Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

Estimation of Lifetime Ocular Ultraviolet (UV) Exposure Levels in the Rural and Urban South Indian Population using Meteorological Data from Tropospheric Emission Monitoring Internet Service

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***Abstract*— Measurement of ultraviolet radiation (UVR) on humans is a complex task. It is not advisable to place large ultraviolet (UV) measuring devices on any human body. It is important to assess the lifetime UV exposure to calculate its adverse effects. There are many ways of assessment of UV radiation on humans. To provide cumulative lifetime exposure assessment, the geographic information and the UV levels through tropospheric emission monitoring internet service is used in the Melbourne Visual Impairment Model. This study provides lifetime UV exposure levels estimated in the South Indian population using this new model.**

***Keywords*— UV exposure; population-based study; troposhere; meteorology**

I. INTRODUCTION

Global atmospheric changes such as depletion of ozone increase the level of ultraviolet radiation (UVR) reaching earth. This can have adverse effects on human health including ocular conditions. The acute effects of UVR on eye were found to be photokeratitis, photoconjunctivitis and other long-term effects such as pterygium, pinguecula, pseudoexfoliation, cataract, squamous cell carcinoma, and macular degeneration [1]. Dosimeters and UVR photodiode sensors are used to assess UV exposure levels at that particular point of time along with the help of spectrophotometers [2]. There are also polysulphone based contact lenses which assess ocular exposure [3]. But these techniques provide only the exposure on that particular day or time. It is also difficult to employ these techniques in large epidemiological studies. The current study describes the method for assessing lifetime UV exposure based on internet service from the Royal Netherlands Meteorological Institute [4] and the Melbourne Visual Impairment Model of ocular UV exposure estimation [5]. The aim of the current study is to estimate lifetime ocular UV exposure levels and understand the difference in the rural and urban South Indian population.

II. MATERIALS AND METHODS

A. Study subjects:

This was a part of the epidemiological named the Chennai Glaucoma study [6] that was designed with a view to gather information on the prevalence of glaucoma in rural and urban South India. The study was approved by the institutional review board and was conducted as per the tenets of Helsenki. A total of 7785 persons, above 40 years of age, from rural Tamil Nadu and Chennai city were examined at a special facility created at the base hospital. Representing the rural south Indian population 3924 subjects participated from 27 contiguous villages of Thiruvallur and Kancheepuram districts of Tamil Nadu. Urban subjects, numbering 3850, randomly chosen from five divisions from Chennai city participated. Every patient underwent a detailed ophthalmic evaluation, which included dilated fundus evaluation. They were called for a follow-up examination after six years to assess the incidence of eye disease. A subset of these subjects was enrolled for this UV exposure estimation study.

B. Personal UV exposure assesment

The standardized questionnaire from Melbourne Visual Impairment Model used for estimating the ocular UV exposure [5]. This questionnaire on lifetime migration (place of residence) was administered by single person to all eligible subjects. Information from birth till the date of questionnaire administration was elicited. Place of residence along with information on the year or period pertaining to was noted for each subject. Information on occupation or specific task performed while residing at those locations was also documented. Exact hours of exposure to sunlight with respect to each task was also documented.

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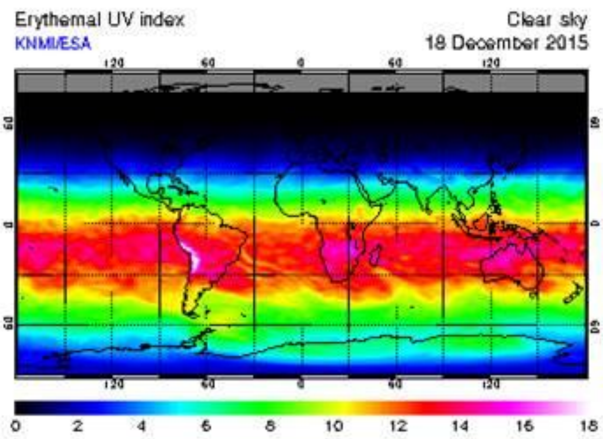
C. Geographical UV Dose Calculation

UV index is an estimation of UV levels, important for its effects on the human skin, where 1 unit equals 25 mW/m^2. UV index estimated for local solar noon, when Sun is at its highest point in the sky (Fig 1). It is valid for clear sky condition and does not account for cloud shielding. Of the global UV radiation at the ground, 94% is UV-A, 6% is UV-B of the

Figure 1: UV index levels



This figure describes the UV index forecast from the tropospheric emission monitoring internet service, taken on 18th Dec 2015.

erythemal UV irradiance, however, 17% is UV-A, 83% is UV-B [7].

The UV dose is the effective UV irradiance (given in kJ/m^2) reaching the Earth's surface integrated over the day. The UV dose is based on CIE action spectrum for susceptibility of caucasian skin to sunburn (erythema). UV dose is the integration of the erythemal UV index, as derived from satellite observations, from sunrise to sunset, with a time step of 10 minutes (www.temis.nl.)[5]. The integration takes cloud cover into account and thus leads to an estimate of the daily erythemal UV dose: total amount of UV radiation absorbed by human skin during the day, expressed in kJ/m^2. But as it is not possible to estimate the cloud cover minute by minute, UV dose is estimated for clear sky situation.

The latitude and longitude of each place from the questionnaire was noted for each life period. Respective UV dose (J/cm^2) for each place was computed for each month. UV dose was recorded from www.temis.nl on 28th day of every month over a twelve month period. Thus annual UV dose for the respective location was calculated. The data at each place will be taken as the location factor for each location in the Melbourne Visual Impairment Model.

D. Lifetime ocular UV exposure estimation

Information collected from the personal UV exposure estimation questionnaire and the UV dose for the respective location calculated based on geographic location details are fitted in the Melbourne Visual Impairment Model as given below:

$$OE\ eff = {}_{s=1}\Sigma^{n}\, years_s \times LF_s \ +$$
$$_{p=1}\Sigma\, years_p \{[hrsday_p \times 5/7 \times LF_p] \times [hatday_p \times 0.53 + (1\text{-}hatday)]_p] \times [sungday_p \times 0.07 + (1\text{-}sungday)]_p] \times [glsday_p \times 0.21 + (1\text{-}glsday)]_p]\}$$
$$+$$
$$\{[hrsleis_p \times 2/7 \times LF_p] \times [hatleis_p \times 0.53 + (1\text{-}hatleis)]_p] \times [sungleis_p \times 0.07 + (1\text{-}sungleis)]_p] \times [glsleis_p \times 0.21 + (1\text{-}glsleis)]_p]\}$$

Where
OE_{eff} = lifetime effective ocular exposure
$years_s$ = number of school years in period $_s$
LF_s = Location factor, constant value for $_s$ location
$years_p$ = number of years in life period $_p$
$hrsday_p$= number of hours spent outside in weekday, period $_p$
LF_p = Location factor, constant value for p location
$hatday_p$= % of time that the person wore hat in weekday, period $_p$
$sungday_p$= % of time that the person wore sunglasses in weekday, period $_p$
$glsday_p$= % of time that the person wore glasses in weekday, period $_p$
$hrsleis_p$= number of hours spent outside in leisure time, period $_p$
$hatleis_p$= % of time that the person wore hat in leisure time, period $_p$
$sungleis_p$= % of time that the person wore sunglass in leisure time, period $_p$
$glsleis_p$= % of time that the person wore glasses in leisure time, period $_p$

Use of protective devices such as hat, umbrella, spectacles or sun glasses during outdoor exposure of work was graded and weighted as 0-Never, 0.25 - Less than half of the time, 0.50- Half of the time, 0.75 – More than half of the time, 1-always.

E. Statistical analysis

Collected data were fed into Microsoft Excel and checked for data entry errors. Statistical analysis was performed using SPSS Version 15(SPSS In, Chicago, IL). Subjects were classified into four groups based on baseline age – 40 to 49 years, 50 to 59 years, 60 to 69 years and 70 years and above. Statistical significance was set at the $p < 0.05$ level.

III. RESULTS

We have included 2091 subjects (1080 rural subjects and 1011 urban subjects). Posthoc power analysis revealed 100% power in estimating the difference of UV dose levels between rural and urban population.

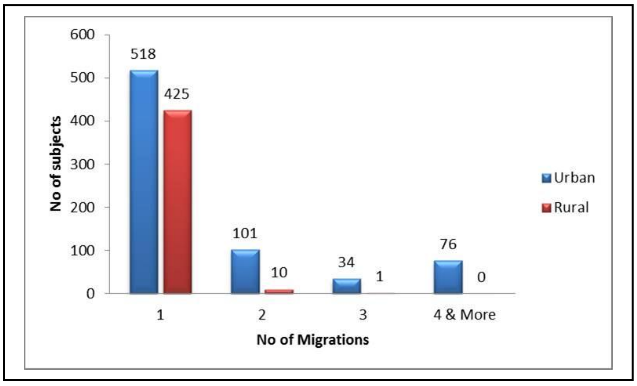
A. Distribution of migration details among rural and urban population

In this study, the participants were questioned on the migrations from their birth. The details of number of migrations by each individual are plotted in the graph (Fig. 2). Majority of subjects had less than 1 migration in their lifetime (89.4%). About 59.6% of the rural participants did not migrate from their birth place.

B. Age and gender distibution of the study population

The age and gender distribution of the study population is given in the table below (Table 1). There was significant difference in the number of male versus female participants with increasing age group (p <0.001).

Figure 2: Number of migrations



This figure provides the description of number of migrations from birth in rural and urban study population

TABLE 1: Distribution of male and female in different age groups

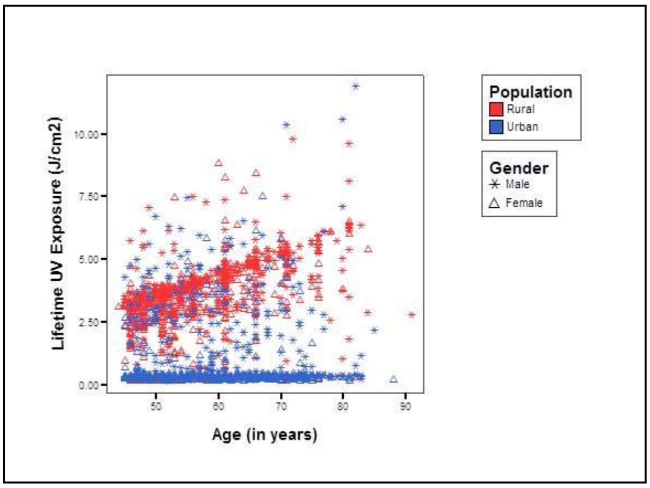
Age Group (in years)	Male	Female
40-49	128	347
50-59	327	453
60-69	270	291
>70	169	106
Total	894	1197

p value: <0.001, chi square test

C. Distribution of lifetime ocular UV exposure levels among male and female of urban and rural population

Median lifetime ocular UV exposure levels among rural and urban was estimated to be 3.35 (IQR 1.98) and 0.33 (IQR 0.12), respectively (p <0.001). Median lifetime ocular UV exposure levels among male and female was estimated to be 2.15 (IQR 3.53) and 0.37 (IQR 3.06) respectively (p <0.001). Distribution of lifetime ocular UV exposure levels among male and female of urban and rural population with increasing age is given in the scatter plot (Fig. 3)

Figure 3: Distribution of lifetime ocular UV exposure levels among male and female of urban and rural population



IV. DISCUSSION

To the best of our knowledge this is the first study describing the difference in lifetime ocular UV exposure in the rural and urban South Indian population. Current study has used the tropospheric emission monitoring system to get the details of UV exposure and averaged it to achieve the annual UV dose for each geographic location. Use of internet based system is described here which can be used in epidemiological studies to estimate lifetime personal UV exposure levels.

Current study documents the (delete the) clear difference in UV exposure levels among rural and urban South Indian population. This difference could explain the reason for the differences in the prevalence of ocular diseases such as ptreygium, pinguecula, cataract etc., where exposure to UV is one of the major risk factor [8-11].

It is also evident that increasing age is directly proportional to the UV exposure levels as the levels are of sequential accumulation with years of exposure. It is also evident that men are at more risk than women in terms of exposure. The number of hours of exposure is higher among male than the female participants. This increases risk of ocular disease due to UV exposure to be more pronounced in male.

The current study has the limitation of using questionnaire to elicit information from birth till date. There is a possibility of recall bias involved in this process. This limitation is kept low as the questions were straight- forward and not complicated questions.

Thus the current study concludes on the significant difference in the lifetime ocular UV exposure levels among rural and urban South Indian populations. This would help the clinicians to plan the management of preventive care while prescribing the spectacles or creating awareness in subjects working at rural areas.

ACKNOWLEDGMENT

We thank the funding agency, the Chennai Willingdon Corporate Foundation, for their continued support throughout the study. Mr Ronald van der A, Climate Observations KNMI (Royal Netherlands Meteorological Institute) for his help towards data capturing from TEMIS.

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