Determination of Sun Protection Factor (SPF) of Various Commonly Used Sunblock Cosmetics

A project submitted

by

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ID: 13346018

Session: Summer 2013

to

The Department of Pharmacy

In partial fulfillment of the requirements for the degree of

Bachelor of Pharmacy (Hons.)

Dhaka, Bangladesh

January, 2018

Dedicated to my parents, siblings and my project supervisor Dr. Mesbah Talukder

Certification statement

This is to certify that, this project titled 'Determination of Sun Protection Factor (SPF) of Various Commonly Used Sunblock Cosmetics' submitted for the partial fulfillment of the requirements for the degree of Bachelor of Pharmacy from the Department of Pharmacy, BRAC University constitutes my own work under the supervision of Dr. Mesbah Talukder, Associate Professor, Department of Pharmacy, BRAC University and that appropriate credit is given where I have used the language, ideas or writings of another author.

Amin Sajid

Dr. Mesbah Talukder

Acknowledgement

First and foremost, I would like to express my gratitude to Almighty Allah for keeping me in good health and helping me in the completion of this research and preparation of this paper.

I would also like to express gratitude towards my parents for their constant efforts in giving me support and inspiring me to purse my dreams. Without whom I would not be the person I am today.

I would like to express my special appreciation and thanks to my supervisor Dr. Mesbah Talukder, Associate Professor, Department of Pharmacy, BRAC University for his continuous provision, guidance and patience since the first day of the project work. As a person, he has continuously inspired and motivated me with his skilled knowledge which made me more passionate about the project when it began. I am really indebted to our honorable chairperson, Dr. Eva Rahman Kabir, Chairperson, Department of Pharmacy, BRAC University, for her support, encouragement and kind cooperation all through the project.

Finally, I would like to thank the laboratory officers and assistants for their continuous guidance and cooperative attitude.

Amin Sajid

Abstract

Solar radiations especially UV-A and UV-B are responsible for developing skin cancer and sun burn respectively. To prevent the occurrence of such harmful effects, various sunblock products principally sunscreens are used. Sun Protection Factor (SPF) is a measure of protection from solar radiation that sunblock cosmetics provide and is labeled in the packaging of such product. Present study was performed to verify whether the manufacturers are providing the labeled amount of SPF or not and to compare various sunblock products claiming to provide protection from UV-B radiation using an *in vitro* method. Absorbance of ultraviolet radiation of these products were measured using an UV-vis spectrophotometer and then SPF was calculated by using the absorbance values. Sunblock cosmetics selected for the study were based on a pilot scale survey involving 130 participants (87 female and 43 male). All the respondents were students of BRAC University and the selection was random. Based on the survey total twenty commonly used sunblock cosmetics were purchased from various locations to determine the SPF values. Out of the 20 products, 1 gave SPF value higher than the claimed amount, 7 were close, 5 were lower and 7 had zero SPF value. Then the found values were used to verify and compare the effectiveness of the products based on purchasing place. The study concluded that the found SPF of sunblock products purchased from pharmacy and abroad were very close to the labeled amount and the SPF of products purchased from other locations including shopping mall, chain shop were either zero or very lower than the labeled amount.

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List of Acronyms

CF	-	Correction Factor
DALYS	-	Disability-Adjusted Life Years
EE	-	Erythema Effect Spectrum
FDA	-	Food and Drug Administration
FIR	-	Far Infrared Region
I	-	Solar Intensity Spectrum
IARC	-	International Agency for Research on Cancer
IR	-	Infrared
MED	-	Minimum Erythema Dose
NIR	-	Near Infrared Region
SPF	-	Sun Protection Factor
UV	-	Ultraviolet
UVA	-	Ultraviolet- A
UVB	-	Ultraviolet- B
UVC	-	Ultraviolet- C
UVR	-	Ultraviolet Radiation
UV-vis	-	Ultraviolet-visible
WHO	-	World Health Organization

Chapter 1: Introduction

Even though life on earth could not endure without the sun's life-generating energy, the constant bombardment of radiation has its harmful side-effects as well. Limited exposure to sunlight can provide enormous health benefits, but overexposure can lead to life-threatening health issues. Careful managing of exposure to solar radiation and properly using sunblock agents is the crucial part of maintaining good health.

1.1 Rationale of the study

Continuous depletion of ozone layer has put us at a greater risk of getting affected by the harmful radiations of the sun. Use of sunblock cosmetics has become an essential part of our everyday life. Another serious concern in our country is counterfeit cosmetics. So, protection from sun rays is difficult to ensure by using sunblock cosmetics because of the counterfeit product. Therefore, the purpose of the study is to enlighten about the harmful effects of solar radiations, necessity of using sunblock agents, measuring and comparing the effectiveness of some frequently used sunblock cosmetics based on in vitro determination of Sun Protection Factor (SPF).

1.2 Aim of the study

The aim of the study is to determine the sunblock cosmetics using behavior of the students of BRAC University and based on this, uncovering whether their protection measures are adequate or not by measuring Sun protection Factor (SPF) of some frequently used sunblock cosmetics.

1.3 Objectives of the study

This study is designed in two distinct parts:

1. **Survey:** All the participants of the survey were students of BRAC University. The objectives of the survey are to know about the usage of sunblock agents, awareness and knowledge about SPF and to know about the commonly used sunscreen and other sunblock agent manufacturers.

2. **Lab experiment:** Sun Protection Factor (SPF) of some frequently used sunblock products found from the survey was determined in the laboratory. The objectives

of the experiment are to verify and compare between the labeled and found SPF, also comparing the SPF of the sunblock agents based on different purchase locations.

Thus, from the study, we can get a general idea about the effectiveness of various commonly used sunblock agents, purchased from different locations.

1.4 Solar radiations and their effects

1.2.1 Solar radiations

In terms of electromagnetic spectrum, sunlight that reaches earth's surface can be divided into three categories namely ultraviolet (6%), visible (52%), and infrared (42%) radiation (Diffey & Kochevar, 2007).

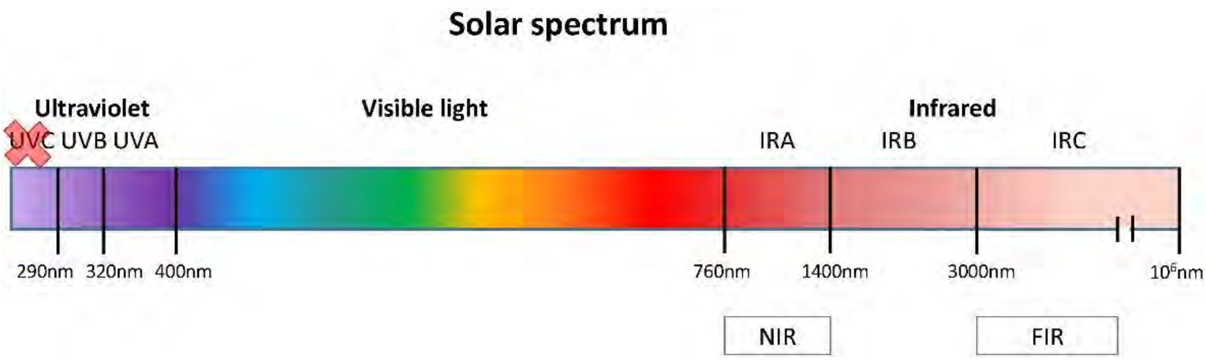

Figure 1.1: Composition of solar spectrum

UVC is blocked by the ozone layer, marked by red X (NIR- near infrared region, FIR- far infrared region). Figure taken from Barolet, Christiaens, and Hamblin (2016).

Among these, study of the ultraviolet radiation has great importance because while blessing human with life generating energy and lots of beneficial effects, it also causes some deleterious effects ranging from acute response such as sunburn, to potentially life-threatening conditions such as skin cancer. International Commission on Illumination divides ultraviolet radiation into three components: UVC (100-290 nm), UVB (290-320 nm) and UVA (320-400 nm) (Diffey & Kochevar, 2007). Although, the most powerful UV radiation, UVC is effectively absorbed by the ozone layer but UVB and UVA reach the earth surface, penetrates skin layers and responsible for developing sunburn and skin cancer respectively (Polefka, Meyer, Agin, & Bianchini, 2012).

1.2.2 Beneficial effects of solar radiations

Solar UV radiation is well known for stimulating the production of vitamin D, blood circulation, boosts up the immune system and enhancing the general feeling of well-being. Most of the beneficial effects of solar radiation are mediated by UVB induced synthesis of vitamin D in skin. Moreover, solar radiation provides other positive effects including improved energy and elevated mood, prevention and treatment of skin and bone disorders.

Stimulating the synthesis of vitamin D

Production of vitamin D in the skin is triggered by exposure to UVB radiation through a photosynthetic reaction. Exposure to the sun for half-hour in a bathing suit initiates the release of 50,000 IU (1.25 mg) of vitamin D into the blood circulation within 24 hours for most white individuals, 20,000–30,000 IU in tanned people and 8,000–10,000 IU in dark-skinned individuals (Mead, 2008). Vitamin D plays a crucial role in escalating phosphorus and calcium absorption from the gut which has significant function in skeletal growth, blood cell formation and immune function (World Health Organization, n.d.). Thus, limited exposure to sunlight can prevent hypovitaminosis D. Recent ressearches suggest that vitamin D may also be involved in maintaining the immune system, that even subclinical hypovitaminosis D may result in the development of numerous cancers and contribute to the formation of autoimmune disorders for example type 1 diabetes and multiple sclerosis (Lucas, McMichael, Smith, & Armstrong, 2006).

Prevention of bone disease

Rickets is one of the most common diseases in children that occurs due to inadequate level of vitamin D. As this vitamin increases the absorption of calcium and transports it from the intestine to bones, lack of this vitamin results in lack of calcium in bones and subsequent softening of the bones (World Health Organization, n.d.). So, proper sunlight exposure can prevent rickets as it stimulates vitamin D production.

Prevention and treatment of skin disorders

Lupus vulgaris caused by *Mycobacterium tuberculosis* is known as tuberculosis of the skin. This disease produces skin lesions with nodular appearances on the face and neck. In past lupus was treated by UVB radiation. An ultraviolet-B lamp, developed by a Danish doctor Neils Finzen, was so effective in curing the disease that in 1903 he won the Nobel prize (Juzeniene & Moan, 2012). Nowadays, lupus vulgaris is very rare and typically treated effectively with antibiotic medication. Modern ultraviolet phototherapy specially with UVB is an effective treatment for skin diseases such as vitiligo, psoriasis, localized scleroderma and atopic dermatitis (Juzeniene & Moan, 2012).

1.2.3 Harmful effects of solar radiation

Despite the vital functions and therapeutic roles, the detrimental effects of overexposure to ultraviolet radiation generally far outweigh the rewards. Additional to the well-known acute outcomes such as sunburn or allergic reactions, overexposure to sunlight can result in chronic consequences that pose a life-long threat to health. Excessive exposure to ultraviolet radiation affects not only the skin and eyes but also the immune system. The effects of imbalanced UV radiation exposure can accumulate over time and increases the chances of development of skin cancers or cataracts later in life.

Harmful effects of UVA radiation

Solar UVA radiation penetrates deeper into the skin layers and causes chronic hazardous effects such as skin cancer. Ultraviolet radiation especially UVA from sunlight is a proven human carcinogen because of its capability to develop skin cancer namely malignant melanoma and non-melanocytic cancer (NTP (National Toxicology Program), 2016). Chances of skin cancer development is highly related with the frequency and duration of exposure to sunlight. The International Agency for Research on Cancer (IARC), an affiliate of World Health Organization (WHO), classifies solar ultraviolet radiation in group 1 which contains all the major 120 carcinogens including arsenic and tobacco (El Ghissassi et al., 2009). According to a report of WHO, a total of 60,000 deaths yearly are caused by overexposure to solar UV radiation in which 48,000 are caused by malignant melanomas and 12,000 by skin carcinomas (Lucas et al., 2006). This report also considered UV radiation from sun as a global disease burden because more than 1.5 million DALYS (disability-adjusted life years), which is a measure of loss of full functioning due to death and disease, are lost every year because of excessive exposure to UVR. UVA radiation is also responsible for photoaging which is premature aging of the skin (Polefka et al., 2012).

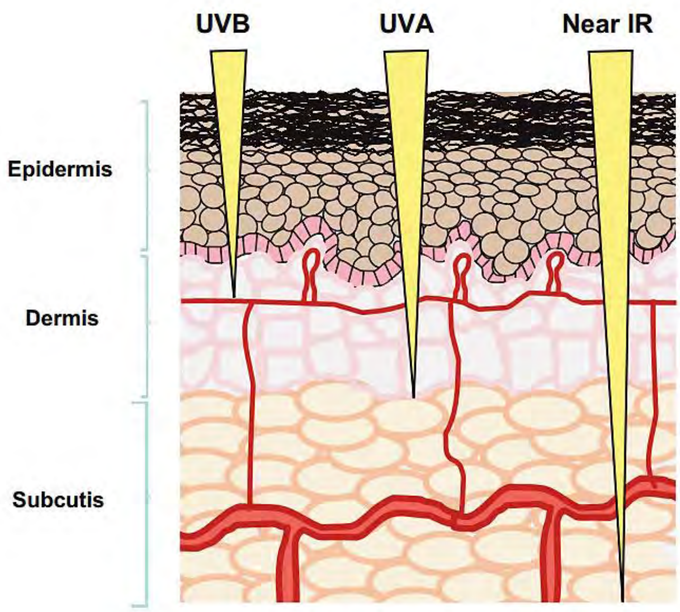

Figure 1.2: Penetration of skin layers by solar radiations

UVB radiation penetrates only into the epidermis layer of skin; UVA reaches dermis and IR penetrates deepest into the subcutaneous layer. Figure taken from Polefka et al. (2012).

Harmful effects of UVB radiation

In contrast to the UVA radiation, the effects of overexposure to solar UVB radiation are acute and occur almost immediately. This radiation is responsible for sunburn, suntan, inflammation, immunosuppression and damaging effects to the eye such as cataract (Polefka et al., 2012). Recent researches suggest that UVB is liable for DNA damage and probably also linked with cancer initiation, but the exact mechanism is yet to be discovered.

1.2.4 Maintaining the balance

While some UVR exposure is necessary for induction of vitamin D synthesis which is required for musculoskeletal health, under and overexposure can lead to increased disease burden. Suboptimum expose to UV radiation causes vitamin D deficiency which results in the formation of bone diseases such as rickets, osteomalacia and osteoporosis. On the other hand, excessive exposure leads to life-threatening cancers. Therefore, balanced exposure to sunlight in necessary for maintaining good health.

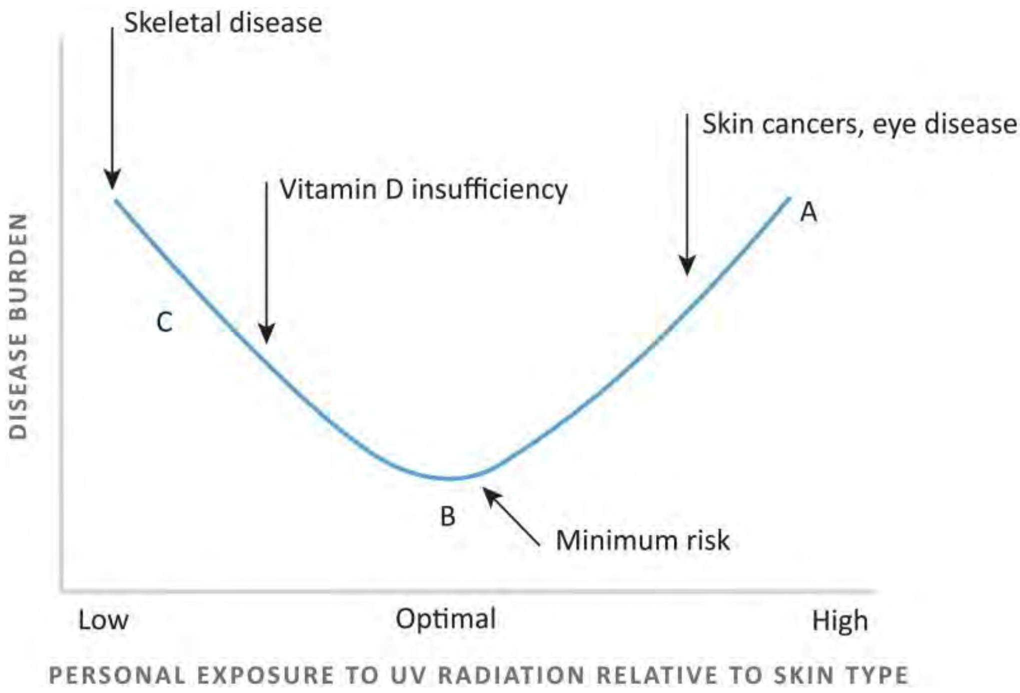

Figure 1.3: Relationship between UV radiation exposure and burden of disease

Point A represents overexposure to UV radiation and point C denotes suboptimum exposure both of which results in higher disease burden. Point B represents optimum exposure where disease burden is minimal. Figure taken from Lucas et al. (2006).

According to the estimation of M. F. Holick (2001), exposure of the entire body in a bathing suit to one MED (Minimum Erythema Dose- threshold dose that produces sunburn) is equivalent to ingesting 10,000 IU of vitamin D. So, exposure of 6-10% of the body to one MED is equivalent to ingesting 600-1000 IU. Institute of Medicine Committee to Review Dietary Reference Intakes for Vitamin D and Calcium (2011) recommends that daily intake of vitamin D for children is 400 IU and for adult is 600 IU. Based on these data, exposure of 6-10% of the body surface (arm, lower leg, or face and hands) to one MED daily should be adequate for maintaining optimum level of vitamin D (Lucas et al., 2006). Some researchers suggested that around 5–30 minutes of sunlight exposure between 10 AM to 3 PM at least twice a week to face, arms, legs, or back without any sunscreen should lead to sufficient synthesis of vitamin D (Michael F. Holick, 2002; M. F. Holick, 2007).

1.3 Photoprotection and photoprotective agents

Protection from solar radiation is necessary for avoiding the undesired effects. Photoprotection can be provided in various ways which include systemic and topical protection.

1.3.1 Classification of photoprotective agents

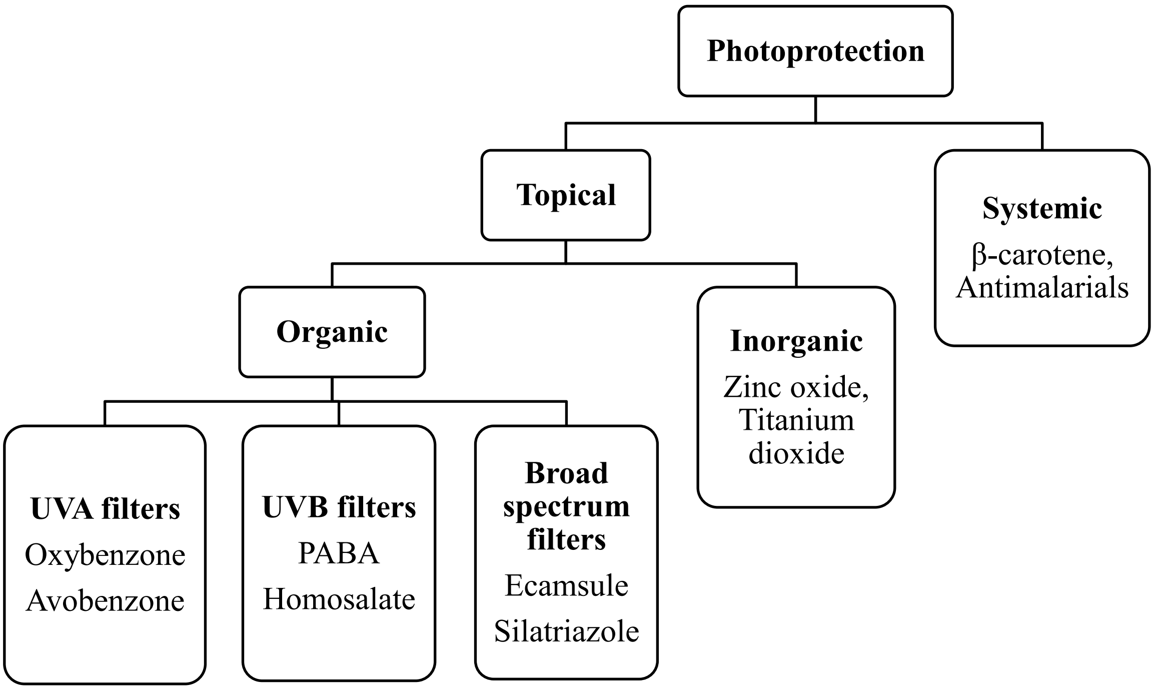

Figure 1.4: Classification of photoprotective agents

Figure adopted from Kaimal and Abraham (2011).

Topical photoprotection- Sunscreen

Topical sunblock agents such as sunscreen contain ultraviolet radiation blocking agents which either absorb ultraviolet radiation or act as physical sunblock by reflecting it. Thus, reducing the risk of skin cancer, sunburn and other harmful effects because radiations cannot reach the human skin.

Types of sunscreen agents

Sunscreen agents are classified into two categories based on their chemical properties.

1. Organic agents: Organic UV filters absorb ultraviolet radiation within a specific wavelength range, depending on their chemical structure. These filters absorb energy and move from a lower energy ground state to a higher energy excited state. So, when applied as sunscreen, they absorb UV radiation and moves to an excited state. From this state any of following processes can occur- energy can be dissipated to the environment as heat, the filter can undergo chemical modification or degradation takes place (Kaimal & Abraham, 2011). Organic filters generally block either UVA or UVB radiation but new generation broad-spectrum filters such as ecamsule (mexoryl SX), silatriazole (mexoryl XL), bemotrizinol (tinosorb S), bisoctrizole (tinosorb M) provide protection against both radiations.

2. Inorganic agents: These agents work by reflecting, scattering and absorbing UV radiation (Kaimal & Abraham, 2011). Inorganic or mineral filters include zinc oxide, titanium dioxide which provides protection against both UVA and UVB radiation. The disadvantageous opaque nature and whitening effect of these agents can be minimized by using ultrafine or micronized particles (Kaimal & Abraham, 2011).

Agents used in sunscreen formulation

Use, concentration and combination of active ingredients in sunscreen formulation varies depending on different regulatory authorities. The following table 1.1 includes United States Food and Drug Administration approved sunscreen active ingredients, their maximum permitted concentration in the formulation, absorbance behavior and protection provided against ultraviolet radiations.

Table 1.1: Sunscreen active ingredients approved by FDA.

Active ingredients	Maximum conc.	Peak abs. (nm)	Protection range (nm)	Radiations blocked
Inorganic agents				
Titanium dioxide	25%	Varies	290-350	UVB, UVA
Zinc oxide	25%	Varies	290-400	UVB, UVA
Organic agents				
UVA filters				
Oxybenzone	6%	290, 325	270-350	UVB, UVA2
Sulisobenzone	10%	366	250-380	UVB, UVA2
Dioxybenzone	3%	352	206-380	UVB, UVA2
Meradimat (menthyl anthranilate)	5%	336	200-380	UVA2
Avobenzone	3%	360	310-400	UVA1, UVA2
Ecamsule (terephthalydene dicamphor sulfonic acid)	10%	345	295-390	UVA1, UVA2
UVB filters				
PABA	15%	283	260-313	UVB
Padimate O	8%	311	290-315	UVB
Octinoxate (octyl methoxycinnamates)	7.5%	311	280-310	UVB
Cinoxate	3%	290	270-328	UVB
Octisalate (octyl salicylate)	5%	307	260-310	UVB
Homosalate	15%	306	290-315	UVB
Trolamine salicylate	12%	260-355	269-320	UVB
Octylocrylene	10%	303	287-323	UVB
Ensulizole (phenyl-benzimidazole sulfonic acid)	4%	310	290-340	UVB

Note. Adapted from Sambandan and Ratner (2011); "Sunscreen drug products for over-the-counter human use; final monograph. Food and Drug Administration, HHS. Final rule" 1999); Wang and Lim (2011)

Protection provided by sunscreen formulation

UVA protection: There is no universal standard system for rating and labeling the UVA protection provided by the sunscreen. Different regulatory authorities have made different rules for labeling the UVA protection which makes it confusing. Sunscreens that are labeled as ‘broad spectrum,' give protection against both UVA and UVB radiation. Another common expression is UVA-PA (protection against UVA) system where protection rating is given ranging from PA+ to PA++++. A new star rating system has been established consisting of 4 or 5 stars depending on the regulatory authority, where 1 star represents low UVA protection and 4 or 5 stars represents the highest UVA protection (Valins, Viera, Amini, & Berman, 2010).

Figure 1.5: Star rating system of sunscreen

Figure taken from (Michelle, 2017)

UVB protection: In contrast to the UVA, UVB protection provided by a sunscreen is always represented by Sun Protection Factor (SPF). SPF is the measurement of the shield that sunscreens provide against UVB radiation. The following table 1.2 represents various SPF values and the corresponding amount of UVB radiation blocked.

Table 1.2: Relationship between SPF values and protection against UVB radiation

SPF values	UVB radiation blocked
0	0%
2	50%
4	75%
10	90%
30	96.6%
50	98%
70	98.7%
100	99%

Note. Table adapted from (Schalka & Reis, 2011)

It is observable from the table that there is no significant difference in UVB absorbance values between SPF 30, 50, 70 and 100. So, it is not always necessary to use sunscreens having higher SPF values. As high SPF values are obtained by using a high amount of active ingredients, depending on the skin type it may produce irritation. A broad-spectrum sunscreen having SPF 30 is recommended in most of the situations (American Academy of Dermatology, n.d.).

Systemic photoprotection

In addition to topical photoprotection, numerous compounds have been evaluated for their ability to provide systemic photoprotection after oral administration. Antioxidant is the primary class of compound that has been studied because sun-induced toxicities in the skin are mediated at least partially by oxidative mechanisms, including free radical production and singlet oxygen generation (Rosen, 2003). β-carotene, ascorbic acid, antimalarials, α-tocopherols (i.e., vitamins A, C, and E), green tea polyphenols, retinol, antihistamines, selenium, PABA, corticosteroids, aspirin and indomethacin are some of the common systemic photoprotective agents (Kaimal & Abraham, 2011).

Chapter 2: Methodology

This study is divided into two distinct parts- survey and lab experiment. In the survey, sunblock cosmetics using behavior among the students of BRAC University and commonly used sunblock brands were determined. Based on the survey, Sun Protection Factor (SPF) of some commonly used sunblock agents were determined by an in vitro spectrophotometric method using Mansur's equation. All the data found in survey and lab experiment were analyzed using Microsoft Excel. The following flowchart (figure2.1) represents the overall methodology of the study.

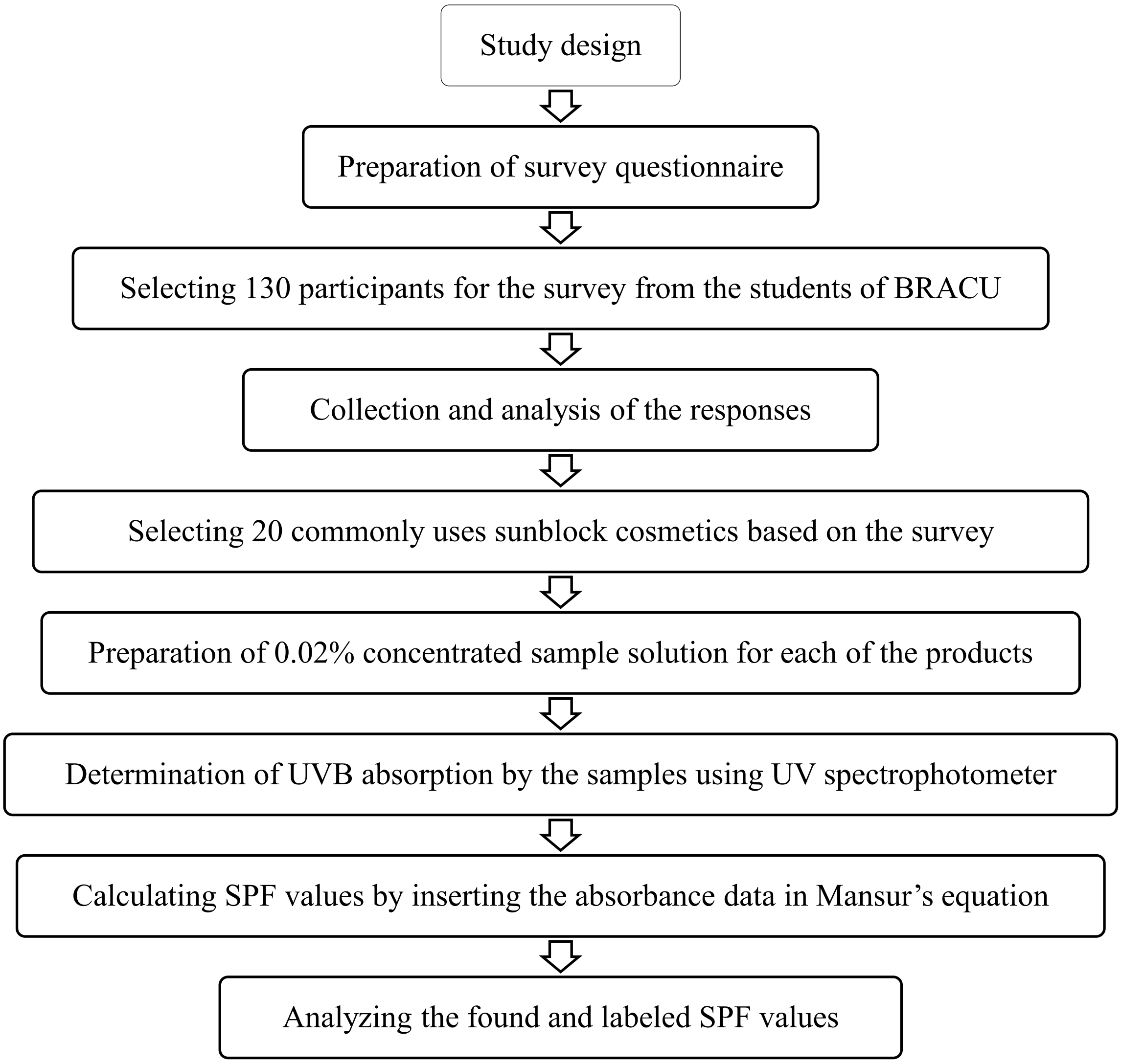

Figure 2.1: Overview of methodology of the study

2.1 Survey

2.1.1 Study design

A cross-sectional study was carried out to evaluate the sunblock using behavior among the students of BRAC University and to know about sunblock using behavior of the participants and commonly used sunblock cosmetics manufacturers.

2.1.2 Questionnaire preparation

The questionnaire was divided into two parts- demographic characteristics and sunblock using behavior. There were total 11 questions- 4 single response, 4 multiple response and 3 descriptive questions.

2.1.3 Pre-testing

Before carrying out the actual survey, ten pretest survey responses were collected. Feedback from the participants were also collected to make necessary modification in the questionnaire. Then final draft of the questionnaire was revised based on the pretest. Most of the changes were made to improve respondent-comprehension of the questions.

2.1.4 Data collection

A total of 134 participants were selected from the students of BRAC University by simple random sampling method. Each of the participants received a questionnaire and instructions were given. After filling up, the questionnaires were collected and screened for errors. 130 questionnaires were selected for analysis and the rest were discarded due to incomplete answers.

2.1.5 Data analysis

The responses of 130 participants were inputted in pivot table of Microsoft Excel 2016 and analyzed. All conversions, calculations and graphs were made there.

2.2 Lab experiment

Sun Protection Factor (SPF) values of the commonly used sunblock products found from the survey were determine by an UV-spectrophotometric method. The method was very simple and rapid compared to the in vivo test.

2.2.1 Materials

Apparatus

1. UV-spectrophotometer (Shimadzu UV- 1800)
2. Ultrasonic bath (Power Sonic 405, Lab Tech)
3. Electronic balance (Shimadzu ATY 224)
4. Beaker
5. Pipette
6. Pipette pump
7. Volumetric flask (50 ml, 25 ml)
8. Measuring cylinder
9. Funnel
10. Filter paper
11. Spatula

Reagents

1. Ethanol (Merck, analytical grade)
2. Distilled water

2.2.2 Method

Sunblock cosmetics collection and purchase

Based on the survey, 20 commonly used sunblock cosmetics having labeled SPF values were either collected from the participants or purchased. Cosmetics collection or purchase were done in such a way that the purchase locations of the products were different.

Sample preparation

100 mg of the sunblock product was weighed in an electronic balance and transferred to a 50 ml volumetric flask. Then it was diluted to volume with ethanol, followed by ultrasonication for 5-10 minutes in an ultrasonic bath to ensure proper mixing. After that the mixture was filtered through filter paper, rejecting the first 10 ml. Then 2.5 ml aliquot was transferred to 25 ml volumetric flask and diluted to volume with ethanol. Thus, 0.02%

concentration was obtained, and it was the sample solution for the study (Dutra, Oliveira, Kedor-Hackmann, & Santoro, 2004). Absorption of ultraviolet radiation by this sample solution was then measured spectroscopically. The same procedure was followed for all the sunblock cosmetics.

Spectrophotometric measurement

The absorption spectra of all the samples were obtained in the range of 200 to 400 nm using a UV-visible spectrophotometer, equipped with a computer. The spectrophotometer was operated by the computer using a software named UV probe. Two 1 cm quartz cell were used as sample and blank solution holder. As ethanol was used to dilute the samples, so it was also the blank solution. At first, both quartz cells were filled with the blank solution and loaded into the two chambers of the spectrophotometer. Then in the software a baseline was created after selecting wavelength scanning mode and setting the range of scan to 200- 400 nm. After creating the baseline, blank solution was replaced by sample solution from the sample chamber of the spectrophotometer. Afterwards, wavelength scanning was started, graphical plot and absorbance values were obtained in the software. From the software, absorbance values of 290 nm, 295 nm, 300 nm, 305nm, 310 nm, 315 nm and 320 nm were noted for SPF calculation (Dutra et al., 2004). Three determinations were made for each sample using the same process.

SPF determination

As mentioned earlier, SPF values were calculated using Mansur's equation. Mansur developed a very simple process for in vitro determination of SPF which utilizes UV spectrophotometry and the following equation (Dutra et al., 2004).

Mansur's Equation:

$$SPF = CF * \sum_{290}^{320} EE * I * Abs.$$

Where, CF= Correction Factor, EE= Erythema Effect Spectrum (λ), I= Solar Intensity Spectrum (λ), Abs.= Found Absorbance (λ). The value of correction factor is always 10 because the equation was initially developed by using transmittance value instead of absorbance and while modifying the equation, Mansur used 10 as correction factor (Dutra et al., 2004; Sayre, Agin, LeVee, & Marlowe, 1979)

The values of EE * I are constants and predetermined by Sayre et al. (1979) which are given in the following table.

Table 2.1: Normalized values of EE * I

Wavelength	EE * I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0180
Total	1

Note. Table adapted from (Sayre et al., 1979)

Finally, inserting the absorbance values of the samples at 290 nm, 295 nm, 300 nm, 305 nm, 310 nm, 315 nm, and 320 nm, determined by spectrophotometric measurement, SPF values were calculated from Mansur's equation.

Chapter 3: Result and Discussion

3.1 Survey analysis

3.1.1 Demographic characteristics

Out of 130 participants, the majority were females (67%) and the remaining were males (33%). All of them were students of BRAC University from various departments, studying in different semesters. They were divided into two education levels- juniors (1st and 2nd year) and seniors (3rd and 4th year). 47% of the participants were studying in junior years and 53% were senior students. Table 3.1 represents demographic characteristics of the 130 participants.

Table 3.1: Demographic profile of the study sample (N = 130)

Variable	Number of Responses	%
Gender		
Female	87	67
Male	43	33
Education level		
Junior	61	47
Senior	69	53

3.1.2 Use of sunblock cosmetics

Participants were asked about their sunblock using behavior. Among the respondents, 63 people (48%) use and 67 individuals (52%) do not use sunblock cosmetics which is illustrated in table 3.2 and figure 3.1.

Table 3.2: Sunblock cosmetics using behavior of the participants

Sunscreen use	Number of Responses
Use	63
Don't use	67
Total	130

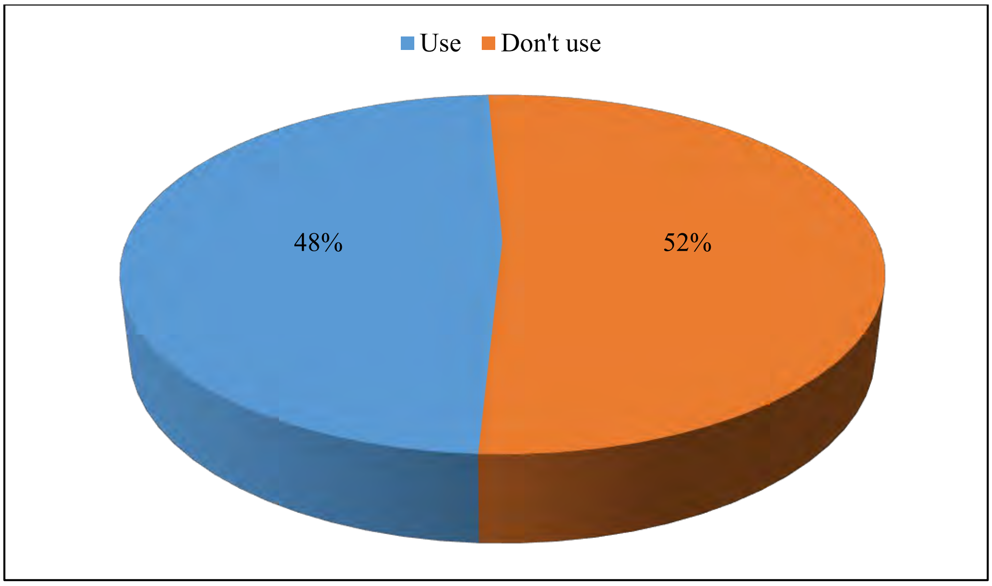

Figure 3.1: Sunblock cosmetics using behavior of the participants

When sunblock using behavior was compared between the demographic variables, a significant difference was found in case of two genders. Majority of the females use sunblock cosmetics- 52 individuals (60%) and only 11 individuals (26%) of the males use sunblock. Table 3.3 and figure 3.2 describes sunblock using behavior between genders.

Table 3.3: Comparison of sunblock cosmetics using behavior between genders

Gender	Use	Don't use	Total
Female	52	35	87
Male	11	32	43
Total	63	67	130

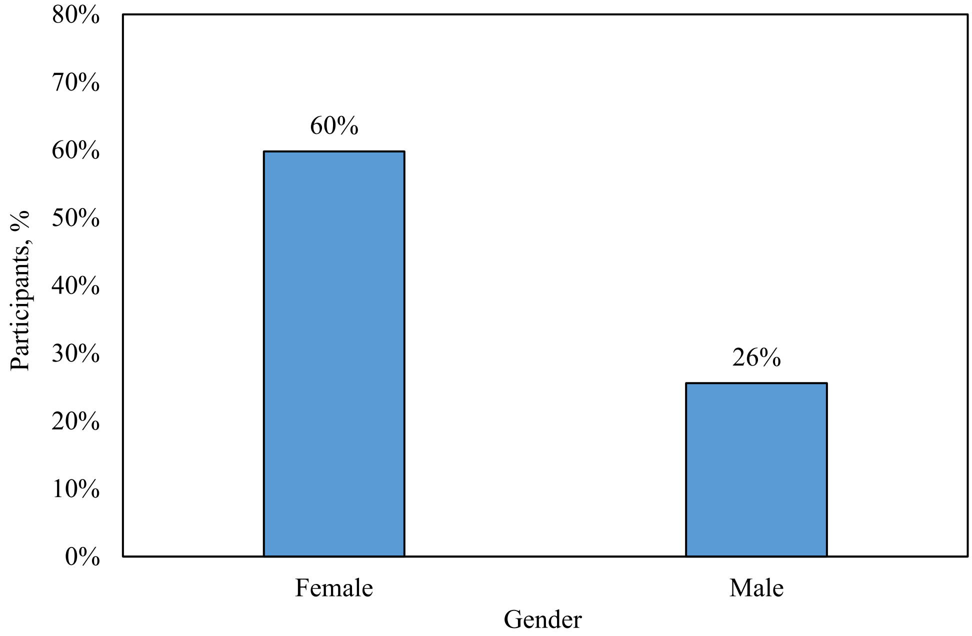

Figure 3.2: Comparison of sunblock cosmetics using behavior between genders

In case of the second demographic variable- education level, overall 25 junior year students (41%) and 38 senior year students (55%) use sunblock cosmetics. A significant difference was found between female junior and senior students. 30 individuals (79%) of the female seniors use sunblock while 22 female juniors (45%) use it. Table 3.4 and figure 3.3 represents sunblock cosmetics using behavior between education levels.

Table 3.4: Comparison of sunblock cosmetics using behavior between education levels

Education level	Gender	Use	Don't use	Total
Junior	Female	22	27	49
	Male	3	9	12
	Total	25	36	61
Senior	Female	30	8	38
	Male	8	23	31
	Total	38	31	69
Grand Total		63	67	130

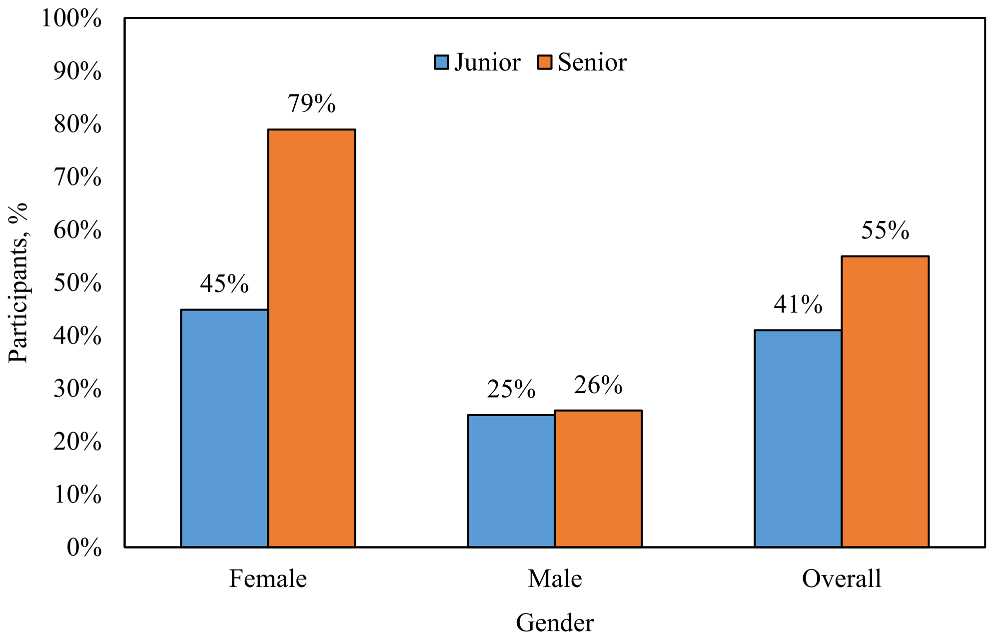

Figure 3.3: Comparison of sunblock cosmetics using behavior between education levels

3.1.3 Frequency of using sunblock cosmetics

63 participants who use sunblock were asked about the frequency of using such cosmetics. The using frequency was divided into four categories- regularly, often, occasionally and rarely. The following table 3.5 and figure 3.4 denotes the frequency of using sunblock cosmetics.

Table 3.5: Frequency of using of sunblock cosmetics

Frequency of using	Female	Male	Total
Regularly	29	6	35
Often	5	2	7
Occasionally	9	2	11
Rarely	9	1	10
Total	52	11	63

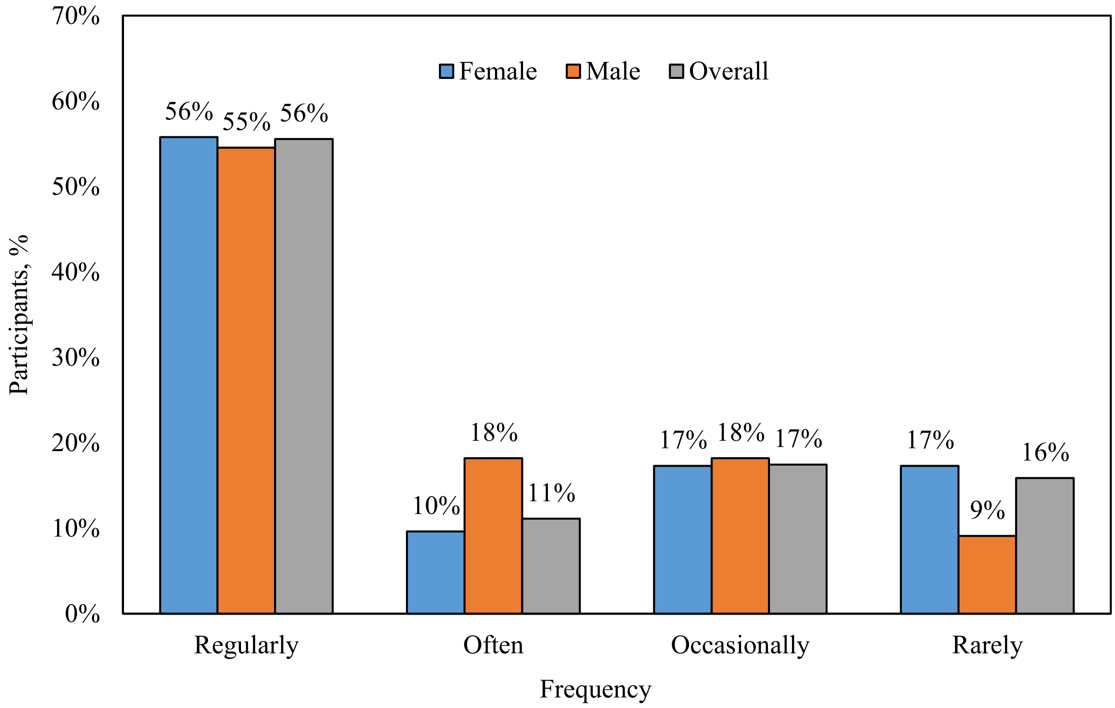

Figure 3.4: Frequency of using of sunblock cosmetics

More than half of the sunblock cosmetics users responded using regularly and the remaining responded infrequent (often, occasionally and rarely) using. 35 individuals (56%) use sunblock regularly out of 63 users. Almost equal percentage of female and male users were found regularly using- 56% and 55% respectively. The remaining 28 infrequent users were using sunblock often (11%), occasionally (17%) or rarely (16%).

3.1.4 Purchase location of sunblock cosmetics

Sunblock users were further asked about the purchase locations of such cosmetics. Purchase locations were divided into five categories- mall/chain shop, authentic cosmetic store, abroad, internet/online and drug store. A total of 92 responses came from 63 participants as it was a multiple answer question which is described in table 3.6 and figure 3.5.

Table 3.6: Purchase location of sunblock cosmetics

Purchase location	Number of Responses
Mall/Chain shop	36
Authentic Cosmetic shop	27
Abroad	18
Internet/Online	7
Drug store	4
Total	92

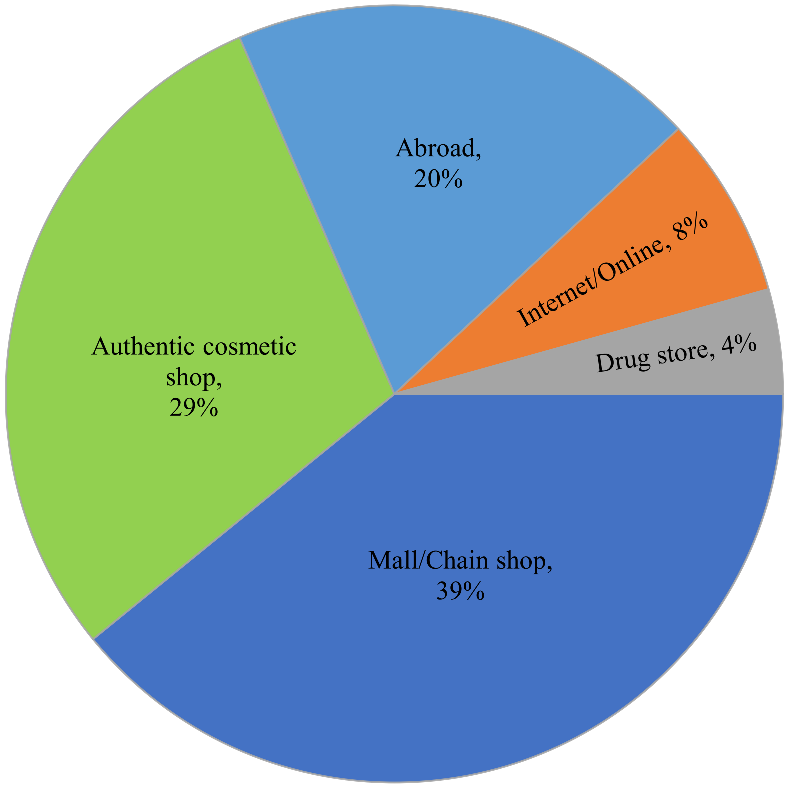

Figure 3.5: Purchase location of sunblock cosmetics (percentage of total responses)

Higher tendency were found in purchasing sunblock cosmetics from mall/chain shop, authentic cosmetic shop and abroad- 39%, 29% and 20% of the total responses respectively. Out of 63 sunblock users, 36 people responded buying from mall/chain shop, 27 from authentic cosmetic shop and 18 from abroad. For internet/online and drug store, 8% and 4% responses were found respectively.

3.1.5 Reason(s) for using sunblock cosmetics

Participants were asked about the reason(s) for using sunblock cosmetics and reasons were categorized into prevent sunburn, protection from solar radiation, tanning, prevent premature aging of skin and prevent skin cancer. It was a multiple answer question and 172 responses were found from 63 sunblock users. Table 3.7 and figure 3.6 represents the reasons of the participants for using sunblock cosmetics.

Table 3.7: Reason(s) for using sunblock cosmetics

Reason(s)	Female	Male	Total
Prevent sunburn	39	11	50
Protection from solar radiation	31	9	40
Tanning	32	5	37
Prevent premature aging of skin	16	8	24
Prevent skin cancer	15	6	21
Total	133	39	172

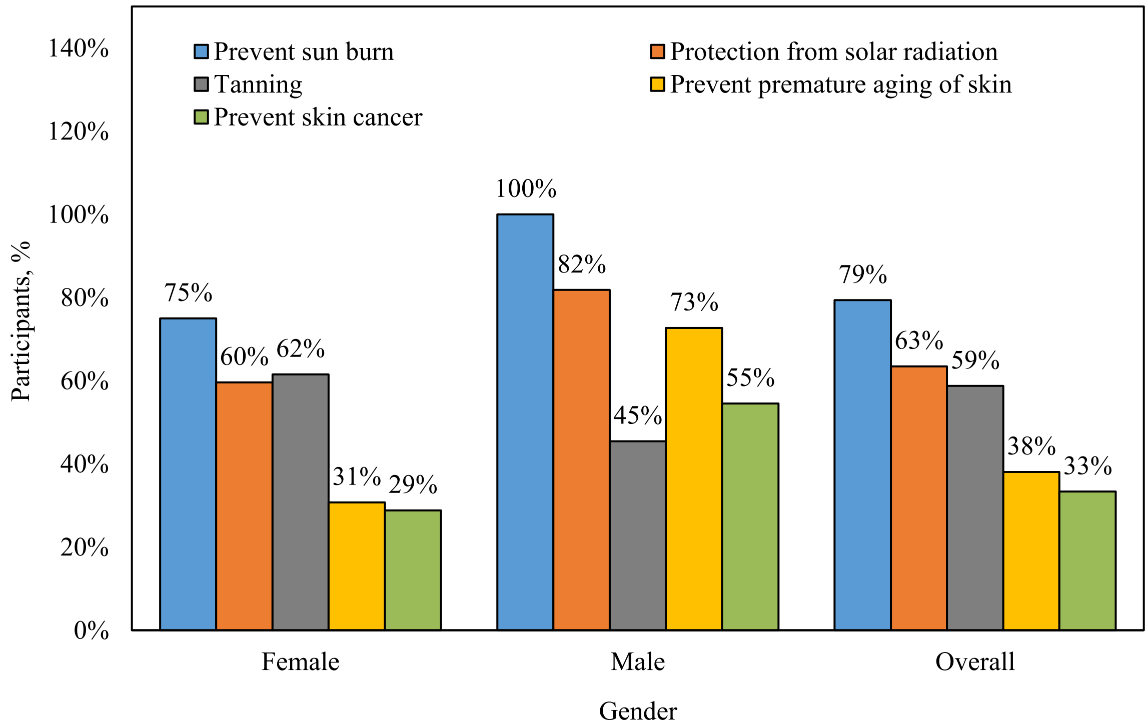

Figure 3.6: Reason(s) for using sunblock cosmetics

Majority of the sunblock users responded that they use it for preventing sun burn and lowest responses were found for preventing skin cancer. 79% of the users marked ‘prevent sunburn’ and 33% marked ‘prevent skin cancer.' All the male users responded that they use sunblock to prevent sunburn.

3.1.6 Sunblock packaging checklist

Participants were asked about what are the things that they check before purchasing a sunblock cosmetic. The answers provided for them were SPF value, brand name, expiry date, use/function, manufacturer, UV-A protection, barcode check. It also was a multiple answer question and 185 responses were found from 63 participants which is denoted in table 3.8 and figure 3.7.

Table 3.8: Sunblock packaging checklist

Packaging checklist	Number of Responses
SPF value	49
Brand name	44
Expiry date	35
Use/Function	20
Manufacturer	20
UV-A protection	15
Barcode check	2
Total	185

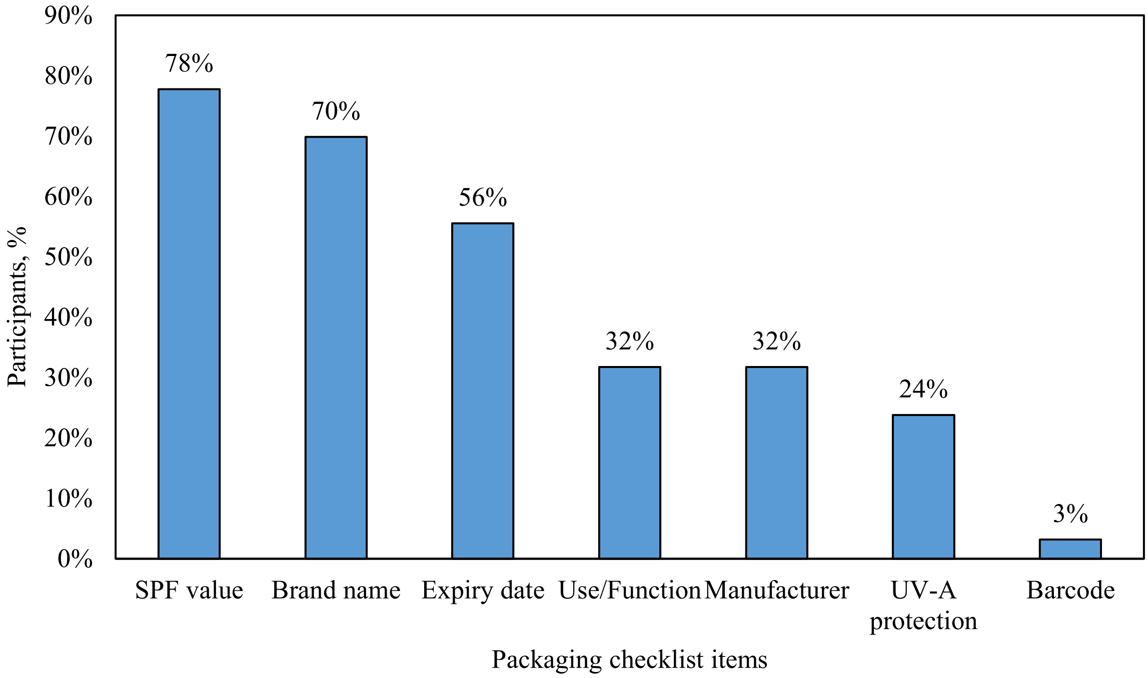

Figure 3.7: Sunblock packaging checklist

Out of 63 participants, 49 individuals (78%) check for SPF value before purchasing. However, only 15 individuals (24%) check for UV-A protection. Majority of the participants (70%) also purchase sunblock because of the brand name.

3.1.7 Commonly used sunblock manufacturers

Lastly, the 63 sunblock users were requested to write some information such as brand name, manufacturer, SPF value of their sunblock cosmetic/s. It was divided into two sections- one was only for sunscreen and other for sunblock cosmetics except sunscreen such as body lotion, lipstick, lip balm. From the provided data, frequently used sunblock cosmetics manufacturers are listed in table 3.9.

Table 3.9: Commonly used sunblock manufacturers

Sunblock manufacturer	Number of Responses
Sunscreen	
Neutrogena	12
Nivea	8
Lakme	8
Lotus	6
Keya Seth	5
Garnier	4
Lady Diana	4
Olay	3
Banana Boat	3
Except sunscreen	
Lakme	13
Maybelline	11
Nivea	11
MAC	11
L'oreal	10
Vaseline	9
Garnier	9
Ponds	6
Body Shop	5
La Femme	4

3.2 Lab experiment analysis

Some of the commonly used sunblock cosmetics such as Neutrogena, Lakme, Nivea, Lotus, L'oreal, Ponds, Olay, MAC, Bioderma, La Femme, Banana Boat were then purchased or collected from various purchase locations and were taken in the lab for SPF determination. In addition, a few sunscreens such as SolaScren (Incepta Pharmaceuticals), SUNSTOP (UAS pharmaceuticals) were bought from local drug store which were not listed by the participants.

3.2.1 Found SPF values of commonly used sunblock cosmetics

Sun Protection Factor (SPF) value of the sunblock cosmetics, determined by Mansur's in vitro method along with purchase location, labeled SPF and usage time are mentioned in the following table 3.10.

Table 3.10: Purchase location, usage time, claimed and found SPF of various commonly used sunblock cosmetics

Brand	Purchase location	Usage time	Labeled SPF	Found SPF
A	Abroad	0 month	40	6.79
A	Abroad	6 months	40	6.19
A	Abroad	>1 year	40	6.19
A	Internet/ Online	0 month	40	0.74
A	Mall/ Chain shop	4 months	25	0.61
B	Abroad	3 months	55	28.70
B	Authentic cosmetics shop	2 months	45	26.36
B	Authentic cosmetics shop	6 months	45	22.92
B	Mall/ Chain shop	>1 year	50	0.08
C	Drug store	0 month	28	22.74
D	Drug store	0 month	30	24.95
E	Drug store	4 months	100	0.19
F	Abroad	0 month	15	21.19
G	Abroad	0 month	50	39.61
H	Abroad	>1 year	15	9.45
I	Abroad	0 month	50	15.85
J	Authentic cosmetics shop	0 month	50	23.26
K	Mall/ Chain shop	6 months	15	0.28
L	Internet/ Online	0 month	50	0.39
M	Internet/ Online	0 month	30	0.63

Note. Brand F, H and K are foundations and the remaining are sunscreens.

Out of 20 sunblock cosmetics, 7 had SPF values close to the claimed amount and 1 (brand F) had 41% higher SPF value than the claimed amount. However, 7 sunblock cosmetics were found to give no protection from solar radiation (SPF= 0), though having SPF values labeled in the packaging. Moreover, 5 of the products had SPF values remarkably lower than the claimed amount. Figure 3.8 gives the overall representation of the sunblock cosmetics based on SPF found.

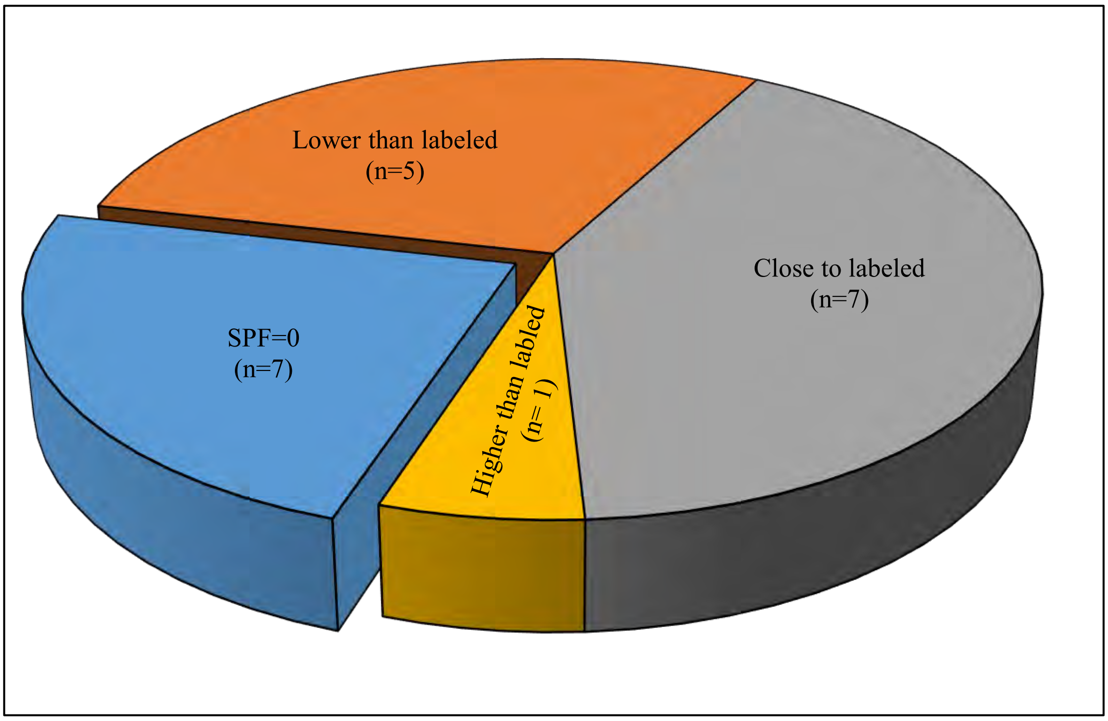

Figure 3.8: Sunblock cosmetics categorized by found SPF values

Close to labeled- At least 50% of the claimed SPF, Lower than labeled- less than 50% of the claimed SPF but not zero.

3.2.2 Comparison of found SPF values of sunblock cosmetics based on various purchase locations and usage time

Decent amount of SPF values were found from the sunblock cosmetics purchased from drug stores, abroad and authentic cosmetic shops. Although one sunblock (brand E) bought from drug store, not manufactured by any pharmaceutical company, gave SPF value 0 but the remaining two were manufactured by pharmaceutical companies and gave good SPF values. Unfortunately, products purchased from mall/chain shop and internet/online were failed severely; all the 6 products tested gave no SPF value meaning no protection from solar radiation. One of the sunblock cosmetics (brand F) purchased from abroad gave SPF value higher than the claimed amount. Figure 3.9 represents SPF values of sunblock cosmetics separated by purchase locations.

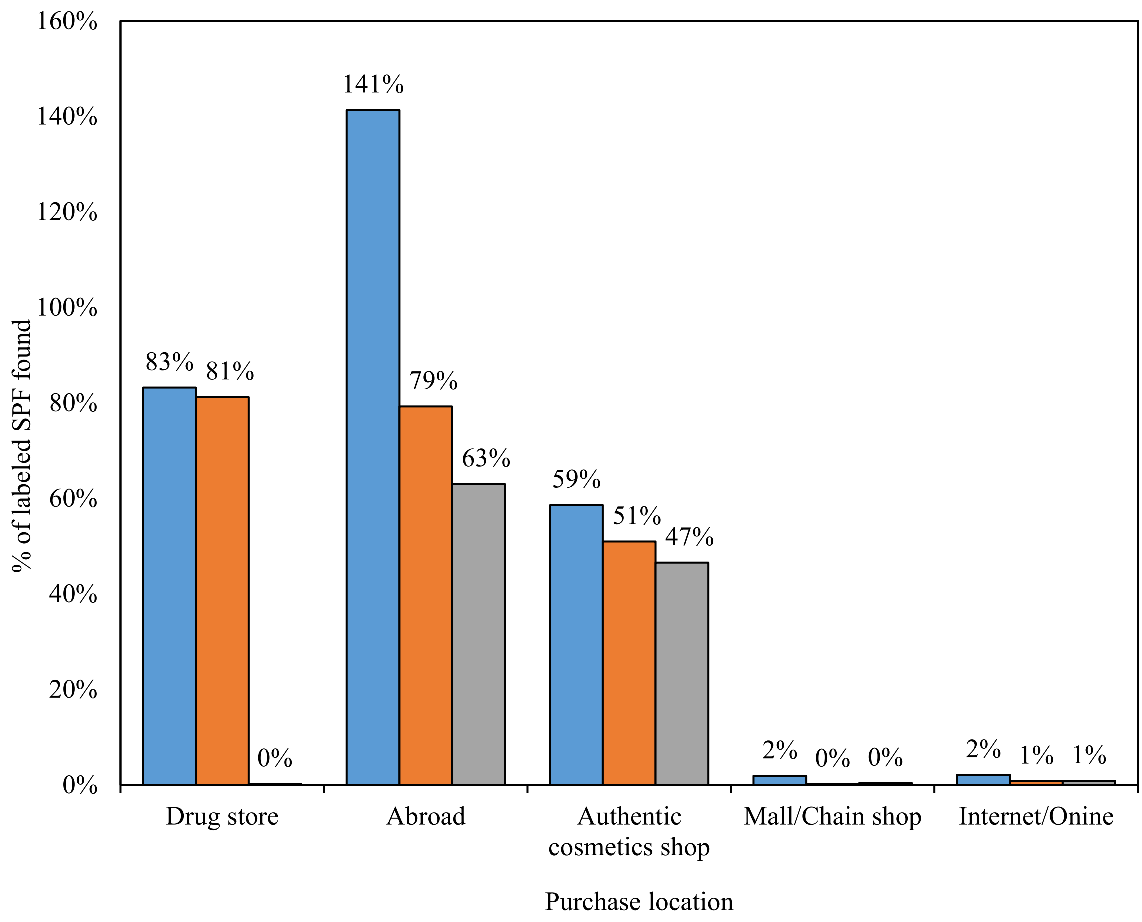

Figure 3.9: Percentage of the labeled SPF values found in different sunblock cosmetics

SPF values of five similar products of brand A were determined and compared. These products were different in terms of purchase location and usage time. Figure 3.10 represents SPF values of sunscreens of brand A having different usage times- new, 6 months used and more than 1 year used. No significant change in the values was found. So, usage time has no major effect on SPF value. Figure 3.11 represents SPF values of sunscreens of brand A, purchased from different locations and significant change was observed. Product purchased from abroad gave remarkably higher SPF than products from online/internet and mall/chain shop.

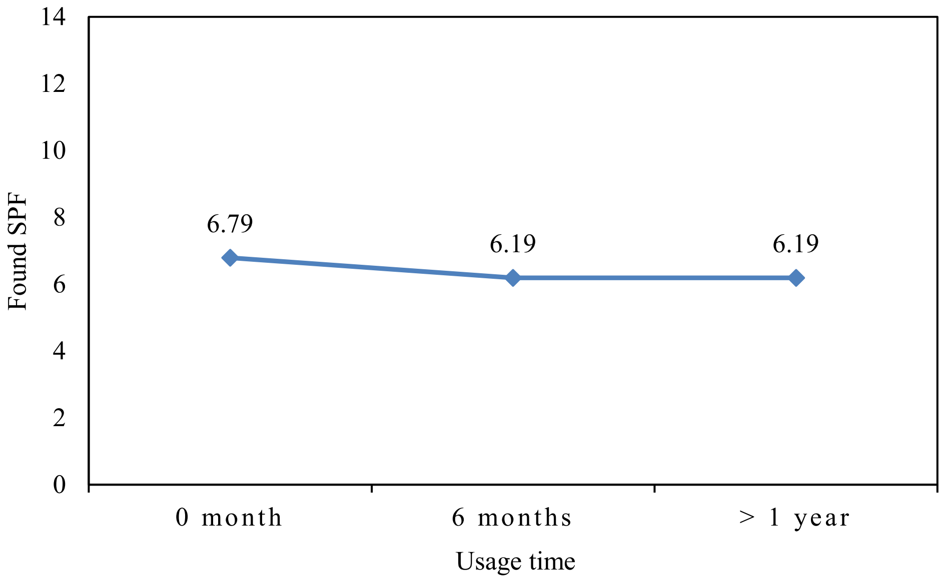

Figure 3.10: SPF values of brand A sunscreens (different usage time)

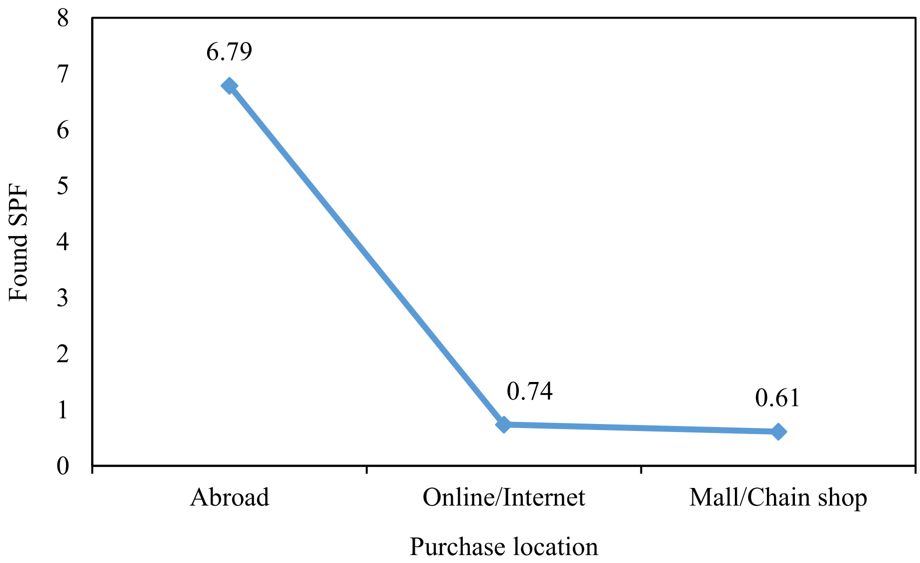

Figure 3.11: SPF values of brand A sunscreens (different purchase locations)

Sunscreen of brand B also gave a similar result. Products purchased from abroad and authentic cosmetic shops offered significantly higher SPF than the product of mall/chain shop which is illustrated in figure 3.12.

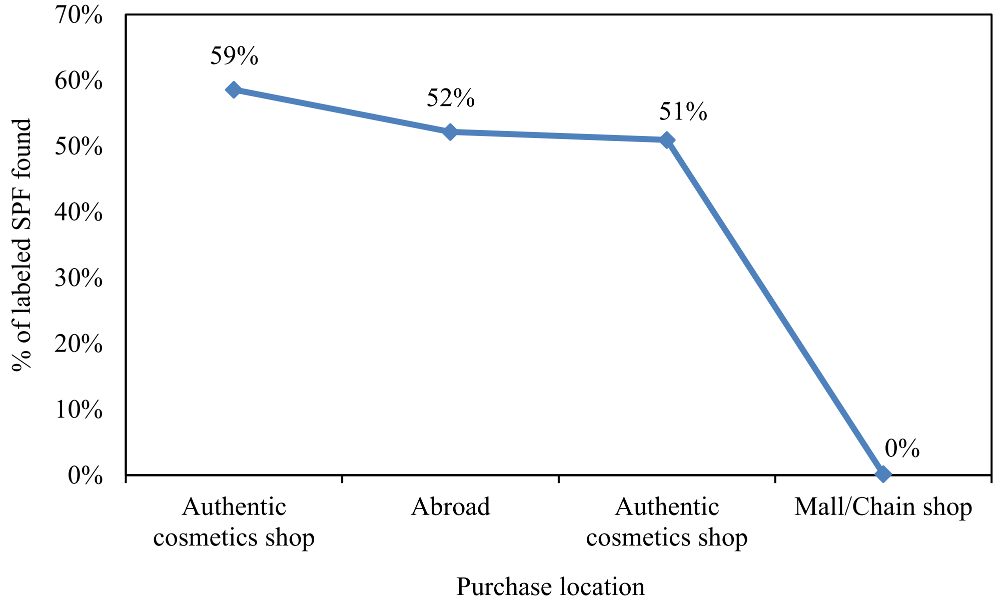

Figure 3.12: Percentage of labeled SPF values found of brand B sunscreen (different purchase locations)

3.2.3 Comparison of found SPF values of sunscreens manufactured by different pharmaceutical companies

Two of the sunscreens purchased from drug store were manufactured pharmaceutical companies. Brand C was from a Bangladeshi pharmaceutical and brand D from an Australian pharmaceutical company. Both products have SPF values very close to the claimed amount, 81% and 83% respectively (figure 3.13).

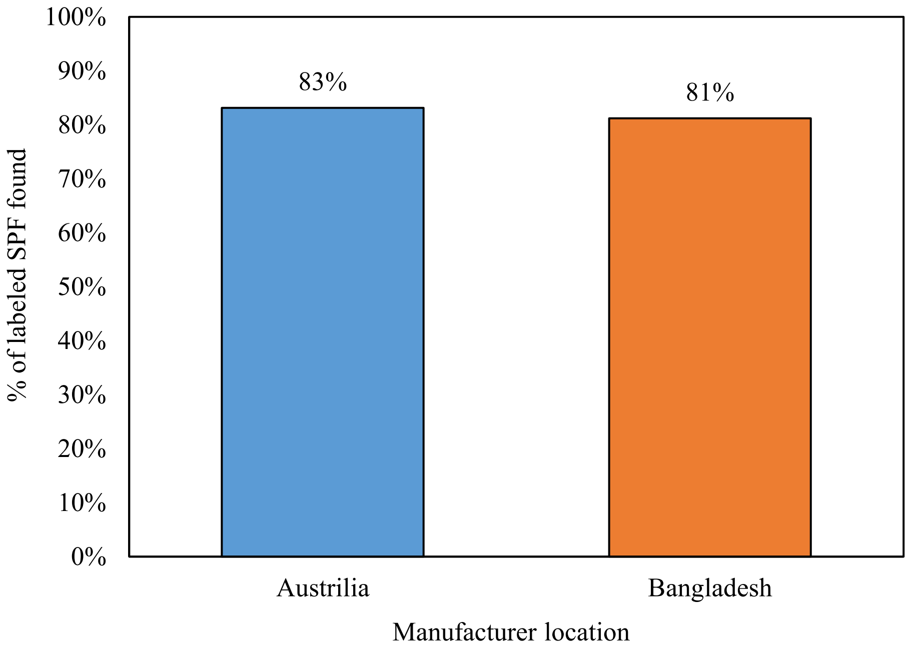

Figure 3.13: SPF values of sunscreens manufactured by pharmaceutical companies

3.3 Discussion

With the goal of preventing skin cancer, broad spectrum SPF 30 or higher sunblock products should be used daily. Survey found out that about half of the students of BRAC University are using sunblock ranging from frequent to infrequent usage. However, people remaining outdoors for a long period of time should use some kind of sun protection. One positive sign is that majority of the people using sunblock are regular users. Counterfeit cosmetic production is a major concern in our country. Laboratory experiment found that out of 20 sunblock products, tested for SPF value, 7 products did not give any protection from sun rays. Moreover, all the products purchased from mall, chain shop and online gave no or very poor protection. On the other hand, products purchased from abroad and local drug stores especially products that are manufactured by pharmaceutical companies gave excellent SPF value. Unfortunately, the survey found out that more than half of the individuals are purchasing sunblock products from mall/ chain shop, moderate number of people from abroad and lowest purchase was observed from drug stores. So, the half of the individuals are not risk free and protected from solar radiation, though using sunblock cosmetics. Sunscreens manufactured by pharmaceutical companies are providing excellent protection, but purchase of these products are minimum.

Chapter 4: Conclusion

This study concludes that about half of the students of BRAC University are taking active measures to protect themselves from solar radiation. However, this protection is not adequate because of the counterfeit sunblock products that the majority of participants are purchasing. Out of twenty sunscreens, tested for Sun Protection Factor (SPF) value, seven products failed badly for having zero SPF.

In future, an extensive project based on this study can be done using large-scale survey and in vivo SPF measurements to determine the overall pattern of sunblock using behavior and adequateness of sunblock cosmetics throughout Bangladesh.

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