wave
Wolff Life Sun S 100W	1.5	1.8
Philips Performance 100W-R	0.96	4.8
Typical high-pressure lamp	0.17	3.2
Mercury arc sunlamp	12	0.29

The only sunbed with higher short wave irradiance than that of natural sun in Oslo is that equipped with sunlamp Wolff Life Sun S 100W, which is spectrally most similar to natural sun. The UV index is twofold for the device with Philips Performance 100W-R, with the UVA and CIE-weighted long wave irradiances markedly higher than for summer sun in Oslo. The UV index for the high-pressure lamp is equal to that of summer sun, but UVA is much higher and UVB irradiances much lower. For the mercury arc sunlamp the situation is opposite. The percentage of short wave irradiance is as high as 99.3 % and the UV index is 10 times higher than for summer sun in Oslo. Mean short and long wave irradiances of the inspected tanning devices in 2003 (Table A3) were 1.5 and 3.5 times, respectively, higher than the irradiance of natural summer sun in Oslo.

Figure A1 in Appendix A shows how the spectra for three of the devices/lamps resemble the spectrum for natural sun, but with some distinct differences such as the irradiance peaks, i.e. mercury lines at 297, 313 and 365 nm. Furthermore, the CIE-weighted irradiance of the high-pressure lamp is lower than that of natural sun for wavelengths below 335 nm and higher for longer wavelengths.

6 Conclusions

Implementation of the first Norwegian regulations in 1983 had important implications for the use and sale of tanning devices. The UVC- and UVB-rich mercury arc sunlamps were replaced by tanning devices with UVA-rich fluorescent lamps. The mean UVA and long wave irradiances of the new devices were much higher than that of tropical sun. Despite the possibility in the regulations for UVB irradiances in tanning devices higher than that of Norwegian summer sun, these were instead much lower. The mean UV index was therefore almost the same as for summer sun in Oslo. As harmonized European limits were implemented in the Norwegian regulations in late 1992, the mean short wave irradiance of the approved models increased to the same level as summer sun in Oslo. Long wave irradiance was still much higher than for natural sun. No time trends were seen within the two periods, 1983-1992 and 1993-2005. The variation in short wave irradiance was large until the UV type 3 limits were implemented. CIE-weighted long wave irradiance of approved models has been about 3-3.5 times higher than for natural summer sun in Oslo in the whole period.

Inspections are essential. Despite strict Norwegian regulations, inspections revealed tanning devices in use with too high short wave irradiance, and being 1.5-2 times that of natural summer sun in Oslo, while long wave irradiances differed less between inspected and approved devices. The irradiances of the inspected sunbeds were similar to other European studies and the ongoing discussion on stricter European regulations is important. Stricter and more uniform European regulations would hopefully lead to production and distribution of more sunlamps and tanning devices complying with UV type 3 requirements.

Our results do not favour any attendance level. Lack of training requirements means that attended facilities may not have provided proper guidance. The debate is also essential with respect to restricting admission to indoor tanning for those with low tanning ability and for minors.

The approval and inspection results form important basis for assessing changes in time with respect to UV irradiance and compliance with regulations. Important changes that may influence future status are more inspections by local authorities, changes in common European irradiance limits as recommended by the Scientific Committee on Consumer Products (6) or establishment of a melanoma action spectrum.

This study has not explored the extent of sunbed use, and can therefore not give any dose estimates. However, the current study adds knowledge of spectral UV information of tanning devices, and is useful for planning and interpretation of studies on sunbed use in relation to adverse health effects (e.g. risk of skin cancer) and potential health benefits (e.g. photosynthesis of vitamin D).

7 Future work

Based on the results in this report, the following topics should be further explored:

- Inspection surveys should be carried out every 5 year to assess changes.
- Surveys exploring the use of sunbeds should be carried out. Important input parameters would be the age when starting indoor tanning, as well as skin type and frequency and length of tanning sessions.
- Common and stricter European regulations should be encouraged since the European market strongly influences the situation in Norway. The attitude towards stricter irradiance limits is positive in several countries and in Europe in general.

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WHO: www.who.int/uv/en/ and www.who.int/uv/intersunprogramme/en/

EUROSKIN: www.euroskin.eu

ICNIRP: www.icnirp.org/

Appendix A – Tables and figures

Table A1. CIE-weighted (erythema) UV irradiances (W/m²) of the approved models of tanning devices in Norway in 1983-2005. This table is from the publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen et al., DOI: 10.1111/j.1751-1097.2008.00330.x, Published article online: 9. April 2008)

		Approved in 1983-1992				Approved in 1993-2005			
		Short wave†	Long wave†	% short wave	UVI‡	Short wave†	Long wave†	% short wave	UVI‡
Mean§ irradiance									
Whole device	*n*	227	229			217	217		
	Mean	0.050	0.091	35.5	5.6	0.101	0.112	47.4	8.5
	(95% CI)	(0.045, 0.055)	(0.088, 0.095)			(0.098, 0.105)	(0.109, 0.115)		
Maximum‖ irradiance									
Whole device	*n*	227	229			217	217		
	Mean	0.053	0.095	36.1	5.9	0.117	0.120	49.6	9.4
	(95% CI)	(0.048, 0.058)	(0.091, 0.099)			(0.113, 0.120)	(0.116, 0.123)		
Irradiance of each part of the tanning device¶									
Canopy	*n*	91	92			203	203		
	Mean	0.050	0.102	33.1	6.0	0.104	0.112	48.1	8.6
	(95% CI)	(0.041, 0.058)	(0.097, 0.107)			(0.100, 0.108)	(0.108, 0.115)		
Face	*n*	6	6			119	119		
	Mean	0.086	0.099	46.7	7.4	0.086	0.115	42.8	8.0
	(95% CI)	(0.048, 0.123)	(0.060, 0.138)			(0.078, 0.095)	(0.109, 0.120)		
Bench	*n*	89	90			191	191		
	Mean	0.054	0.101	34.8	6.2	0.108	0.115	48.4	8.9
	(95% CI)	(0.045, 0.062)	(0.096, 0.106)			(0.104, 0.112)	(0.112, 0.118)		

† CIE-weighted short wave UV: 280-320 nm; long wave UV: 320-400 nm.
‡ UVI = UV index.
§ Mean irradiance of the tanning device.
‖ Maximum irradiance measured anywhere in the tanning device.
¶ Measurements for each part of the tanning device were only available for a few devices approved in 1983-1992.

n = number of sunbeds; CI = confidence interval.

Yearly number of approved models; models where data is missing (i.e. measured in Sweden) in parentheses: 1983: 10 (1), 1984: 78 (4), 1985: 23 (2), 1986: 20 (5), 1987: 46 (7), 1988: 24 (2), 1989: 11 (0), 1990: 4 (0), 1991: 27 (5), 1992: 17 (5), 1993: 9 (4), 1994: 10 (1), 1995: 22 (2), 1996: 2 (1), 1997: 34 (8), 1998: 25 (3), 1999: 32 (0), 2000: 6 (0), 2001: 9 (0), 2002: 14 (0), 2003: 27 (0), 2004: 22 (0), and 2005: 24 (0).

There were 43 different manufacturers of the 229 models approved in 1983-1992 and 27 different manufacturers of the 217 models approved in 1993-2005, all together 53 different manufacturers of the 446 models in 1983-2005.

Pearson correlation coefficient between mean CIE-weighted short wave irradiances of approved models and calendar year was 0.24 in 1983-1992 and 0.17 in 1993-2005. Corresponding correlation coefficients for long wave irradiances were 0.26 and 0.06, respectively.

Coefficients of variation (CVs) for mean short wave irradiance were 77% in 1983-1992 and 25% in 1993-2005, respectively. CVs for the mean long wave irradiances were 31% and 21% for the two periods, respectively.

All statistical analyses were performed using SPSS 13.0 for Windows.

Table A2. Tanning establishments or studios (*n* [%]) complying with regulations as inspected in surveys in 1998-1999 and in 2003, as well as in a follow-up inspection survey in 1999. The percentage for each requirement is given in parenthesis with respect to the total number of establishments or with respect to the number of attended, partially attended and unattended establishments, respectively.

Requirements with respect to tanning establishment or studio	Total	Attendance level*1		
		Attended	Partially attended	Unattended
First inspection survey 1998-1999	**130**	**30**	**52**	**48**
All tanning models approved	130 (100)	30 (100)	52 (100)	48 (100)
All sunbeds equipped with correct sunlamps	15 (11.5)	6 (20.0)	5 (9.6)	4 (8.3)
User instruction and exposure schedule present	56 (43.1)	5 (16.7)	16 (30.8)	35 (72.9)
Poster with precaution text present	37 (28.5)	5 (16.7)	15 (28.8)	17 (35.4)
Warning label present in all sunbeds	20 (15.4)	13 (43.3)	3 (5.8)	4 (8.3)
Approval label present in all sunbeds	14 (10.8)	8 (26.7)	3 (5.8)	3 (6.3)
All requirements fullfilled	1 (0.8)	0 (0)	0 (0)	1 (2.1)
Second inspection survey 1999	**56**	**4**	**29**	**23**
All tanning models approved	56 (100)	4 (100)	29 (100)	23 (100)
All sunbeds equipped with correct sunlamps	27 (48.2)	1 (25.0)	13 (44.8)	13 (56.5)
User instruction and exposure schedule present	43 (76.8)	2 (50.0)	19 (65.5)	22 (95.7)
Poster with precaution text present	41 (73.2)	3 (75.0)	21 (72.4)	17 (73.9)
Warning label present in all sunbeds	44 (78.6)	2 (50.0)	21 (72.4)	21 (91.3)
Approval label present in all sunbeds	34 (60.7)	2 (50.0)	18 (62.1)	14 (60.9)
All requirements fullfilled	20 (35.7)	1 (25.0)	11 (37.9)	8 (34.8)
Inspection survey 2003	**52**	**10**	**16**	**26**
All tanning models approved	50 (96.2)	10 (100)	16 (100)	24 (92.3)
All sunbeds equipped with correct sunlamps	17 (32.7)	5 (50.0)	4 (25.0)	8 (30.8)
User instruction and exposure schedule present	37 (71.2)	2 (20.0)	11 (68.8)	24 (92.3)
Poster with precaution text present	27 (51.9)	4 (40.0)	8 (50.0)	15 (57.7)
Warning label present in all sunbeds	18 (34.6)	4 (40.0)	7 (43.8)	7 (26.9)
Approval label present in all sunbeds	12 (23.1)	3 (30.0)	7 (43.8)	2 (7.7)
All requirements fullfilled	2 (3.8)	0 (0)	1 (6.3)	1 (3.8)
Requirement with respect to sunbeds, 1998-1999:				
Total number of sunbeds	1034	105	433	496
Mean number of sunbeds in each studio	8.0	3.5	8.3	10.3
Correct sunlamps in sunbed	293 (28.3)	-	-	-
Requirement with respect to sunbeds, 2003:				
Total number of sunbeds	307	41	72	194
Mean number of sunbeds in each studio	5.9	4.6	4.5	7.5
Correct sunlamps in sunbed	180 (58.6)	19 (46.3)	42 (58.3)	119 (61.3)

*1 Attendance level is determined by: In an attended facility there is personnel present to guide the customer with respect to exposure time and tanning frequency or to answer questions; in an unattended facility there is no personnel available; in a partially attended facility there are personnel present in an adjacent facility if assistance is needed.

Table A3. CIE-weighted (erythema) UV irradiances (W/m²) of the inspected sunbeds in Norway in 1998-1999 and 2003. This table is from the publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen et al., DOI: 10.1111/j.1751-1097.2008.00330.x, Published article online: 9. April 2008)

		1998-1999				2003			
		Short wave†	Long wave†	% short wave	UVI‡	Short wave†	Long wave†	% short wave	UVI‡
Mean§ irradiance									
Whole device	*n*	1034	1034			307	307		
	Mean	0.186	0.099	65.3	11.4	0.153	0.111	58.0	10.6
	(95% CI)	(0.183, 0.189)	(0.098, 0.100)			(0.147, 0.158)	(0.109, 0.114)		
Maximum‖ irradiance									
Whole device	*n*	1034	1034			307	307		
	Mean	0.239	0.120	67.1	14.2	0.180	0.127	59.2	12.2
	(95% CI)	(0.234, 0.243)	(0.119, 0.122)			(0.173, 0.187)	(0.124, 0.130)		
Irradiance of each part of the tanning device									
Canopy	*n*	1033	1033			305	305		
	Mean	0.168	0.093	64.4	10.4	0.143	0.106	57.4	10.0
	(95% CI)	(0.165, 0.171)	(0.091, 0.094)			(0.137, 0.149)	(0.103, 0.109)		
Face	*n*	946	946			289	289		
	Mean	0.243	0.118	67.3	14.4	0.162	0.117	57.9	11.2
	(95% CI)	(0.238, 0.248)	(0.116, 0.120)			(0.155, 0.170)	(0.114, 0.120)		
Bench	*n*	1034	1034			307	307		
	Mean	0.154	0.088	63.6	9.7	0.155	0.110	58.5	10.6
	(95% CI)	(0.152, 0.157)	(0.086, 0.090)			(0.148, 0.161)	(0.107, 0.114)		

† CIE-weighted short wave UV: 280-320 nm; long wave UV: 320-400 nm.
‡ UVI = UV index.
§ Mean irradiance of the tanning device.
‖ Maximum irradiance measured anywhere in the sunbed.

n = number of sunbeds; CI = confidence interval.

The totally 1341 inspected devices constitute 89 different tanning models from 16 different manufacturers. There were 49 models from 12 manufacturers in 1998-1999 and 67 models from 13 manufacturers in 2003. Twenty-seven models and 9 manufacturers were the same in 1998-1999 and 2003.

All statistical analyses were performed using SPSS 13.0 for Windows.

Table A4. Approval data, i.e. CIE-weighted (erythema) UV irradiances (W/m²), for the inspected sunbeds, weighted according to the number observed of each model

		1998-1999				2003			
		Short wave†	Long wave†	% short wave	UVI‡	Short wave†	Long wave†	% short wave	UVI‡
Mean§ irradiance									
Whole	*n*	1026	1026			304	304		
device	Mean	0.092	0.071	56.4	6.5	0.104	0.093	52.8	7.9

† CIE-weighted short wave UV: 280-320 nm; long wave UV: 320-400 nm.
‡ UVI = UV index.
§ Mean irradiance of the tanning device.
‖ Maximum irradiance measured anywhere in the sunbed.

n = number of sunbeds; CI = confidence interval.

Table A5. UV irradiance of natural summer sun at noon at selected locations and of tanning devices. This table is from the publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen et al., DOI: 10.1111 / j.1751-1097.2008.00330.x, Published article online: 9. April 2008)

	Unweighted UV[†] (W/m²)				CIE-weighted UV[‡] (W/m²)			
	UVC	UVB	UVA	% UVB	Short wave	Long wave	% short wave	UVI[§]
Natural summer sun								
Brisbane, Australia (27°S, 153°E), 279 DU[¶¶]	-[‖]	2.5	67.6	3.5	0.281	0.045	86.1	13
Gran Canaria, Spain (28°N, 15°W), 303 DU	-[‖]	2.2	63.3	3.3	0.236	0.042	84.7	11
Crete, Greece (35°N, 24°E), 320 DU	-[‖]	2.0	61.8	3.1	0.207	0.041	83.4	10
Nice, France (44°N, 7°E), 340 DU	-[‖]	1.7	58.2	2.9	0.167	0.039	81.2	8
Oslo[¶], Norway (60°N, 11°E), 341 DU	-[‖]	1.2	47.3	2.4	0.106	0.031	77.3	5
Tromsø, Norway (70°N, 19°E), 349 DU	-[‖]	0.8	38.3	2.0	0.065	0.025	72.3	4
Fluorescent lamps in tanning device[††]								
Wolff Life Sun S 100W in bench of Miami Sun Suveren 31 IG[‡‡]	-[§§]	1.6	69.1	2.3	0.159	0.056	74.0	9
Philips Performance 100W-R in bench of Hapro Lumina 3211	-[§§]	1.3	204.7	0.6	0.102	0.149	40.6	10
High-pressure lamp in tanning device[††]								
Philips HPA 400W/30S in facial position of Hapro Lumina E40 Sli	-[§§]	0.27	210	0.1	0.018	0.098	15.5	5
Mercury arc sunlamp[‖‖]								
Osram Ultra Vitalux 300W	0.019	5.5	15	27	1.29	0.009	99.3	52

[†] Unweighted UVC: 100-280 nm; UVB: 280-315 nm; UVA: 315-400 nm.
[‡] CIE-weighted short wave UV: 280-320 nm; long wave UV: 320-400 nm.
[§] UVI = UV index.
[‖] Measurements at NRPA of natural sun have shown UVC to be less than $1 \cdot 10^{-6}$ W/m².
[¶] The corresponding ACGIH-weighted UVB for Oslo is 0.02 W/m².
[††] The most frequently observed sunlamp types during the inspection surveys.
[‡‡] Miami Sun Suveren 31 IG is not approved with the sunlamp Wolff Life Sun S 100W.
[§§] UVC was not measured; NRPA laboratory measurements have shown UVC in sunbeds to be less than $3 \cdot 10^{-4}$ W/m².
[‖‖] A previously used mercury arc sunlamp in Norway.

[¶¶] DU = Dobson units.

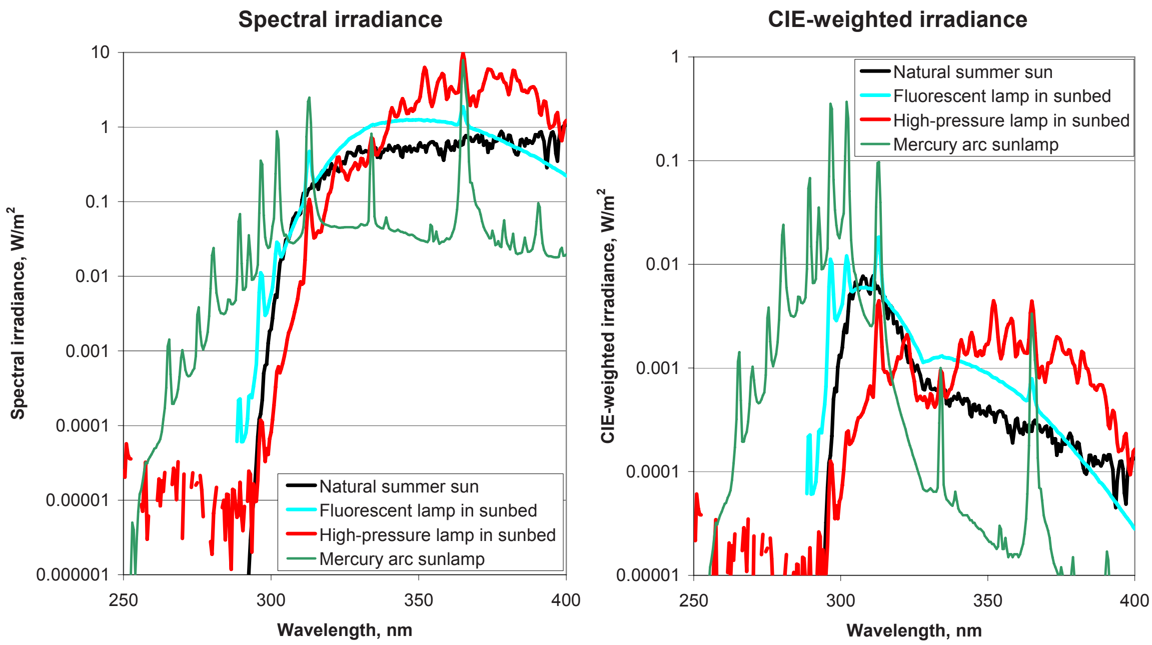

Figure A1. Unweighted and CIE-weighted (erythema) UV irradiance for typical summer sun in Oslo compared to frequently observed sunlamp in the inspected tanning devices, the fluorescent lamp Wolff Life Sun S 100W in bench of Miami Sun Suveren 31 IG (data available from 290 nm), the most common high-pressure lamp, Philips HPA 400W/30S in facial position of Hapro Lumina E40 Sli, and a mercury arc sunlamp commonly used up to about 1980 in Norway, Osram Ultra Vitalux 300W. This figure is modified from the publication in Photochemistry and Photobiology ("Trends in UV Irradiance of Tanning Devices in Norway: 1983–2005", Lill Tove N. Nilsen et al., DOI: 10.1111 / j.1751-1097.2008.00330.x, Published article online: 9. April 2008).

Appendix B – Measurement methods

Approvals

All approvals are based on type testing according to the European Standard, EN 60335-2-27 part 2: ”Particular requirements for appliances for skin exposure to ultraviolet and infrared radiation”. NRPA has performed such tests since 1995.

The measurements at NRPA were performed with a temperature stabilized spectral radiometer of type Macam SR9910 from Macam Photometrics LTD equipped with a double grating monochromator. The front optics was an optical light guide with a 15 mm diameter cosine adapted teflon diffusor. The bandwidth was 1.3 nm (FWHM), and wavelength increment 0.5 nm. The instrument was calibrated with traceability to NIST (National Institute of Standards and Technology) via SP Swedish National Testing and Research Institute. The wavelength and irradiance calibration of the instrument was checked with a mercury lamp and a 1000W QTH-lamp, before and after the measurements. The measurement uncertainty was within ±6 %. The measurements were performed at 24°C and with the appliance supplied at rated voltage (in Norway: 230 VAC ± 10 %), as stated in the European Standard. All fluorescent tubes have been seasoned for 50 hours (up to 1997) or 5 hours and facial lamps for 1 hour prior to the measurements according to the European Standard. The homogeneity and maximum UV-irradiance in the sunbeds was found using a filter-radiometer radiometer (Solar Light Co PMA 2100, UVB sensor head PMA 2101). Since 1997, the approvals were based on the maximum UV irradiance measured anywhere in the tanning device according to the European Standard. Up to 1997, the mean irradiance was usually recorded, i.e. the mean irradiance measured over the surface of the device or at a distance stated in the instructions for use.

Sunbed inspections: some sunbeds are easy to find and inspect, whereas others need closer inspection.

Inspection surveys

Irradiance measurements were performed according to the European Standard in a representative selection of tanning devices in both inspection surveys. Two different radiometers were used; a large double monochromator scanning spectroradiometer from Macam Photometrics LTD fitted with a quartz optical light guide (one sigma level 6 %), and a broadband radiometer (Solar Light Co PMA 2100, sensor head PMA 2101 for the UVB and PMA 2110 for the UVA). The spectroradiometer was irradiance-calibrated against 1000-watt quartz tungsten halogen lamps, traceable to NIST (National Institute of Standards and Technology) via SP Technical Research Institute of Sweden. The wavelength scale was calibrated to match known emission lines from a low pressure mercury lamp. As a routine, the wavelength and irradiance calibrations were tested before and after measurements on a tanning device, and corrections applied if necessary. The broadband radiometer was corrected according to the spectroradiometer. The spectral responsivity of the PMA 2101 UVB sensor head resembles roughly the CIE erythema action spectrum, which made it useful for field measurements. The spectral responsivity of the PMA 2110 UVA sensor head is fairly flat and was thus used to measure the UVA for some of the high-pressure lamps. Broadband measurements were converted to integrated CIE-weighted short and long wave irradiances, applying source-specific conversion factors for the UVB sensor. Conversion factors were derived from intercomparisons of broadband and spectroradiometric measurements on a selection of tanning devices during the first inspection survey and from several type tests at the NRPA laboratory in the whole period 1998-2003. The source-dependent conversion factors varied within ±20% for total UV and within ±35 % for UVB and UVA. The variation is mainly due to a mismatch between the actual spectral sensitivity of the UVB sensor and the ideal CIE-action spectrum and temperature effects for the UVB sensor head. Choosing the wrong conversion factor for a specific tanning device may result in up to ±35 % uncertainty in measurements of CIE irradiance, in addition to the uncertainty in the spectroradiometer calibrations (6 %). The uncertainty was typically less than ±20 %, as the spectral irradiance distribution of most tanning devices was known from laboratory measurements on a large set of different fluorescent tubes and tanning devices.

In the 1998-1999 survey, UV irradiance was measured in 15 tanning devices with the spectroradiometer and in 82 devices with the broadband sensor. In 2003, UV irradiance was measured in 17 devices with the broadband sensor and none with the spectroradiometer. The remaining inspected tanning devices were either identical to one of the devices already measured during the inspections or a device measured previously at NRPA’s laboratory, except for 10% of the inspected devices where the irradiances were approximated based on similar models.

Appendix C- Glossary

UV – Ultraviolet (UV) radiation is the non–ionizing part of the electromagnetic spectrum and ranges between 100 nm and 400 nm.

UVA – is UV radiation from 315 nm to 400 nm.

UVB – is UV radiation from 280 to 315 nm.

UVC – is UV radiation from 100 nm to 280 nm.

Short wave irradiance – is the UV wavelength region from 250 to 320 nm.

Long wave irradiance – is the UV wavelength region from 320 to 400 nm.

Effective irradiance – is a quantity of electromagnetic radiation which is weighted according to a specified action spectrum.

Action spectrum – is the rate of a physiological activity plotted against wavelength. It shows which wavelength is most effective to induce a specific reaction.

ACGIH - is the American Conference on Governmental Industrial Hygienists. The ACGIH-weighting function is a reference action spectrum for UV-induced acute erythema and photokeratitis in humans which is valid for the wavelength range 200-315 nm (38), i.e. UVC and UVB.

CIE – is the Commission Internationale de l'Eclairage. The CIE-action spectrum is a reference action spectrum for UV induced erythema in Caucasian human skin (39) valid for the UV region from 250 to 400 nm.

UV index (UVI) – is the total CIE-weighted irradiance multiplied with 40 m^2/W (42).

UV irradiance – is the power of UV radiation onto a unit surface area, given in W/m^2.

UV dose – is the energy of UV radiation a person receives per unit area and over the time of exposure, given in J/m^2.

UV type – describes the four types of tanning device with respect to the short and long wave UV irradiance:

UV type appliances according to the European Standard, EN 60335-2-27 (37):

UV type	**Irradiance efficiency [W/m²]** Short wave 250-320 nm	**Irradiance efficiency [W/m²]** Long wave 320-400 nm	**Description UV type**
1	< 0.0005	≥ 0.15	Appliance provided with a UV emitter such that the biological effect is caused by radiation having wavelengths longer than 320 nm and characterized by a relatively high irradiance in the range 320 to 400 nm.
2	0.0005 to 0.15	≥ 0.15	Appliance provided with a UV emitter such that the biological effect is caused by radiation having wavelengths both shorter and longer than 320 nm and characterized by a relatively high irradiance in the range of 320 to 400 nm.
3	< 0.15	< 0.15	Appliance provided with a UV emitter such that the biological effect is caused by radiation having wavelengths both shorter and longer than 320 nm and characterized by a limited irradiance over the whole UV radiation band.
4	≥ 0.15	< 0.15	Appliance provided with a UV emitter such that the biological effect is mainly caused by radiation having wavelengths shorter than 320 nm.

The European Standard, EN 60335-2-27, uses wavelength regions that differ from the standard UV wavelength regions. CIE-weighted irradiance limits are given for **short wave** (250-320 nm) and **long wave** (320-400 nm) UV wavelength regions, respectively.

UV emitter (EN 60335-2-27): Radiating source designed to emit non-ionizing electromagnetic energy at wavelengths of 400 nm or less, disregarding the screening effect of any screen or guard that may enclose it.

Dobson units (DU) – is the unit for measurement of atmospheric ozone. One Dobson unit refers to a layer of ozone that would be 10 µm thick under standard temperature and pressure. For example, 300 DU of ozone brought down to the surface of the Earth at 0°C would occupy a 3 mm thick layer.

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