SUMMARY OF “PHOTOBIOLOGICAL SAFETY EVALUATION OF UV NAIL LAMPS”

-All of the nail lamps examined (except for 1 which is rarely used in nail salons fell into the risk 2 category of lighting sources, the highest risk category allowed to be used by the general public in unsupervised conditions.
-The ONLY time the lamps fell into the Exempt category was when the irradiance was measured 20 cm outside of the box...
-If a photosensitivity exists, for any reason, the skin of the customer must be protected.
-Because of the numerous items that can make someone photosensitive at any time, without their knowledge, there is no way to determine what a “safe” exposure limit really is.

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Photobiological Safety Evaluation of UV Nail Lamps

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ABSTRACT

We evaluated six UV nail lamps representative of major US manufacturers to evaluate radiant hazards as defined in ANSI/IESNA RP-27 Recommended Practice for Photobiological Safety. Lamps were evaluated at three positions, 1 cm above the inner surface approximating exposure to the hand and the 20 cm RP-27 non-general light source distance, oriented normal and 45° to the opening. Hazard to skin at intended use distance classified these devices into Risk Group 1 or 2 (Low to Moderate) with S(λ) weighted Actinic UV ranging 1.2–1.7 μW cm^{-2} and 29.8–276.25 min permissible daily exposure. At 20 cm on center and 45° UV risk to skin and eyes were all within Exempt classification. Actinic UV ranged 0.001–0.078 μW cm^{-2} and unweighted near UV (320–400 nm) ranged 0.001–0.483 mW cm^{-2}. Likewise the retinal photochemical blue light hazard and retinal thermal and cornea/lens IR were also Exempt. One device had aphakic eye hazard slightly rising into Risk Group 1 (Low). There were no other photobiological risks to normal individuals. Total exposure following programmed times and steps accumulate to only a small fraction of RP-27 permissible daily occupational exposure. These risks are further mitigated in realistic nonoccupational use scenarios as it is unlikely to be a daily occurrence.

INTRODUCTION

Ultraviolet lamp systems designed for artificial nail coating photo curing processes are found in widespread use in nail salons in the United States, Canada and around the world. These sources, commonly referred to as UV nail lamps, are understandably popular in that they enable both rapid service and aesthetically appealing often intricately detailed results. Concern regarding the photobiological safety of these devices has been raised following a report in the dermatological literature (1) observing two cases of nonmelanoma skin cancer (NMSC) on the dorsum of the hand in middle-aged women with previous exposure to UV nail lights. These physicians alleged that UV nail lamps are comparable to indoor tanning devices and hypothesized that they may present a risk factor for the development of skin cancer warranting further investigation.

In response to the subsequent media coverage of this report we were requested by representatives of the Nail Manufacturers Council on Safety (NMC) to conduct a rigorous photobiological safety evaluation of a variety of nail curing lamps in furtherance of their ongoing UV safety investigations (2). The NMC is an organization formed in 1990 by the parent nonprofit trade association the Professional Beauty Association to gather and provide scientific, technical and training information in several areas including professional standards, sanitation/disinfection and working to ensure safety in their industry (3).

This report details our findings from spectral evaluation of devices, submitted for testing by member companies of the NMC, with respect to photobiological risks to skin exposed inside these devices as well as to skin and eyes at standard distances outside the devices. This study has been presented in part at the RadTech UV/EB Technology Conference & Expo 2012 (4) and subsequently at the 2012 meeting of the American Society for Photobiology (5).

MATERIALS AND METHODS

Testing standards. The measurements described were conducted in accordance with ANSI/IESNA RP-27.2–00 Recommended Practice for Photobiological Safety for Lamps and Lamp System—Measurement Techniques (6) to obtain the information required to determine optical radiation safety as specified by ANSI/IESNA RP-27.1–05 Recommended Practice for Photobiological Safety for Lamps and Lamp System—General Requirements (7) and ANSI/IESNA RP-27.3–07 Recommended Practice for Photobiological Safety for Lamps—Risk Group Classification & Labeling (8). These specifications include risk analyses based upon the earlier American Conference of Government and Industrial Hygienists (ACGIH) Threshold Limit Values (9) for exposure to ultraviolet, visible and near infrared radiation and subsequently adopted as consolidated international standards by the International Illumination Commission (CIE) and the International Electrotechnical Commission (IEC) respectively (10,11).

Under ANSI/IESNA RP-27.1–05, the information a manufacturer should provide, upon request, includes representative spectral distribution data for the optical radiation from the product(s) it manufactures in the form of: (1) spectral radiant power; or (2) spectral radiance; or (3) spectral intensity, or (4) spectral irradiance and the lumen to radiant power conversion factor. Manufacturers should also provide, upon request, available radiometric information relating to the potential hazards associated with the products.

Instrumentation. The spectroradiometer used for these measurements is a Gooch and Housego (formerly Optronic Laboratories) model OL 756 system. This spectroradiometer utilizes a dual source device to check the photometric gain relative to a small tungsten source and wavelength accuracy by checking Hg lines emitted from a small fluorescent source. Before each calibration and measurement the wavelength calibration and gain are checked or established.

The OL 756 spectroradiometer configured with 0.25/0.50/0.25 mm slits and an integrating sphere with a 6 or 20 mm entrance aperture was calibrated using a tungsten filament spectral irradiance standard traceable

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to NIST. The calibration was transferred in 1 nm increments from 250 to 800 nm using procedures established by the Optronic Laboratories for the spectroradiometer and tungsten spectroradiometric standard. The calibration spectrum used is the average of three spectral measurements of the standard. The accuracy of this instrument as used provides an uncertainty of measurement of <5% allowing for source positioning uncertainty estimated at no greater than ~2.5%. Secondary calibration to a deuterium spectroradiometric standard lamp was conducted, scaled to the traceable tungsten lamp and appended to the calibration to extend the spectral measurement range down to 200 nm.

The radiometer/photometer (IR meter) used to measure infrared radiation beyond 800 nm is an IL1400A equipped with thermopile or NIR detectors as appropriate.

Test articles. Six UV nail lamp specimens were submitted for testing by member companies of the NMC. Sample devices were received at various times over a several-month period and each was independently evaluated with the calibrated spectroradiometer. The UV nail lamps consisted of two distinct types of devices, those incorporating fluorescent UV-A sources and units that were LED-based ones.

Three of the devices were fluorescent UV nail lamps systems incorporating 2, 3 or 4 small 9 W lamps. Lamps were of two base types with tubes oriented either perpendicular (in the case of the 2 lamp device) or parallel to the fingers of a hand undergoing a procedure. The tubes in the 3 and 4 lamp units were arrayed in an arc-like configuration to irradiate from above and from the sides of the hand while the perpendicular oriented tubes of 2 lamp unit were in a planar configuration above the fingertips. The other three of the devices were LED-based incorporating arrays of 6 or 32 LEDs or in the case of a single finger unit 1 LED. The LED arrays were mounted in planar configurations oriented generally perpendicular to the fingers in approximately equidistant arcs above the fingertips. The LED32 devices had four of its LEDs oriented in two lateral pairs positioned on either side. For this report, the devices described above are designated as F2, F3, F4, LED1, LED6 and LED32 indicating the number of fluorescent lamps or LEDs respectively.

Some of the UV nail lamp systems were enclosed with openings where the hand is inserted. Others were more open designs where the hand would rest on the surface the device is sitting upon. Consequently, some of the devices had to have openings cut into the bottom of the enclosure to allow the integrating sphere to be positioned at 1 cm above the surface where the hand would rest. Openings were cut as tightly as possible so as to lessen the effects of such modifications on cooling and internal reflective surfaces.

Measurement methods. Spectroradiometric scans were measured at 1 nm intervals from 200 to 800 nm on the devices operating on a circuit adjusted to 120 V AC following a minimum 3 min warm-up period. Spectra were saved to magnetic media and identified using a unique file name to establish the identity of the device measured.

The entrance aperture of the spectroradiometer was positioned to receive the full intensity at each of the three different measurement positions chosen to approximate expected intensities to which a user's skin or eyes might be exposed. Infrared meter readings were taken at equivalent locations and distances. Spectra were measured at two distances, (1) 1 cm above the surface upon which the finger tip rests, to approximate exposure of the fingernail during procedures and; (2) 20 cm, the standard distance for non general light sources (non-GLS) specified by RP-27. At 20 cm, two exposure geometries were considered, centered along a horizontal line directly in front of the opening of the device and also oriented at 45° elevated above this line (Fig. 1).

Summary of analysis. The methodology and equations used in the spectral risk analysis are detailed in ANSI/IESNA RP-27.1–05 & 27.3–07. It should be noted that measurements of this system reported herein were conducted at both a use distance (inside at ~1 cm) and the standard (20 cm) exposure distance, which is estimated to be 5–10 cm closer than users face and eyes would be if sitting erect and not looking down into the device and as such may overestimate potential exposure hazard expected under such use conditions.

Risk assessments of spectral hazards including wavelengths beyond the range, >800 nm, of the spectroradiometer were derived from the sum of the relevant spectroradiometric data and the correspondingly adjusted IR meter readings. The adjustment to the IR measurement consisted of subtracting the integral of the overlapping range, 770–800 nm, of the spectroradiometric data from the analogous meter value. Spectral hazard weighting functions >800 nm were normalized to their highest values and applied as a flat correction function to the meter-based portion of the calculation. For sources with predominant emission in less hazardous longer IR wavelengths, or hazard functions limited to shorter IR ranges, these analyses will result in a relative overestimation of the spectral IR risk.

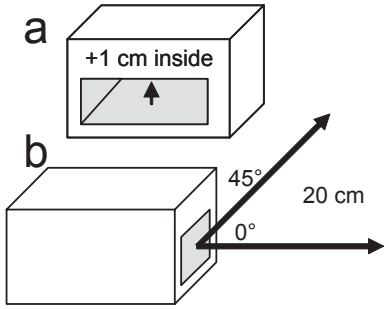

Figure 1. *Measurement Geometry* Spectral analysis was conducted, (a) 1 cm above the surface upon which the finger tip rests during procedures and, (b) non-GLS 20 cm oriented directly in front of the device opening and elevated at an angle of 45°.

The results of the various spectral risk calculations were used to classify the tested UV nail lamp devices into ANSI/IESNA RP-27.3–07 Risk Groups. The criteria for risk group classification are derived from, and relate to, the ACGIH Threshold Limit Values and corresponding applicable exposure limits.

RESULTS

The spectral irradiances measured for the devices are shown in Fig. 2. The fluorescent phosphor emissions are similar but not identical and peak at ~370 nm which is ~30 nm shorter than the LEDs, which peak at ~400 nm. The peak intensity of the LED sources was approximately twice that of the shorter wavelength peak of the fluorescent sources. There were no discernible UV emissions above instrumental detection limits ($\sim 1 \times 10^{-9}$ W cm^{-2}) shorter than ~290 nm for the fluorescent lamps and none less than ~350 nm in the LED sources. Likewise LED emissions began to merge with spectroradiometric background noise ($\sim 1 \times 10^{-8}$ W cm^{-2}) at wavelengths longer than ~650 nm in the visible.

The evaluation of photobiological safety to skin inside the chamber at intended use exposure geometry (Fig. 1a) found that all of the devices fall into Risk Group 2-Moderate Risk (RG-2) for Actinic UV except for unit LED1 (Table 1), which was in Risk Group 1-Low Risk (RG-1). The calculated S(λ) weighted Actinic UV ranged from 0.18 μW cm^{-2} for LED1 up to 1.39 μW cm^{-2} for the four lamp fluorescent unit F4. Permissible exposure times based on the S(λ) weighted irradiance ranged from 16 575 to 2162 s (~4.6 h to ~36 min) respectively. Risk group classification of the devices to eye risks at these distances was not evaluated as ocular exposure at that distance under normal use conditions as it is not practicable.

At the standard 20 cm non-GLS distance measured horizontal at 0° on center, and 45° of the lamp opening (Fig. 1b), the radiant output of all devices was below the maximum allowed for RP-27 Exempt classification for UV risk to skin and eyes (Table 2). Actinic S(λ)-weighted UV ranged from 0.001 μW cm^{-2} for the LED1 unit up to 0.078 μW cm^{-2} for the F3 unit. Unweighted near UV (320–400 nm) ranged from 0.001 to 0.483 mW cm^{-2} with the LED units trending lower in both metrics, slightly overlapping the less intense fluorescent devices.

Likewise at both 20 cm positions, the retinal photochemical blue light hazard, Blue Light B(λ) weighting, were all within the

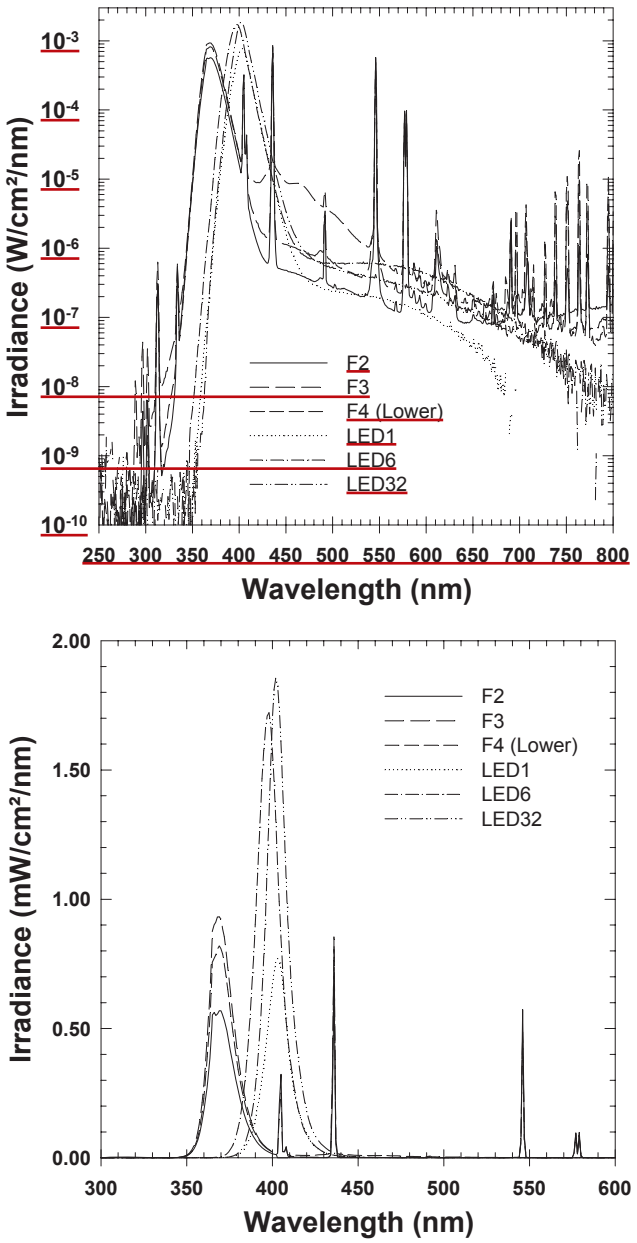

Figure 2. *Irradiance Spectra* The spectral irradiances of each UV nail lamp measured at approximate nail exposure distance is shown in both log (upper plot) and linear (lower plot) scale. The upper plot shows signal background noise at $<10^{-9}$ W cm^{-2} at wavelengths below ~300 nm for the fluorescent sources and below *ca* 350 nm for the LED sources. LED sources likewise fall to lower limits of detection at $<10^{-8}$ W cm^{-2} at wavelengths above ~650 nm. The fluorescent phosphor emissions are similar, but not identical and peak at ~370 nm which is ~30 nm shorter than the LEDs which peak at ~400 nm with about double the intensity.

RP-27 Exempt range. However, one of the devices, the three lamp fluorescent unit F3, was found to present an Aphakic Blue, A(λ) eye hazard (individuals implanted with non-UV blocking intraocular lenses), which was within the RG-1 Low Risk range with an exposure limit of 7 399 s (~2 h) for the 45° measurement. None of the other devices was found to exceed this limit, however, the Aphakic Blue, A(λ) permissible exposure times determined for two of the units approached the 10 000 s minimum for exempt classification and at closer distances or slightly greater variance in irradiance would be expected to enter the RG-1 (low risk) classification.

Table 1. Spectral analysis of UV risk to skin inside device.

UV nail lamp	Actinic UV S(λ) (μW cm^{-2})	Exposure limit (s)	Risk group classification
F2	1.023	2932	RG-2 (Moderate)
F3	1.676	1789	RG-2 (Moderate)
F4 Lower	1.387	2162	RG-2 (Moderate)
F4 Upper	1.349	2225	RG-2 (Moderate)
LED1	0.181	16575	RG-1 (Low)
LED6	0.832	3606	RG-2 (Moderate)
LED32	0.387	7759	RG-2 (Moderate)

Assessment of eye risks inside the device were not conducted.

Thermopile meter readings at either 20 cm position detected negligible IR so retinal thermal and cornea/lens IR, were also Exempt, where indicated, at nearly undetectable levels, therefore, some of the less powerful units were not measured.

DISCUSSION

All of the various UV nail lamps submitted for evaluation were found to be significantly less hazardous than might have been anticipated based on the initial concern raised by MacFarlane and Alonso (1). These findings are consistent with Diffey's concurrent evaluation (12) and Markova and Weinstock's more recent advice (13).

Diffey's thorough adaptation of a multivariate, population-based epidemiologic analysis of relative risk, found only one case of NMSC predicted to occur out of *ca* 45 000–400 000 lifetime regular users depending on the age at which monthly use commenced (12). However, this was based on the spectral output of a single UV nail device.

The work of Markova and Weinstock found that a UV nail lamp user would need some 250 years of weekly sessions to equal the UV burden from a single narrow band UV-B dermatological phototherapy hand treatment (13). Unfortunately, their cursory evaluation of two additional UV nail lamp units is limited by their use of an inappropriate spectrometer. This relatively inexpensive instrument employs a single fixed grating and diode array detector and consequently lacks both the single measurement dynamic range and stray light rejection required to properly evaluate photobiological UV risk as succinctly specified in Annex D of both CIE and IEC/CIE international standards (10,11).

Our comprehensive formal photobiological safety evaluation found only moderate UV risk from the most intense of these devices. It is important to understand that the RP-27 risk group classification is based on an occupational exposure assumption. This means, *e.g.* that an exposure limit determined at 10 007 s, or ~2.78 h, relative to a minimum Exempt Class exposure limit of 10 000 s would be permissible on a daily basis without any requirement for warning or protective measures in the workplace. It seems highly improbable that even the most dedicated nail salon client or avid home user would approach this level exposure.

The RG-2 Moderate UV risk associated with most of the UV nail lamps evaluated at hand exposure distances was associated with permissible daily occupational exposure limits of ~30–130 min. Review of usage instruction pamphlets supplied

Table 2. Analysis of spectral risk to skin and eyes at 20 cm from device directly in front and at 45°.

UV nail lamp	F2		F3		F4		LED1		LED6		LED32	
Observation angle at 20 cm	0°	45°	0°	45°	0°	45°	0°	45°	0°	45°	0°	45°
Actinic UV, S(λ) (μW cm^{-2})	0.010	0.009	0.078	0.052	0.027	- -	0.001	0.002	0.002	0.0016	0.014	0.016
Exposure limit (s)	2.97E+05	3.29E+05	3.84E+04	5.75E+04	1.10E+05	- -	3.21E+06	1.57E+06	1.84E+06	1.84E+06	2.10E+05	1.88E+05
Risk group classification	Exempt	Exempt	Exempt	Exempt	Exempt	- -	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt
Near UV 320–400 nm (mW cm^{-2})	0.105	0.091	0.354	0.483	0.286	- -	0.002	0.001	0.009	0.0073	0.34	0.324
Exposure limit (s)	9528	10934	2827	2070	3491	- -	6.38E+05	6.76E+05	1.09E+05	1.36E+05	2943	3089
Risk group classification	Exempt	Exempt	Exempt	Exempt	Exempt	- -	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt
Retinal thermal, R(λ) (W cm^{-2}sr)	0.0013	0.00073	0.0000018	0.0000015	-nc-	- -	0.0004	0.0004	0.0004	0.0003	0.0134	0.0129
Exposure limit (s)	5.28E+11	5.59E+12	1.47E+23	3.10E+23	-nc-	- -	4.15E+13	6.45E+13	4.65E+13	1.66E+14	4.90E+07	5.71E+07
Risk group classification	Exempt	Exempt	Exempt	Exempt	-nc-	- -	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt
Blue light, B(λ) (W cm^{-2}sr)	0.000053	0.000050	0.0003	0.0004	0.00054	- -	4.00E−05	4.00E−05	4.20E−05	3.10E−05	0.0013	0.00093
Exposure limit (s)	1.89E+06	1.98E+06	3.10E+05	2.45E+05	1.86E+05	- -	2.26E+06	2.53E+06	2.40E+06	3.23E+06	74556	1.07E+05
Risk group classification	Exempt	Exempt	Exempt	Exempt	Exempt	- -	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt
Aphakic blue, A(λ) (W cm^{-2}sr)	0.0018	0.0016	0.00999	0.014	0.0074	- -	0.0002	0.0002	0.0003	0.0002	0.0068	0.0064
Exposure limit (s)	55607	63753	10007	7399	1.35E+04	- -	4.34E+05	4.72E+05	3.92E+05	5.05E+05	14715	15590
Risk group classification	Exempt	Exempt	Exempt	RG-1 (Low)	Exempt	- -	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt
Cornea/Lens IR (mW cm^{-2})	0.27	0.014	0.12	0.048	-nd-	- -	-nd-	- -	-nd-	-nd-	3.60E−05	5.70E−05
Exposure limit (s)	1.25E+05	6.49E+06	3.83E+05	1.26E+06	-nc-	- -	-nc-	- -	-nc-	-nc-	1.80E+10	1.00E+10
Risk group classification	Exempt	Exempt	Exempt	Exempt	-nc-	- -	-nc-	- -	-nc-	-nc-	Exempt	Exempt
Low luminance retinal IR (W cm^{-2}sr)	0.0012	0.00018	0.00085	0.00035	-nd-	- -	-nd-	- -	-nd-	-nd-	0.01	-nc-
Exposure limit (s)	-nc-	-nc-	-nc-	-nc-	-nc-	- -	-nc-	- -	-nc-	-nc-	-nc-	-nc-
Risk group classification	Exempt	Exempt	Exempt	Exempt	-nc-	- -	-nc-	- -	-nc-	-nc-	Exempt	-nc-

Spectral weighting functions S(λ),R(λ), B(λ), A(λ); (-nc-) not calculated; (-nd-) none detected; (- -) not measured.

with several of the UV nail lamps revealed that the accumulated exposure time for even the more complex aesthetic nail procedures is significantly less than this, in some cases many times less. For example nail lamp LED32 has four preprogrammed exposure settings, 16, 30, 45 and 60 s relative to the 7759 s Actinic UV S(λ) maximum permissible exposure time we calculated for this unit. Clearly, the total exposure following programmed exposure times and exposure steps accumulate to only a small fraction of the permissible daily exposure under ANSI/IESNA RP-27. This risk is further reduced in realistic use scenarios as it is unlikely to be a daily occurrence, *e.g*. exposures of 10 min or less per nail service that is repeated twice monthly.

The direct target of the UV nail lamp apparatus is of course the nail and so it is logical to consider the UV susceptibility of the viable tissue of the nail bed. A UV transmittance study of human fingernails (14) found that the nail plate completely blocked UV-B and attenuated UV-A to between $\sim$0.5% and $\sim$2.5% of incident radiation upon the nail surface. Consequently, the UV exposure risk to the nail bed is comparable to that of skin protected by a durable high SPF topical sunscreen. Given the mobility of the hands and fingers it is impossible to describe a single typical sun exposure geometry for the fingertips adjacent to the nail. However, casual observation of the fingers of an individual in a comfortable upright position suggests that given the natural downward angle and relaxed curved position fingertips might receive considerably less ambient exposure than the dorsum of the hand.

The UV exposure typically required to induce a minimally perceptible erythema or minimal erythema dose (MED) varies with anatomical location (15). The dorsum of the hand is naturally the most UV acclimatized, photoadapted, UV-resistant body site. To produce similar sunburn, the back of the hand requires about four times more UV exposure than the cheeks, chest or abdomen and about double the exposure to the dorsal arm or ventral forearm. While cumulative lifetime UV exposure is associated with increased incidence of NMSC one should also note that UV photoadaptation also affords enhanced repair capacity (16,17) of UV-induced genomic lesions.

MacFarlane and Alonso (1) suggested a comparison between UV nail lamps and tanning beds and relative risks therefrom. In the United States, sunlamps are regulated by the FDA as Class 1 medical devices subject to special controls. These include a performance standard, codified in Federal Law as 21CFR 1040.20 (18), and several attendant FDA guidance policies including a technical guidance document (19) for manufacturers on how to calculate the acceptable maximum timer setting and exposure schedule for tanning bed devices. While not part of the RP-27 photobiological safety evaluation, application of these sunlamp calculations to the UV nail lamps provides an objective index of direct comparison of these two types of UV sources.

When we subjected our UV nail lamp spectral data to the analysis that would be required of tanning devices, the FDA prescribed maximum exposure time, or Te, would be; 234 min for F2, 145 min for F3, 176 min for F4, 1342 min for LED1, 303 min for LED6 and 630 min for LED36. Therefore, the maximum timer settings for these sources if employed as miniature hand tanners would range from about 2.4 to 22.4 h, obviously much longer duration than any aesthetic nail procedure. The FDA sunlamp exposure guidance policy (19) also includes a 4-week, 3-day-a week, exposure schedule for unacclimatized tanners which defines the first week initial exposure, or Ti. The Ti times that we calculated for these UV nail lamps were 2630.18, 1630.17, 1940.44, 15090.67, 3405.68 and 7081.02 s, respectively, which is comparable to the RP-27 Actinic UV S(λ) maximum permissible exposure times shown in Table 1.

Since 2000 there has been a CIE Standard (20) for the Non-Melanoma Skin Cancer Action Spectrum. In 2004, we used this NMSC action spectrum to evaluate UV tanning units under the guidelines of an IEC proposed standard (21) for tanning beds, subsequently published (22) in the proceedings of a CIE Expert Symposium in Vienna. When the UV nail lamps evaluated in this report are compared together with these earlier sunlamp computations (Table 3) we find the nail lamps vastly less hazardous. In terms of NMSC-weighted exposure, the most powerful UV nail lamp was more than an order of magnitude less than the most powerful sunlamp. None of the UV nail lamps exceeded 0.008 mW cm^{-2} of NMSC-weighted UV irradiance.

Ultraviolet radiation is unquestionably photocarcinogenic; however, this must be considered alongside ubiquitous UV in the environment at substantial levels. Using spectral weighting relative to overhead and mid angle sunlight (23,24) the UV nail lamps (Table 3) had 11–46 times less NMSC effective irradiance than an overhead 1 atmosphere solar spectrum and 3–12 times less than mid angle 1.5 atmosphere sun.

Notwithstanding the comparatively trivial UV risks associated with UV nail lamps there are some reasonable and potentially serious concerns involving these devices that should be discussed. We did not evaluate these devices at negative viewing angles where there could be a direct optical path from the sources to the eye. We are advised (J. B. O'Hagan, personal communication) this exposure scenario may present an increased eye risk to small children in close proximity to the treatment area. Accordingly, it may be prudent to position the devices in a manner to preclude this from occurring. Likewise adults, salon employees and clients alike, should be discouraged from peering closely into these devices since higher irradiances will be encountered at distances closer than we evaluated.

Phototoxicity, photoallergy and UV hypersensitivity can also present problematic scenarios from even low level UV skin exposures such as these. Users of sunlamps are cautioned by the FDA (25) not to tan if taking medications that increase photosensitivity. Handling certain fruits and vegetables is likewise known to cause sometimes severe photodermatitis (26–29) and

Table 3. Comparison of IEC indoor tanning annual nonmelanoma skin cancer (NMSC) exposure limits to sunlight and UV nail lamps.

UV source	Annual limit (h/25 kJ NMSC)
UV Type 5 tanning booth	8
CIE AM1G 77/1 overhead sunlight	10
UV Type 4 body tanning lamp	13
UV Type 4 facial tanning lamp	15
UV Type 3 body tanning lamp	17
CIE AM1.5G 77/2 mid-angle sunlight	29
UV Type 3 facial tanning lamp	39
UV nail lamp LED6	88
UV nail lamp F3	96
UV nail Lamp F4	114
UV nail lamp F2	154
UV Nail Lamp LED32	169
UV Nail Lamp LED1	368

The shorter the exposure time to reach the 25 kJ m^{-2} NMSC effective dose, the greater the NMSC risk.

comparable warning statements may be appropriate for UV nail lamps also. Individuals who suffer from various photosensitivity disorders, such as lupus erythematosus, polymorphous light eruption or idiopathic solar urticaria to name a few, are advised against venturing into natural sunlight without proper protection and should be cautious about using UV nail lamps. Certainly people who suffer from xeroderma pigmentosum or who have a clinical history of skin cancer should scrupulously avoid UV exposure altogether.

The most significant hazard for both photosensitive and normal individuals associated with UV nail lamps is the potential for incorrect lamp, or bulb, substitution. The fluorescent UV nail lamps we evaluated had standard lamp bases. Of particular concern are the PL-S 9 W lamp base fixtures. Our laboratory has tested other types of UV devices that utilize this common lamp base. Lamps swapped from two different small UV-B medical phototherapy lamps, a broad band FS type and a narrow band 311 nm phosphor, both easily fit and functioned in two of the UV nail units. Injurious exposure can easily be achieved by incorrectly substituting UV-B lamps in these devices, particularly the broad band FS type.

Of greatest concern was a 9 W short wavelength UV-C germicidal bulb that fit and ignited in both PL-S 9 W UV nail devices. Exposure resulting in significant injury from incorrect substitution of a UV-C germicidal bulb will occur in significantly shorter times than are used for normal UV nail lamp operation. Furthermore, the potential ocular hazard even at arm's length from such a mistakenly substituted UV-C lamp is quite alarming.

These inappropriate PL-S 9 W UV-B and UV-C bulbs are inexpensive and easily available from a number of online general lamp suppliers. We are concerned that similar spectrally mismatched replacements could also be obtained for the other fluorescent lamp base. Consequently, the strongest admonition against replacing any UV nail lamp bulbs with anything other than original equipment manufacturers (OEM) replacements is paramount. We are advised that this information is currently being taught in at least one widely used educational text for nail technicians (30), but all manufacturers of these devices should take steps to ensure that users are properly educated about the importance of correct bulb replacement and warned about the serious risks associated with use of non-OEM bulbs. The potential hazard from the UV-C germicidal type bulb is such that engineering controls preventing such occurrences may be warranted.

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