Is sun exposure perceived as a health risk by the educated young adults? A cross-sectional study in a high-risk country explores its link to vitamin D

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Abstract

Background: High prevalence of vitamin D deficiency in sunshine-abundant countries is paradoxical. This necessitates a better understanding of the determinants of sun exposure practices. This study investigates how risk perceptions regarding sun exposure might influence relevant habits among the young adults and whether it might have any link to vitamin D deficiency in the community.

Methods: A descriptive cross-sectional survey was conducted from August 2019 to February 2020 using a pretested structured questionnaire focusing on knowledge, attitude, and practices regarding sunlight and vitamin D among college and university-level students in Bangladesh. A total of 3,812 students from 25 different institutions were enrolled. Descriptive and inferential statistics were used to analyze the responses.

Results: Among the respondents, 52% thought regular sunlight exposure would be harmful to health, and 29% thought the intensity of ultraviolet (UV) radiation in Bangladesh was very high. While 79% believed direct sunlight should only be sought 'sometimes', 9% thought it should be totally avoided. At least one sun-protection item was used by 72% of respondents, while 52% thought sunscreen should be used always when outdoors. A negative attitude to sunlight was significantly more prevalent among the females ($p < 0.01$). Knowledge about the symptoms of vitamin D deficiency and its potential health effects was generally very low. Only 12% of the participants correctly identified 10 am to 3 pm as the best time to get vitamin D from sunlight. Only 22% took vitamin D ever, and 7% ever checked their serum levels.

Conclusion: This study highlights some crucial determinants of sun exposure practices that can partially explain high vitamin D deficiency in sunshine-abundant regions. Findings and insights from this study could be generalizable for other countries with comparable socio-demographic settings and will facilitate adopting more sustainable policies to address vitamin D deficiency globally.

Background

Vitamin D is essential for the human body as it has a wide range of physiological effects [1, 2]. Several epidemiological and observational studies have suggested that chronic deficiency of vitamin D can be responsible for several human diseases – communicable diseases like tuberculosis and influenza; non-communicable diseases like colon cancer, breast cancer, heart disease, diabetes; autoimmune disease like multiple sclerosis; Parkinson's disease; and bone-related disorders like osteoporosis, rickets, rheumatoid arthritis, etc [3-5]. Therefore, maintaining an adequate level of vitamin D is essential for maintaining good health.

While vitamin D can also be obtained from dietary sources, as much as 90% of serum vitamin D can be synthesized naturally under exposure to sunlight which gave it the name 'sunshine vitamin' [3, 6]. Once human skin is exposed to ultraviolet B (UV-B; the 290-320 nm wavelength) fraction in the sunlight, the precursor of vitamin D (7-dehydrocholesterol) is formed under the skin [2, 4]. But can the abundance of sunlight mean high sunlight exposure for the community?

The global prevalence of vitamin D deficiency is very high – as many as 1 billion worldwide [3]. Albeit paradoxical, despite sunshine being abundant throughout the year, vitamin D deficiency is perhaps even more prevalent in the tropical and subtropical areas including in South Asia [7-9].

The extent of exposure to sunlight in any region depends on multiple factors – time spent under direct sunlight and its frequency, the timing of the exposure (as the intensity of sunlight varies with time in a day), clothing practices, skin complexion (darker skin absorbs more UV-B due to high melanin concentration), use of sun-protection items (e.g., sunscreen, umbrella, and hat), etc. are notable. In addition, what do people think about sunlight exposure (i.e., how good or bad the effect might be) is perhaps highly important for understanding the extent of the problem as well as for policymaking. Another indirect yet highly relevant factor in this regard is the attitude about skin complexion. There is a credible indication in the literature suggesting that fair skin complexion is highly admired and desired among young adults (predominantly the young females), in some parts of the world, especially in South Asian countries where people have brown to darker skin complexion [10, 11]. Such fear of skin

getting darker (as a result of direct sun exposure) and the fear of the negative effects of UV radiation in sunlight (e.g., skin cancer, heat stroke, skin burn, etc.) can therefore be powerful determinants for sunlight-exposure practices (and prevalence of vitamin D deficiency) in any community.

Furthermore, as direct and indirect consequences of knowledge and attitude, practices on individual levels are highly likely to be among the crucial determinants of the prevalence of vitamin D deficiency in any community, country, or region.

Sun-exposure practices among individuals have been extensively studied among European and Middle Eastern populations [12-15]. However, despite South Asia having one of the highest prevalence of vitamin D deficiency in the world, generalizable studies on the knowledge, attitude, and practices regarding sunlight exposure are scarce [16-18]. Almost all of the reported studies have focused on understanding the accuracy of knowledge and practices among a very specific population – students of the disciplines related to medical and life sciences (e.g., medical students, and students of pharmacy, biotechnology, food, and nutrition, etc.). Hence, the understanding is not fully generalizable for young adults, especially university students.

To address these knowledge gaps, this study aims to assess the knowledge, attitude, and practice regarding vitamin D and sunlight exposure among young adults to understand if this could provide any clue regarding the high prevalence of vitamin D deficiency in this region.

Methods

Study setting:

Bangladesh is located between latitudes 20.59°–26.63°N and longitudes 88.01°–92.67°E. Its climate is mostly sub-tropical. Despite the abundance of sunlight throughout the year, a monthly average daily maximum UV index remains 6-7 throughout the year [19]. Bangladesh is one of the least developed countries (LCDs) in the world with a very high proportion of a very young population (45% has age below 25 years [20]. However, the majority of this population is at a very high risk of vitamin D deficiency as recently reported [7-9].

Study design:

A descriptive cross-sectional questionnaire-based study (with a pre-tested structured questionnaire) was conducted physically from August 2019 to February 2020 among Bangladeshi college and university-level students (from schooling years 11 to 16) by following Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist. In this study, their knowledge of vitamin D deficiency and its symptoms, and attitude plus practices about direct sunlight exposure was tested (details about the questions can be found in the supplementary tables S1, S2, and S3).

Sampling:

According to the Bangladesh Bureau of Statistics (BBS), there are approximately 4500 institutions (colleges and universities) with approximately 500,000 active students [21]. To obtain an accuracy level of 95%, and a 5% margin of error, the minimum sample size required was 385 [22]. For collection of responses, 25 institutions from 6 divisions (5 located in urban, 14 in peri-urban, and 6 in rural settings) were selected from the BBS report 2019 by using a stratified random method (a replacement was chosen where permission could not be managed) [21].

Instrument:

A structured questionnaire was drafted based on the study objective and a review of literature relevant to that objective [12-18]. Feedback was also collected from two clinicians, two public health experts, and a statistician as part of the validation and to customize the questionnaire to the local context.

The questionnaire was drafted first in English followed by a translation in Bengali (both languages were necessary as students participating in the study came from both Bengali and English-medium backgrounds). Special precautions were taken

(whenever appropriate) to include the alternative meanings of the technical/medical terminologies. Accuracy of translation (from English to Bengali) was assured by independent forward and reverse translations for both. The questionnaires were then piloted on a group of 30 students (a mix of students from both English and Bengali media of education) and their feedback was incorporated before finalizing the questionnaire.

The final versions of the questionnaire consisted of seventeen close-ended structured questions. Knowledge, attitude, and practice sections had four to eight questions each; a 3 to 5-point Likert scale (wherever appropriate) was used for the attitude-related questions. A separate question was asked (based on the vitamin D deficiency-related symptoms listed in a knowledge-based question) whether the participant thought he/she might have such deficiency. No personally identifiable information (such as name, age, socio-economic status, etc.) was collected during this survey.

Printed versions of the questionnaire contained two pages; on the first page, demographic information (gender, year of study, discipline of study, name of the institution) was to be documented followed by a declaration of consent. The order of the questions was selected to minimize response bias by not revealing the objective of the study.

The procedure of data collection:

Data collection began in October 2019 and continued through February 2020. Written permission was obtained from each of the participating institutions beforehand. Five to ten classrooms were selected conveniently based on recommendations of the departmental/institutional heads/contact persons) for data collection

A team of twenty-three trained data collectors (all postgraduate-level students) administered the questionnaire. Same step-by-step written instructions were followed for each of the data collection episodes (involving at least two data collectors). The prospective participant was not informed about the survey in advance – a general announcement stating that a study on 'health awareness' would be conducted. The term 'vitamin D' or 'sunlight' was not mentioned before the data collection began. Bengali/English version of the questionnaire was given to those who wanted to participate. International students studying in Bangladeshi colleges/universities were excluded from the survey. Special precautions were taken to avoid all kinds of verbal and non-verbal communications among the respondents. After data collection was complete, the questionnaires were collected, packaged, labeled, and sent to the principal investigator (for storage in a secured place).

Data entry and analysis:

Data entry was performed with the help of trained volunteers working in small groups. All the responses were recorded in a user-protected secured cloud server of REDCap and validation of data entry was performed by randomly checking 5% of the responses. Descriptive (percentage and frequency) and inferential (two proportion Z-test) statistical procedures were performed. For two population proportions, the following formula was used to calculate the Z score, which was then used to calculate the *p* value.

Z test statistic

Test of significance for the difference between two proportions with unknown $p_1 - p_2$ values.

$$Z_0 = \left| \frac{p_1 - p_2}{\sqrt{\overline{P}\overline{Q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \right|$$

$$\overline{P} = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2} = \frac{x_1 + x_2}{n_1 + n_2}$$

$$\overline{Q} = 1 - \overline{P}$$

Z_0 → Z statistic.
$p_1 - p_2$ → difference between the two-sample proportion p_1 and p_2
$\overline{P}$ → estimated population proportion
x_1 and x_2 → number of successes in two sample
n_1 and n_2 → number of elements in two sample

Result

Overall, 3,812 students from twenty-five different colleges and universities participated in this study. During data entry, 139 responses were discarded because of incomplete responses. Finally, 3,673 responses were eligible for further analysis; 54% were female and 46% were male. The majority of the respondents were studied at the undergraduate level (65%) and the rest were from higher secondary level. Among the undergraduate students, 33% were from a biology background, 26% were from physical science and engineering background, 23% belonged to social sciences, and 18% were from a business studies background. Among the higher secondary level students, 42% were from the humanities group, 25% were from science, and 23% were from the business studies group.

Participant's attitude about sunlight exposure:

Nearly 30% of the participants believed that the level of UV radiation in the sunlight of Bangladesh was 'very high' (this belief was also prevalent among the female students compared to the male counterparts; $p < 0.01$), while 35% thought this level was 'moderate' (Figure 1).

[Figure 1]

In a separate question, 9% thought that direct sunlight exposure should be 'avoided' (this attitude was predominantly more prevalent among the female respondents compared to the males; $p < 0.01$). The majority of the participants (52%) deemed regular sunlight exposure as harmful (17% thought it was 'very harmful', and 35% thought it was 'fairly harmful'; Figure 1), while 33% responded favorably to regular sunlight exposure. Further details of the responses to all the attitude-related questions can be found in supplementary file (Table S1). Over half of the participants (51%) identified getting darker skin due to sun exposure as a problem. This concern also was more prevalent among the females compared to the males (56% and 45% respectively; $p < 0.01$). This concern was reflected in the response to the question regarding the necessity of sunscreen usage in Bangladesh; more than half of respondents (52%) believed that sunscreen should be used 'regularly' in Bangladesh to stay protected from the negative effects of direct sunlight (58% of the females vs. 45% of the males; $p < 0.01$).

Participant's knowledge about vitamin D and its deficiency:

Overall knowledge of the participants of this study regarding vitamin D deficiency was not very high. Only 12% of them (10% of the females and 13% of the males) could identify 10 am to 3 pm as the best time to produce vitamin D in the human body from direct sunlight in Bangladesh. Instead, a high majority of the respondents thought it was before 10 am (Figure 2). Furthermore, 51% of the respondents thought only <30 minutes of direct sunlight exposure per week would be enough for Bangladeshi people to get sufficient vitamin D (34% thought 15-30 minutes, while 17% thought 5-15 minutes would be adequate). On the contrary, 27% thought it should be >30 minutes; 14% chose 30 minutes to 1 hour, 8% chose 1-3 hours, and 5% thought more than 3 hours would be necessary, while 22% were 'not sure'.

[Figure 2]

While nearly half of the participants (48%) identified bone and waist pain as potential symptoms associated with vitamin D deficiency, a lesser percentage of the respondents could identify the other symptoms of its deficiency – bone loss (39%), tiredness (34%), depression (12%), hair loss (17%), and frequent illness (17%) are among these. Later in the questionnaire, when it was mentioned that these symptoms could be linked to vitamin D deficiency, nearly half of the respondents (47%) replied that they thought they might have such deficiency (52% of the females vs. 40% of the males; $p < 0.01$). Details of the responses can be found in Supplementary file (Table S2). Regarding the potential consequences, while a majority of our study participants (56%) identified osteoporosis, only a few could do so for the other diseases – autoimmune disease (16%), cancer (8%), diabetes (6%), obesity (6%) are among these.

When asked what influenced their (negative) perception about the direct sun exposure (if at all they thought this was harmful), 25% stressed they did not think it was harmful. On the contrary, doctors' advice and advertisements for fairness creams were identified by 30% and 10% of the respondents respectively as the source of negative perceptions about sun exposure.

Participants' practices regarding vitamin D and sunlight:

Almost one-third of the participants (33%) responded that they avoid direct sunlight at home or outside (Figure 3). Among the sun-protection items reported to be used by the participants, umbrella (51%), full-head scarf (22%), and full-body covering (burqa/full-sleeve shirt; 19%) were the most common. Detailed answers to these questions can be found in supplementary file (Table S3).

[Figure 3]

Nearly one-sixth of our study participants (18%) reported using sunscreen or fairness cream when they go outside. Almost half of the participants (49%) reported that they usually spend time outdoor between 10 am to 3 pm, while 5% responded that they usually do not get direct sunlight during this time. Regarding the use of the supplement, while one-fifth of the respondents (20%) reported they routinely took vitamin D, the majority of the participants (68%) reported they never took this as medicine or supplement. Finally, 85% of the respondents never checked their serum vitamin D level.

Discussion

Results from this study highlight that a large portion of educated young adults views sunlight exposure negatively. A similar negative attitude was reported in a study from India, albeit conducted on limited number of biotechnology students only [16]. Regarding the potential influencing factors behind such a negative attitude, fear of the health risk due to exposure to UV radiation in the sunlight of Bangladesh was predominant (Figure 1). However, according to the World Health Organization (WHO), the UV intensity can be classified as 'very high' when the UV index ranges between 8-10 [23]. But the monthly average of the highest daily UV index in Bangladesh ranges from 6 to 7 due to Bangladesh being located in a subtropical region, sunlight intensity remains moderate throughout the year [19]. It should be noted that this range represents only the peak during mid-day for a short duration, implying the UV index remains below 6 for most of the day. Furthermore, WHO's classification of health risk from UV-exposure did not take into account the other confounding variables like skin complexion. According to the Fitzpatrick scale, unlike the European population (who have skin type of I or II), people from the Indian subcontinent (India, Bangladesh, and Pakistan) have skin type IV and V which is naturally much more protected from harmful solar radiation due to high

melanin concentration [24, 25]. Indeed, Bangladesh ranks 183 (and India ranks 173) among the list countries for skin cancer-rates refutes the hypothesis that UV radiation in the sunlight in Bangladesh is indeed a big health concern [26]. Therefore, the fear of 'very high' UV is an overestimation which might have led to a belief that sunlight exposure would be 'unsafe' for health, which is perhaps influencing sun-exposure practices in the wider community. Indeed, this has been reflected in the fact that 72% of the respondents reported they used some sort of sun-protection items to be protected from the adverse effects of sun exposure.

In addition to the exaggerated fear of adverse health effects, high admiration for fair skin complexion especially in the case of females is a deeply ingrained cultural aspect in South Asia [10, 11]. Accordingly, 51% of the respondents of this study identified that getting darker skin due to sunlight exposure was a 'problem' (Figure 1). This concern about skin complexion was found significantly higher among the female participants of this study; $p < 0.01$; supplementary Table S1). This is found in line with the overall negative attitude to sun exposure (e.g., fear of very high UV radiation and belief that sunscreen should be used regularly) also being significantly higher among the young female participants of this study ($p < 0.01$). In this regard, the commercial advertisements promoting fair skin and the portrayal of sun exposure as a problem (also identified in this study as the second most important source of negative perception about sunlight) could be making young females more vulnerable. Such aggressive advertisements have been reported in the past as a stimulator for perpetuating the negative attitude towards sunlight [27]. Therefore, we argue that continuous review and regulation of the aggressive (misleading or even false) commercial narratives targeting the young population promoted by companies that benefit from the fairness products is strongly recommended as this might be contributing to the high prevalence of vitamin D among the young adults. This can be a really important step to protect a vulnerable community (due to young age) that is mostly unaware of the importance of vitamin D and the prevalence of its deficiency in the community.

Regarding the sources of knowledge and attitude regarding the effects of sunlight exposure, 'doctors' advice' was identified as the most important. However, albeit unexpected, another recent study conducted by our group has identified that the majority of the healthcare providers in Bangladesh were overly concerned about the level of harmful UV radiation in the sunlight in Bangladesh [28]. Indeed, a high majority of the medical practitioners could not identify the time from 10 am to 3 pm as the best time to get vitamin D from sunlight in Bangladesh. Therefore, it is highly plausible that the attitude of the educated young adults in this study was perhaps negatively influenced by that of the medical practitioners.

While it was beyond the scope of this project to test serum vitamin D for the participants, response to one particular question could be revealing. Based on the potential symptoms commonly associated with vitamin D deficiency, 47% identified themselves as potentially deficient, while 28% were unsure. Albeit arbitrary, the self-identified deficiency was higher among the females; 52% of the females compared to 40% of the males; $p < 0.01$ (Figure 2). Indeed, a similar trend has been reported in a systematic review from South Asia (76% of females and 51% of males are affected by vitamin D deficiency) [7]. Despite some recent literature showing the overall prevalence of vitamin D deficiency is very high in Bangladesh [7-9], 85% of the participants said they never checked their serum vitamin D level. This is perhaps a reflection of widespread vitamin D deficiency in South Asia being a seriously overlooked public health concern. While the high expense associated with testing serum vitamin D might be a contributing factor, lack of knowledge and awareness could also be crucial determinants in this case.

In line with negative attitude, knowledge about the most crucial vitamin D-related aspects was indeed suboptimal. This applies to the best time in the day for the production of vitamin D from sunlight, the symptoms associated with the deficiency of this vitamin, as well as its potential long-term consequences (Figure 2). The highest number of participants believed only 15-30 minutes of weekly sunlight exposure would be sufficient for the production of adequate vitamin D. In this regard, based on data from multiple studies, Holick et al. (2007) suggested that 5 to 30 min of sunlight exposure twice a week could often be sufficient [2]. However, this recommendation was made mostly based on studies not conducted on the South Asian population. Considering the darker skin complexion and heavier clothing practices in this region, high caution should be practiced before generalizing this recommendation for South Asia. Indeed, this was later highlighted in other literature [29, 30]. As such, while further research is needed in this regard, it is perhaps safe to assume that the required weekly sun exposure for the South Asian

population, and for Bangladeshis as such, would be >30 minutes per week, which was identified by only 14% respondents of this study. As such, finding the right ways to disseminate correct knowledge among young adults could be crucial. But how?

While increasing the number of diagnostic centers for detecting serum levels of vitamin D, encouraging people to take foods rich in vitamin D, and considering food fortification programs are important steps, it is also necessary to consider the socioeconomic context for any policy to be effective. Therefore, a parallel policy towards encouraging people to get sun exposure can be an easy and low-cost option for Bangladesh (and other regions with similar context), since sunlight is abundant throughout the year. However, further research is warranted before making such recommendations to determine the actual levels of ultraviolet radiation throughout any country, and its direct and indirect effects on human health, especially during high UV intensity periods. Large-scale prospective/experimental studies to determine the minimum duration required for the production of vitamin D for different skin complexions should be considered a high priority. Also, attention should be given to finding/establishing effective mass communication strategies (e.g., including relate information in the textbooks, and engaging the medical community) can be considered to disseminate correct knowledge and awareness among the wider community about the critical role of sun exposure for the human body as well as the relevant safety aspects.

To the best of our knowledge, the sample size of 3,673 is the highest among all the studies related to knowledge, attitude, and practices conducted in South Asia and possibly beyond. Furthermore, instead of focusing on a specific demographic group (e.g., medical students, pharmacy students, etc.), the demographic diversity of this study is perhaps more representative than any other similar study. Hence, the insights gained from this study would be really helpful to get a holistic view of the mindset of young adults.

Conclusions

This study provides a unique dataset regarding how educated young adults from a high-risk view of sun exposure in the context of health and wellbeing. The results from this study suggest that Bangladeshi-educated young adults have a suboptimal level of knowledge about the crucial health aspects of vitamin D and its relation to sunlight, while the attitude towards sun exposure is grossly negative. With only a small percentage of young adults taking vitamin D supplements, such a negative attitude towards sun exposure (and the practice of avoiding it) perhaps explains the high prevalence of its deficiency among the young adults in this region. Despite such high prevalence, only a small percentage of educated young adults ever testing their serum vitamin D level underscores its deficiency as a highly overlooked health hazard in this region. The insights gained from this study will provide a better understanding of the famous vitamin D paradox. Overall, this study will pave new ways to facilitate adopting more effective policies to address vitamin D deficiency globally.

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the World Medical Association (WMA) Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects. We obtained written informed consent from all of our study participants regarding their willingness to participate. Furthermore, whenever applicable, written permissions were collected from the participating institutions. Additionally, we also followed STROBE checklist at various stages of this study. Further, the study protocol was evaluated and approved by the internal reviewers of BRAC University (Semester: Fall 2019/ 27-06-2019). Afterward, a subsequent review and approval was also taken from the Biomedical Research Foundation (BRF) ethical review committee (Memo: BRF/ERB/2019/018, dated 03-08-2019).

Consent for publication:

Not Applicable.

Availability of data and materials:

Data generated in this study is not publicly available. Only aggregated summaries are provided in these manuscripts. Please contact the corresponding author (MHS) for any kind of data request.

Competing interests:

The authors declare that they have no conflict of interest.

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Authors' contributions:

MHS and URS conceptualize the idea and supervise the overall project. MHS and BB designed this study and prepare the questionnaire for data collection. MSH coordinated with the required authorities for conducting this study. BB, MMH (Mehedi), SI, MRU, and MH played a major role in data collection. BB, MMH (Mehedi), SI, and MRU contributed equally during entering the data in REDCap. MMH (Mahbub) did all the necessary statistical analysis. MHS and BB substantially contributed to the interpretation of the result and prepared the first draft of the manuscript. All the authors critically revised the manuscript and approved the final version for submission.

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Figures

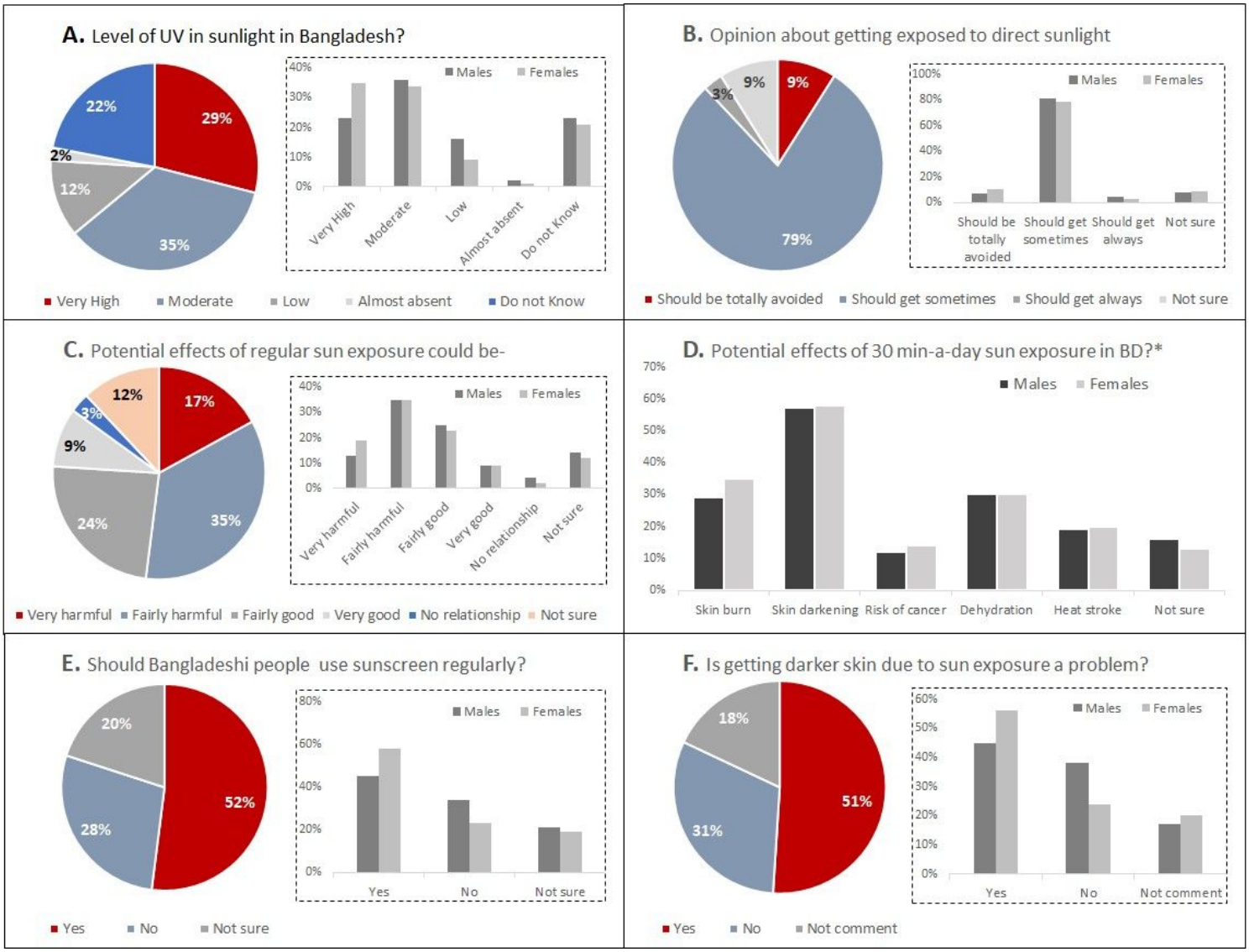

Figure 1

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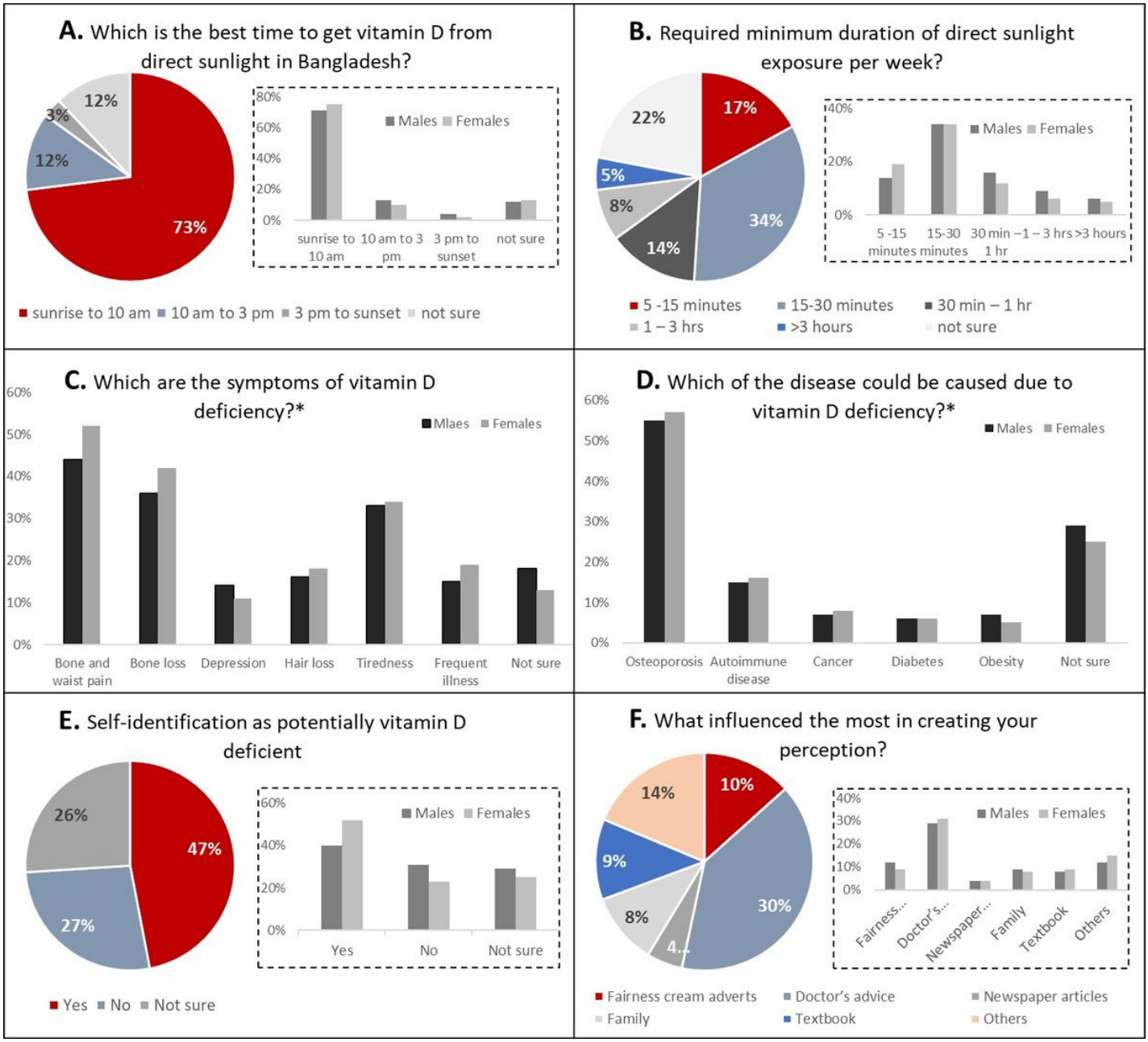

Figure 2

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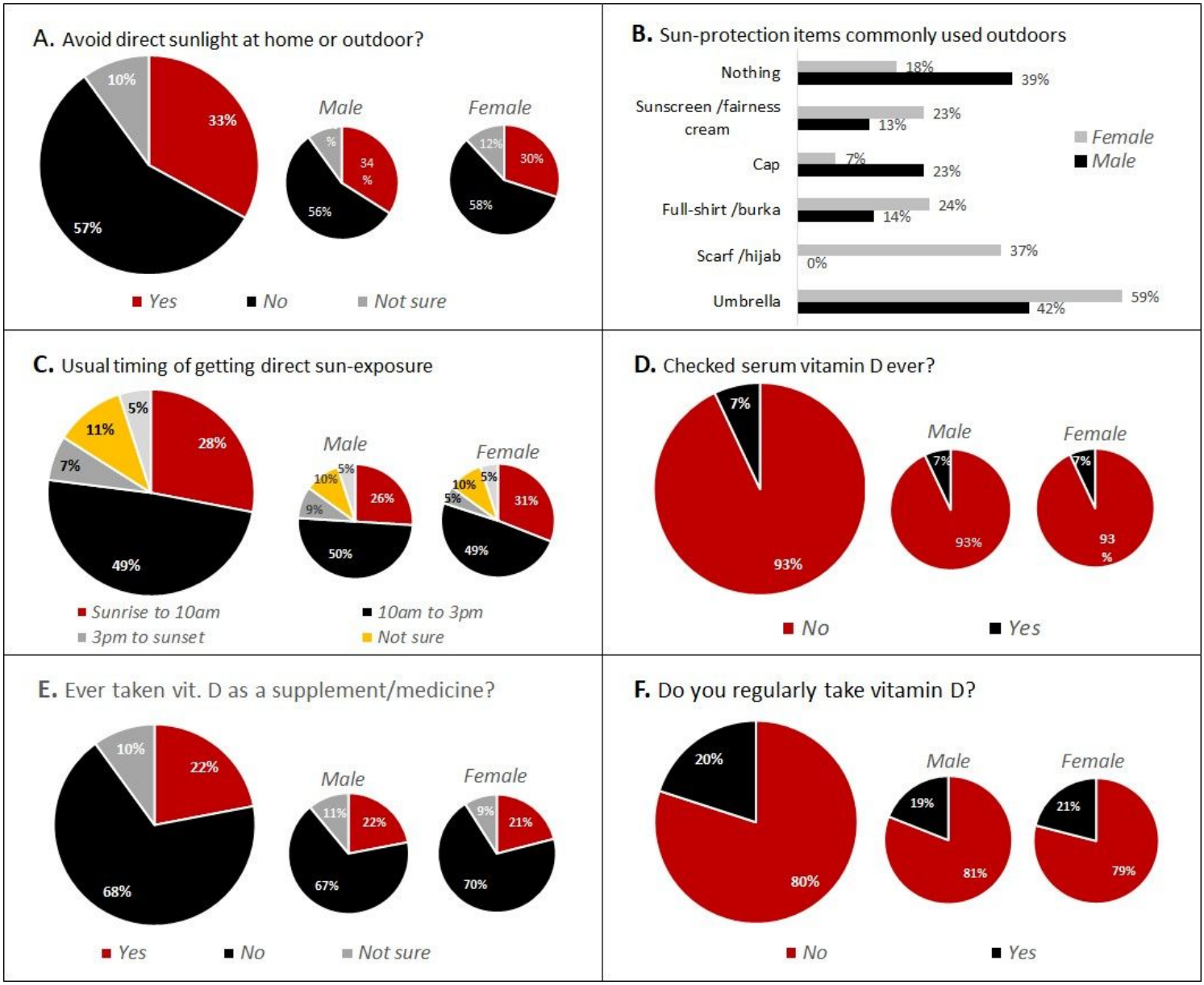

Figure 3

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Supplementary Files

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