Sociocultural Factors Affecting Sun-Seeking Behavior for Infants Living in Rural or Urban Communities in Southern Ethiopia

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ABSTRACT

Introduction: Ethiopians depend on sunlight for vitamin D synthesis due to limited dietary sources. This qualitative study investigated sociocultural factors affecting sun exposure for infants of women from three categories: initial pregnancies, mothers of infants 1-2 y, and grandmothers. *Methods:* Eighteen focus groups with ~10 participants each were held in three urban and three rural communities. In-depth interviews were conducted with local health extension workers (HEWs). *Results:* Reports from grandmothers indicated that awareness of benefits of sun exposure for infants has increased in the last generation. Practicing infant sun exposure is a generally accepted practice among all participants. Mothers wait to expose their infants to sunlight for 1-3 months in rural and ~15 days in urban areas. The prevalent feeling was that roughly 30 minutes of morning sunlight (7-9 am), never afternoon sun, was best for infant health. Barriers mentioned for mothers were headaches, skin irritation, catching a cold from drafts, and general discomfort. Barriers for infant exposure postpartum included fear of the evil eye and catching a cold from drafts. Only 2/82 rural and 26/88 urban women freely associated sunlight with vitamin D. HEWs provided health information for a self-reported 96% of rural and 88% of urban women. Most participants agreed that sun exposure was generally healthy for their infants with urban women citing more knowledge of its benefits for bone health than rural women. *Discussion:* It appears that, besides heavy sunlight, mothers have few aversions to sunlight itself. Rather, they fear illness caused by public exposure (evil eye) and temperature changes (drafts causing colds). Delays in initiating sun exposure and short exposure duration in the mornings only may prevent adequate vitamin D synthesis in this population. Variable understanding of the specific importance of sun exposure amongst rural women and of sources of vitamin D in both groups indicates disparities in knowledge transfer and application. Our data support additional training of both rural and urban HEWs regarding benefits of sun exposure for infants in order to increase this behavior, promote its earlier initiation, and increase its duration in both rural and urban populations.

INTRODUCTION

Vitamin D is a pro-hormone synthesized endogenously in the skin upon exposure to ultraviolet B (UVB) radiation, which includes wavelengths from 290-315 nm.[1,2] It may be obtained in small amounts from consumption of fish oil, deep sea fatty fish, egg yolks, or fortified milk, cheese, and cereals.[3,7,32] Vitamin D regulates the absorption of calcium and phosphorus from the intestines and their excretion by the kidneys to maintain homeostasis of these minerals in the body. Most importantly, it works with parathyroid hormone to regulate bone mineralization balance with blood calcium levels. Vitamin D works anywhere it can attach to its specific cell surface receptor, including the tissues of the breast, prostate, colon, skin, and cells of the immune system.[1,3-5]

Vitamin D deficiency manifests as growth retardation and rickets in growing children and as osteomalacia in adults. In adults, decreased mineralization of bone can contribute to development of osteoporosis and muscle and nerve problems.[1,5,6] Symptoms of deficiency are reversible with a return to acceptable serum levels of Vitamin D, defined as >50 nmol/L.[1,3,5,7-10] Two hospital based case-control studies conducted in the late 1990's in Ethiopia reported a strong association between sun exposure and rickets[11] and a high prevalence of rickets in children with pneumonia.[12] Additionally, a systematic review of published and unpublished information on rickets identified lack of exposure to sunshine and inadequate intake of vitamin D as major risk factors.[11]

Skin pigmentation, clothing coverage, altitude, latitude, age, and various environmental conditions all affect cutaneous synthesis of Vitamin D and will be discussed in detail in the following literature review. Any environmental factor that reduces exposure to sunlight (season of the year, cloudiness, pollution level, time of day) without adequate dietary consumption will lead to decreased levels of Vitamin D and eventual development of deficiency.[1,2,5,8,9,13,14] Foods that contain Vitamin D are not prevalent in the Ethiopian diet and there are no government programs to provide supplements such as the Women, Infants, and Children (WIC) program in America, making the population almost completely reliant on sun exposure.[15,16] The most commonly studied risk factors to maintaining adequate Vitamin D status related to adequate skin synthesis are heavy skin pigmentation and clothing coverage. Lack of consumption of Vitamin D rich foods also contribute to the deficiency. [7,13,1,17] Exclusive breastfeeding is a risk factor for infants, particularly when mothers are already Vitamin D deficient and possess one or more of the other common risk factors.[2,6,18-20]

Vitamin D status among those with darker skin is a major concern worldwide because this darker pigmentation slows Vitamin D synthesis by competing with Vitamin D in the skin for UVB radiation. Dark-skinned women are ten times more likely to have hypovitaminosis D than white women and consistently have lower Vitamin D levels than their light-skinned counterparts by at least half.[17,21] Chen et al. showed that dark-skinned individuals require significantly longer sun exposure than light-skinned individuals to synthesize the same amounts of Vitamin D.[13] Pregnant women are at a particularly high risk of deficiency, and thus, their breast-fed infants subsequently share this risk. [6,16,18,20,29,33]

A conservative dressing style that only allows sun light exposure at the head, the neck region and hands limits direct sun exposure and significantly reduces vitamin D synthesis. Conservative dress habits and use of a veil for religious purposes have been shown to contribute significantly to the occurrence of vitamin D deficiency even in sunshine abundant countries. [4,9,14,21]

Availability of adequate sunshine alone does not always ensure vitamin D adequacy**.** The Middle East and Africa have a history of Vitamin D deficiency despite abundant sunlight.[3] A study of 298 women in Oman showed that only 10% had 25(OH)D_3 concentrations above the level considered optimal for maximal bone health. A more recent 2010 study of 41 Omani women showed that not one had a Vitamin D level above the 50 nmol/L cutoff for sufficiency.[7] Several recent Omani, Saudi Arabian, UAE, and Qatari studies also support the conclusion that despite the abundant sunlight in Africa and the Middle East, most women of childbearing age have 25(OH)D concentrations below the 50 nmol/L cutoff for minimal sufficiency.[3,7,14]

Limited research has been conducted specifically in Ethiopia regarding Vitamin D status due to its position near the equator and subsequent abundance of sunshine. Those studies conducted all show prevalent deficiency similar to that seen in the Middle East and other parts of Africa. Feleke and colleagues compared serum 25(OH)D concentrations of Ethiopian and Norwegian adults and pregnant women. Mean 25(OH)D concentrations for Ethiopian participants residing in Addis Ababa was 23.5 nmol/L for adults and 25 nmol/L for pregnant women compared to 81 nmol/L and 36 nmol/L for Norwegian adults and pregnant women.[22] Gebreegziabher & Stoecker reported that 15.8% of rural women living near Ethiopia's Rift Valley had 25(OH)D levels below 30 nmol/L and 69.4% had levels between 30-50 nmol/L.[23] A study that assessed 25(OH)D levels of lactating women (n=108) in Wondo Genet and Arsi Negele in Ethiopia reported a 39% vitamin D insufficiency. Study participants had modest clothing habits, did not consume vitamin D rich or fortified foods, and covered their babies and themselves from the sun for religious and cultural reasons related to conservatism.[25] The concern that other Ethiopian women and infants specifically are suffering from similarly serious Vitamin D deficiencies is therefore very real. However, little research has been conducted specifically investigating the reasons for this deficiency in the Ethiopian population.

Therefore, the main objective of this study was to assess sociocultural factors (dress, cultural practices, safety, and daily responsibilities) that interfere with adequate sun exposure for mothers and their infants of both rural and urban kebeles. Secondary objectives were to assess the knowledge of the health benefits of sunlight and to examine changes in beliefs regarding sunlight exposure and subsequent practices in the last two generations of Ethiopia rural and urban women.

OBJECTIVES

Primary Objectives

1) To assess sociocultural factors (dress, cultural practices, safety, daily responsibilities) that interfere with adequate sun exposure for mothers and their infants
2) To examine differences in sun seeking behavior between rural and urban women

Secondary Objectives

1) To assess knowledge of the role of sunlight in health
2) To examine changes in beliefs regarding sunlight exposure and subsequent practices in the last two generations of Ethiopian rural and urban women

LITERATURE REVIEW

Vitamin D is derived from a cholesterol-like molecule that is activated by exposure to ultraviolet radiation, specifically UVB waves of light at 290-315 nm.[1,2] There are two different forms of Vitamin D: D_2 (ergocalciferol), made in phytoplankton from ergosterol, and D_3 (cholecalciferol), synthesized in the skin of animals and humans. Both have activity when consumed in the diet. Vitamin D is important in cell proliferation, bone health, and immune system function. Cells activated by Vitamin D contain a vitamin D receptor (VDR) and include the cells of many organs and tissues as well as B and T lymphocytes.[16] Vitamin D status is measured by serum 25(OH)D_3.[1,2,4,6]

Regarding dietary sources, Vitamin D is present naturally in small amounts in egg yolks, fatty fish (herring, tuna, mackerel, salmon, sardines), fish liver oils, and animal-based foods. Dairy products, orange juice, and cereals products are often fortified with vitamin D in the US and Europe.[3,7,32] Most dietary sources of vitamin D have less than 150 IU of vitamin D per serving regardless of fortification. Only fatty fish (300-700 IU per 3 ounce portion) and fish oils (1,400 IU per one tablespoon) contain appreciable levels of vitamin D relative to a reasonable amount of daily consumption and the DRI.[32,36] Ergocalciferol (D_2) is synthesized by irradiated yeast and is used in supplements and to fortify foods commercially. However, many brands of grocery store yeast are not pre-irradiated.[32] Most of the dietary Vitamin D consumed in North America is from fortified grains, dairy products, orange juice, or supplements. Most countries in Europe, Asia, and Africa do not fortify their food with Vitamin D. Many studies have shown that despite food fortification, many North Americans are still Vitamin D deficient, leading to concern that inhabitants of other continents that do not fortify their foods are also deficient.

HISTORY

Vitamin D was first observed as a component of fish oils in the 1920's and was hypothesized to be the result of consumption by fish of zooplankton, which also synthesize Vitamin D upon exposure to sunlight. The magnifying effects of the food chain would hence give fish oil its high Vitamin D content.[1,4]

Health problems associated with Vitamin D deficiency were prevalent during the Industrial Revolution of the 17th and 18th centuries.[1,4,6] Children who lived in the sunless alleys of American and European cities developed "severe growth retardation, widening of the ends of long bones, and bowing and bending of the legs", while women developed flat pelvises that made natural childbirth difficult. These are both clinical signs of severe rickets. It was not until the late 1800's that the effects of ultraviolet radiation were officially investigated and found to cure rickets. Mellanby induced and cured rickets in dogs with fish oil, proving the connection between the disease and nutrition.[1,4,20]

In 1924, Steenbock and colleagues recommended that milk be fortified with provitamin D_2 and then irradiated to prevent and eliminate rickets from the world population. Recommendations such as this ultimately led to the fortification of various dairy and grain products in some countries.[16,20] Rickets was mostly eliminated in the United States by 1960 due to supplemented infant formula and increased understanding of the importance of sunlight and Vitamin D in the etiology of rickets. Rickets began to make a comeback in the US in 1990, mostly in African Americans, and is still a major problem worldwide.[5,6]

STRUCTURE, SYNTHEIS, AND METABOLISM

Vitamin D is not technically a vitamin, but rather a secosteroid synthesized in the skin upon exposure to UVB radiation (290-315 nm).[2,3,5,17] The synthesis process takes several steps performed in several locations throughout the body and utilizes five Vitamin D metabolites: 7-dehydrocholesterol, pre-vitamin D_3, D_3 or cholecalciferol, 25-hydroxyvitamin D_3, and 1,25-dihydroxyvitamin D_3.[1]

7-dehydrocholesterol (7DHC), or provitamin D, is located in the lipid membrane of skin cells and is similar in structure to cholesterol, as its name would suggest (Figure 1). When it absorbs UVB radiation, the B ring splits at the 9,10 carbon-carbon bond and forms one of two conformations: a *cis,cis* (czc) and a *cis,trans* (czt) form.[17] Only the czc form, called pre-vitamin D_3, is capable of producing active Vitamin D_3. The location of the provitamin D_3 in the lipid bilayer reduces the formation of the czt conformer and favors the czc conformer due to van der Waals forces and hydrophobic interactions within the bilayer. Body heat isomerizes the pre-Vitamin D_3 into active D_3 or cholecalciferol, which is sterically unacceptable in the membrane and is ejected into the extracellular matrix.[1,7] D_3 then enters the bloodstream attached to a D-binding protein.[2,7] This process requires several hours. [2] It is also worth noting that a threshold amount of UVB radiation must be absorbed before vitamin D synthesis begins.[7]

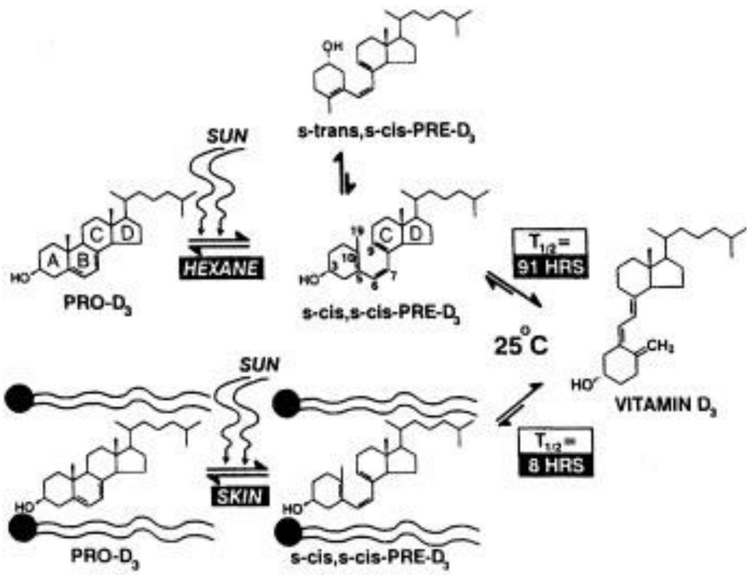

Figure 1: Photolysis of provitamin D_3 into the czc form and subsequent thermal isomerization into active D_3 by body heat. This occurs at 25 degrees Celsius in lizard skin. [1] Human body temperature is around 37 degrees Celsius.

Previtamin D_3 can be photoisomerized into several additional, inert isomers. All of these can then be photoisomerized back into 7DHC with continued UVB exposure, eliminating the potential for exposure toxicity. Extended UVB exposure also inactivates D_3 not yet in circulation.[2]

In the 1960's, scientists discovered that D_3 is again altered in the liver to create a more potent form called 25-hydroxyvitamin D_3 ($25(OH)D_3$) or calcidiol.[1,2,7,27] Whereas unaltered D_3 required 24 hours to see maximum levels of calcium absorption in deficient rat intestines, $25(OH)D_3$ only required 12 hours to see the same effects.[1]

Various *in vivo* and *ex vivo* experiments with pigs and chickens in the 1970's revealed the presence of the fifth and final metabolite, 1,25-dihydroxyvitamin D_3 ($1,25(OH)_2D_3$) or calcitriol. This is formed by activation of $25(OH)D_3$ by the kidneys, creating this most potent form of Vitamin D.[1,2,7] This is the form that binds to the VDR in tissues and organs to produce the characteristic effects of Vitamin D. Synthesis of $1,25(OH)_2D_3$ is tightly regulated in the kidneys and is not subject to change with variations in sun exposure.[2] Intracellular conversion of $25(OH)D_3$ to $1,25(OH)_2D_3$ also occurs in keratinocytes, lymphocytes, and cells of the prostate, lungs, colon, and breast.[1,3]

The $25(OH)D_3$ level reflects amounts of Vitamin D_2 ingested in dietary form and D_3 synthesized cutaneously.[3] The longer half life of $25(OH)D_3$ (two weeks) compared to that of $1,25(OH)_2D_3$ (4-15 hours) makes serum $25(OH)D_3$ the more reliable indicator of Vitamin D status. [3,7,27]

FUNCTIONS IN BODY

Dihydroxyvitamin D or calcitriol regulates the absorption of calcium and phosphorus from the intestines and their excretion by the kidneys to maintain homeostasis of these minerals in the body, particularly in relation to bone health. It works with parathyroid hormone to activate osteoclasts, which release calcium from the bones when calcium is needed in the blood. This negative feedback loop constitutes the major documented function of vitamin D. Vitamin D also has antiproliferative properties visible in its interaction to slow the growth of certain cancer cells as well as activity in the regulation of the innate immune system, particularly related to autoimmunity.[1,3-5,34] Vitamin D also functions as a negative regulator in the renin-angiotensisn system and may be associated with the development and progression of multiple sclerosis, arthritis, lupus, Alzheimer's, Parkinson's, and respiratory infections.[1,34]

Cells that have Vitamin D activity display a VDR on their cell membrane. A VDR has been found in kidney, intestine, skin, dendritic, and osteoblast cells as well as T and B lymphocytes, monocytes, pancreatic beta cells, and myocytes.[1,34] Additionally, the prostate, colon, skin, T cells, monocytes, and osteoblasts have demonstrated the ability to locally synthesize $1,25(OH)_2D_3$.[7,10,34] Combining this knowledge with data showing that those at higher latitudes are more likely to die from breast, colon, and prostate cancer suggests that local synthesis may play a role in mediating cell growth.[1,32,34]

Also, the UV absorption range of 7-dehydrocholesterol correlates with that of DNA, RNA, and many cell proteins. This similarity suggests a possible evolutionary function of Vitamin D as a protective factor against UV damage to cellular DNA.[16] Many studies have shown beneficial effects of Vitamin D in managing and preventing numerous chronic diseases (cardiovascular and respiratory diseases, hypertension, and several degenerative brain diseases) as well as increasing life expectancy, although more research is needed to determine mechanisms.[2,3,27]

DIETARY REFERENCE INTAKES (DRI's)

Due to numerous and conflicting messages regarding adequate calcium and Vitamin D intake, the US and Canadian governments asked the Institute of Medicine (IOM) to assess the available research and set new recommendations for the public. In 2011, the IOM provided a recommendation report updated from the original 1997 recommendations.

The recommended daily allowance (RDA) for Vitamin D for individuals 1-70 years of age regardless of childbearing status was set at 600 IU/d (15 µg/d), while those over 70 years of age are recommended to obtain 800 IU/d (20 µg/d). An adequate intake (AI) was set at 400 IU/d for infants 0-12 months; no RDA has been set for infants. The tolerable upper limit (UL) was set at 4000 IU/d (100 µg/d) for most individuals.[14]

The American Academy of Pediatrics (AAP) recommends no direct sun exposure before 6 months of age and 400 IU/d for exclusively or partially breast fed infants through supplementation within the first two months of life until weaning.[3,18] Some research suggests that the current UL may be too low, as no adverse effects of vitamin D supplementation have been documented in supplementation trials of 10,000 IU dietary ingestion.[29,33,34] Current clinical trials are investigating the effects of higher dosages, and some have already shown no adverse effects for intakes of 14,000 IU/d.[36] Many studies suggest intakes of 800-1000IU would be more beneficial to overall health than the currently recommended 600 IU.[5,10,29] The National Osteoporosis Foundation suggests intakes of 600-800IU and 800-1000IU for relevant age groups to maximize bone health.[35] The Canadian Paediatric Society advocates a minimum of 800-1000 IU/d and also cites benefits for infants postpartum with 4000 IU/d intake in pregnant mothers.[33]

"Sufficient" circulating levels have been defined by the IOM based on statistically significant benefits to bone health at >50 nmol/L of 25(OH)D_3 or 20 ng/mL. The IOM committee did not find enough convincing evidence to set the DRI's based on other suggested roles of vitamin D. Thus, many experts argue that optimal levels of serum 25(OH)D_3 for overall health are actually higher (>75 nmol/L or >30 ng/mL).[3,5,7-10] The Canadian Paediatric Society sets optimal serum levels at 75-225 nmol/L with "insufficiency" defined as anywhere from 25-75 nmol/L, values echoed by the US Endocrine Society and other independent studies (see **Table 1** in *Appendix***)**.[9,33,34]

Several research studies and foundations (National Osteoporosis Foundation, AAP) recommend supplements rather than sun for individuals with concerns about cancer risk and for infants.[5,6,8,18]

SUN EXPOSURE

Sunlight is arguably the best source of Vitamin D. Much research has been devoted to determining the amount of sunlight exposure needed to synthesize adequate amounts of this important compound.[14,26] Due to the length of time required to synthesize D_3, the plateau of synthesis after a certain period, and the breakdown of formed D_3 in the skin with increased sun exposure, it has been recommended by some experts to practice short, regular exposures of large amounts of skin.[2,10]

Sun exposure is measured in the minimal erythemal dose (MED), or the amount of UV exposure required to produce a slight reddening of the skin.[1,2,7] One MED of exposure in a bathing suit (hand, face, arms, and legs) is equal to ingesting 10,000-25,000 IU of vitamin D orally.[1,7,10] Therefore, exposure to an individual's MED once per week would be numerically adequate to maintain acceptable vitamin D levels, although short, regular exposures every day are also a viable method of maintaining adequacy.[1,2] However, confounding factors including individually unique MEDs, time of year, and latitude present barriers to setting population-wide sun exposure recommendations. Studies have shown that poleward of 45-51 degrees latitude, no Vitamin D is synthesized for at least some period of the year.[2,9] However, when exposed to proportional amounts of UVB, individuals with darker skin pigmentations synthesize the same amounts of Vitamin D as lighter skinned individuals relative to their individual MED.[2,7]

Due to the plethora of factors affecting vitamin D synthesis, it is difficult to determine adequate sun exposure recommendations for multiple populations. Alshishtawy calculated that a person with moderately fair skin could expose their hands, face, and arms for 6-7 minutes from 10a-2p in the summer or 9-12 minutes in the winter in Northern Australia (17 degrees south) and make 1000 IU/d, but that the same individual would require 7-9 minutes in the summer and 40-47 minutes in the winter to synthesize the same amount in Tasmania (41-43 degrees south) due to the increase in latitude.[7] Holick suggested obtaining one MED two to three times per week and using sunscreen after the MED is reached for one session.[1,2] The NIH references work stating that 5-30 minutes exposing the face, arms, legs, or back from 10a-3p twice a week will result in sufficient vitamin D synthesis.[32] Webb et al. discussed using the 25% of skin surface area (Rule of Nines) to obtain 25% of one MED per day assuming 1000IU/d recommendation.[2] Kreiter et al. recommended infants obtain their vitamin D via supplement from 2-6 months of age rather than by direct sunlight in accordance with guidelines set by the AAP.[6] None of these recommendations take skin color, age, or other factors into account.

Additionally, an individual's MED is just that—individual to their physiology. Thus, it is very difficult to make practical population or individual recommendations for sun exposure to obtain adequate vitamin D status.

DEFICIENCY

What

Serum 25(OH)D_3 levels of 50 nmol/L have been generally defined as the lower limit of sufficiency for adequate Vitamin D status in order to maximize calcium absorption and maintain parathyroid hormone (PTH) levels.[1,5,7,23] Different studies may define insufficiency and deficiency differently, however. Increased PTH levels have been seen with concentrations below 30 nmol/L.[10,17,28] Vitamin D deficiency results in growth retardation and rickets in children and osteomalacia, or bone wasting, in adults. Rickets is characterized by beading of the ribs, bowing of the legs, widening of the ends of flat bones, and, occasionally, hypocalcemic tetany and seizures.[1,5,6] Secondary hyperparathyroidism caused by calcium and phosphorus leeching from the bones into the blood can also initiate osteoporosis in adults.[1] Muscle pain and weakness are other common symptoms of Vitamin D deficiency that can be misdiagnosed as fibromyalgia.[1,9]

Where

Vitamin D deficiency is present on all continents and in all skin types. In a recent analysis of worldwide rickets and hypovitaminosis D prevalence, serum vitamin D levels below 75 nmol/L were prevalent in every region studied. Additionally, levels below 25 nmol/L were the most common in the Middle East and South Asia.[39] Cases of rickets and osteomalacia have increased in recent years, possibly due to increased attention to sun protection to prevent cancer. However, those with darker skin pigments living above or below 35°N and S latitudes are at a higher risk for developing deficiency.[1-3,7]

Factors Affecting Deficiency

Although intake and absorption impairments may cause deficiency, without a doubt, the main cause of Vitamin D deficiency is inadequate exposure to sunlight.[3] Factors that affect skin synthesis of Vitamin D from UVB exposure include skin pigmentation, sunscreen application, clothing coverage and general amount of exposure, age, zenith angle of the sun, and various environmental and intrinsic factors.[1,8,9,13] In addition, sunscreen with an SPF of only eight has been shown to reduce Vitamin D synthesis by 97.5%.[1,5,14]

Melanin pigmentation helps protect skin cells from UV damage but also competes with 7-dehydrocholesterol for UVB activation; therefore, darker-skinned individuals are not able to synthesize Vitamin D as quickly as lighter-skinned individuals.[2,5,6] Heavily pigmented skin (type V/VI) is 5-10 times less efficient at converting 7DHC to cholecalciferol than lighter skin (type I/II).[13] A study by Chen et al. showed Type V skin had a 40% increase in serum $25(OH)D_3$ compared to a 210±53% increase in Type II skin when exposed to the same amount of UVB relative to the average MED of their skin type for a 12 week trial. Chen et al. also found that dark skin had a higher threshold to begin synthesis of previtamin D than light skin.[6,13] One study in 2008 found that dark skinned women had a 43% risk of hypovitaminosis D compared to the 4% risk for light skinned women.[21] This and another study showed that the average nmol/L for dark-skinned individuals is half that of light-skinned individuals during the same seasonal exposure.[17,21] Therefore, dark-skinned individuals (skin types V/VI) have a higher risk for Vitamin D deficiency than their lighter skinned counterparts.[1,2,6,7,13,17,19] There is an inverse relationship between 7DHC in the skin and age.[13] Older people have roughly four times less 7-dehydrocholesterol in their skin.[1,5] Synthesis of adequate amounts of Vitamin D is still possible by obtaining short, regular exposures to sunlight.[2]

The zenith angle of the sun refers to the angle of the sun's rays relative to a local vertical from the Earth's surface.[1,2] When the zenith angle of the sun is increased, such as during winter at latitudes above and below 35°N and S, fewer UVB photons can penetrate the atmosphere and reach the surface of the earth.[1] Smaller zenith angles can be achieved during the summer, around noontime, and nearer to the equator.[2,5]

Breast milk provides 15-50 IU/L of Vitamin D, which is not adequate to meet the recommended 400 IU/d when infants consume roughly 1 L/d.[6,18] Unsupplemented breastfeeding clearly does not provide adequate amounts of Vitamin D to infants, particularly when the mothers are Vitamin D deficient themselves, which is often the case with dark skinned mothers.[2,6,19,20] All cases of rickets seen at a North Carolina university from 1990-1999 were African American infants. Of these, 19 of 23 had $25(OH)D_3$ levels below 17 ng/mL. The four patients that had barely adequate levels had all been receiving some form of Vitamin D therapy for roughly a month before clinic referral. All 30 infants were breastfed, suggesting that infants reliant on breastfeeding for their total nutrition, such as those from Ethiopia, will have Vitamin D deficiencies.[1,6,16,39]

Time of day, season of the year, pollution level of the air, cloud coverage, ozone, and altitude are all environmental factors affecting Vitamin D production in the skin.[1-3,5] A study of 138 female Emirati university students showed that serum 25(OH)D_3 concentrations in April were 31.3±12.3 nmol/L compared to 20.9±14.9 nmol/L in October, demonstrating a clear seasonal effect.[3] Additional intrinsic factors such as race, genetics, and BMI also affect individual synthesis.[8]

VITAMIN D DEFICIENCIES IN ETHIOPIA AND SURROUNDING AREAS

As may be expected, the Middle East and Africa have a history of Vitamin D deficiency despite abundant sunlight. In fact, they possess the highest rates of rickets worldwide along with elevated rates of hypovitaminosis D.[3,39] In 2004, the Ministry of Health in Oman worked with the CDC, WHO, and UNICEF to analyze the vitamin D status of 298 non-pregnant women of childbearing age in that country, revealing that nearly half of these women had circulating serum levels below 37.5 nmol/L. Several recent Omani, Saudi Arabian, Kuwaiti, Iranian, UAE, and Qatari studies also support the conclusion that despite the abundant sunlight in Africa and the Middle East, most women of childbearing age have a 25(OH)D status below the 50 nmol/L cutoff for minimal sufficiency with many falling below the 25 nmol/L mark.[3,7,14,39] The concern that Ethiopian women and infants are suffering from similarly extreme Vitamin D deficiencies is very real, as shown by Gebreegziabher & Stoecker and Feleke and colleagues.[22,23]

Clothing Covering

Matsuoka et al. demonstrated that white and black cotton, plain weave fabric attenuated UVB penetration by 59% and 80%, respectively. White and black plain weave polyester allowed greater amounts of longer wavelengths to penetrate (321-400 nm). Wool effectively blocked all penetration by UVB. Tubes of 7DHC covered in each type of fabric formed no previtamin D compared to the uncovered tubes, which formed previtamin D during the entire 40-minute exposure time. Cotton and polyester clothing prevented previtamin D synthesis with whole body exposure to the equivalent UVB strength of six MED’s.[14]

Reed et al. evaluated the effect of *hijabs* and body covering on the Vitamin D status of East African women in Seattle and found that women with the highest 25(OH)D_3 levels were Vitamin D insufficient, i.e. all had <30 ng/mL serum 25(OH)D_3. Studies of Turkish and Kuwaiti women as well as studies of relocated Muslim women in Australia and Washington state, USA support this association.[9,21,39] It stands to reason that individuals living in locations with either little sunlight or with intense sunlight requiring full-body covering with clothing to avoid burns are at the highest risk for Vitamin D deficiency.[4] Thus, those living in the Middle East, north Africa, and sub-Saharan Africa may be expected to demonstrate lower 25(OH)D_3 levels than recommended.

Clothing coverage in Ethiopia is related to the religious tenants of Orthodoxy, Protestantism, and Muslim culture. Many urban Ethiopians wear Western-style clothing to work in offices. When not in the office, most women wear long cotton dresses with or without sleeves around town.[40] There are few strict clothing requirements in Orthodoxy and Protestantism and even fewer documented in previous research. Most Muslim women typically wear an *abaya*, a dress made by wrapping meters of fabric around the wearer from head to toe, and a *hijab*, or head scarf. Sometimes, a *nikab* or *niquob* is worn as a veil over the mouth and nose. Men also wear robes that cover them from head to toe.[40] The modest dress code women typically follow may significantly reduce the amount of UVB radiation reaching the skin and essentially halt previtamin D synthesis.[12,18]

Ethiopian Health Care System for Pregnant and Current Mothers

Health information is disseminated and care provided for Ethiopians by government health extension workers (HEWs), community health development agents (HDAs), and traditional birth attendants (TBAs). HEWs are government employees (usually women) who are assigned to provide health information and are the main care providers for a community.[31,41] They have at least a tenth grade education and one year of training in primary health care with an emphasis on both preventive and curative health.[41] One HEW is assigned to a community for every 2,500 residents in the Health Extension Programme (HEP). Each *kebele*, or community, typically has two HEWs deployed in its service.[31,44] Since 2005, the Ethiopian government has deployed over 33,000 HEWs to rural communities. In 2012, the Federal Ministry of Health updated their nutrition policy to provide volunteer health workers to communities in a ratio of one volunteer for every 5 households in "one-to-five" networks in which the volunteer communicates between community members and health workers.[31,41]

This change was meant to "strengthen and accelerate social and behavioral changes and the overall wellbeing of the population".[31] These volunteers report to community HEWs among others. Community health development agents are older men and women who have more years of training than HEWs and are assigned to communities at a ratio of one per 30-50 households.[31,41] TBAs provide support services to women at birth and during the postpartum period. These individuals have less education than the other two categories of government employees, completing only a midwifery-oriented biomedical training course and gaining skills through apprenticeship and experience.[41]

Only 45% of the Ethiopian population has access to healthcare; of this, only 28% have access to antenatal coverage, 15% to family planning services, and 5% to skilled delivery assistance.[43,44] Maternal mortality from 2010 and 2011 ranged from 350-676 deaths per 100,000 live births. Infant mortality is 37-52 per 1,000 live births.[41,44] While half of women received antenatal care, only 10% gave birth in the presence of a skilled health provider and only 7% received postnatal care within 2 days postpartum.[41] Most Ethiopians (85%) reside in rural areas.[31,41] Rural residence and limited access to skilled providers creates challenges to infant and maternal health during and after pregnancy.[41] As such, antenatal care visits are three times higher in urban than rural women.[43] The experimental Maternal Health in Ethiopia Partnership (MaNHEP) operated by the Federal Ministry of Health from 2009-2013 successfully addressed Goals 4 and 5 of the Millennium Development Goals to reduce child and maternal mortality. It improved the completeness of community maternal and newborn health (CMNH) care to rural areas via HEWs, HDAs, and TBAs, improved utilization of this care and trust of health professionals by rural women, and promoted adoption of these changes in other communities around those utilized in the study. Efforts are under way to scale up this initiative for permanent implementation.[41] The larger National Nutrition Programme (NNP) initiated by the government in 2008 has resulted in scaled up nutrition programming that provides micronutrient supplementation of vitamin A and zinc, support of salt iodization, and education and training to deal with malnutrition and HIV/AIDS. There is little mention of Vitamin D in the program goals.

Pregnancy and Postnatal Care Beliefs

According to the Ethiopia Demographic and Health Survey of 2011, 61% of women did not believe health facilities were necessary for birth.[41] Women's autonomy plays a large role in desire and ability to utilize pre and post natal health care. This is a large contributor to these behaviors in a country where women's autonomy is severely limited. Women's level of autonomy in making daily household purchases, visiting family or friends of their own volition, and disagreement with wife beating are all positively correlated with antenatal care seeking and giving birth at a health facility. Level of education of wife, urban residence, and women's employment were also positively correlated with antenatal care seeking but not postpartum health care seeking.[42,43] Interestingly, wealth mediated urban and rural residence: wealthy women were 53% more likely to seek maternal health care than poor women regardless of residence.[43] Muslims sought health care much less than Christians (Orthodox, Protestant, Catholic), possibly due to lower education.[43]. Overall, healthcare-seeking behaviors were most influenced by socioeconomic factors including education, residence, and employment.[42] Little else is published empirically about women's perceptions of pregnancy healthcare.

Evil Eye

Some rural people believe that newborns should not be seen due to fear of the evil eye, which may completely eliminate sunlight exposure in infancy.[15] The evil eye is a cultural phenomenon observed in studies of different cultures on every continent. Throughout Ethiopia, the belief systems of organized religion (Orthodox, Monophysite Christianity, Protestant) are mixed with "pagan" belief systems based in traditional culture. These systems define the existence of spirits and demons, including the *buda*, or those that possess the evil eye. This *buda* targets the beautiful, wealthy, those who have done extraordinary things, those who express public fear or anxiety, and those proud of their beautiful children with a hateful, envious or jealous, and sidelong look. Infirmary may strike the victim immediately or within hours, days, or weeks of such a look. Cures relevant for infants include religious treatment by a local priest or wizard. Endorsement of the evil eye is more common in rural areas of Ethiopia and is particularly widespread amongst the Manze Amhara of the central highlands of Ethiopia.[38]

Perception of Sunlight

Desire to reduce cancer development may also play a role in sun avoidance.[8,29] Humeral causes (exposure to sunlight, heat, and cold) were the third most commonly mentioned causes of breast cancer in Ethiopian women receiving breast cancer treatment at a clinic in Addis Ababa. Sunlight exposure was related to *mich*, or exposure to bad air. Some women related *mich* to "sudden exposure to sunlight," and attributed their condition to sun exposure related to *mich* ("*Mich,* followed by sun exposure," "The temperature is hot in my village and I usually expose my breast to the sun. I think this is the cause…") Although the exact role of *mich* in disease is still unclear, it is apparent that Ethiopian belief systems are the result of interwoven cultural tradition (the belief in humeral causes of disease) and monotheistic faith (Orthodox Christian, Protestant, etc.) and may influence perceptions of the beneficial effects of sunlight in addition to the influence on disease state perceptions.[37] Public health campaigns to decrease the incidence of skin cancer may unintentionally contribute to the severe Vitamin D deficiency levels worldwide.[6,8] Even the American Academy of Pediatrics recommends that infants avoid direct sunlight until 6 months of age.[18]

Dietary Factors

Nutritional adequacy of Vitamin D rich food consumption has the ability to overcome lack of synthesis due to clothing covering, skin synthesis, and all other factors.[9] Some studies have found that milk intake at least three times per week, fatty fish intake, and cod liver oil supplements mitigated the insufficiency caused by clothing coverage.[9,21] However, the Ethiopian diet consists mainly of cereal-based dishes.[40] Other common ingredients and foods include eggs, tomatoes, potatoes, cabbage, carrots, onions, ground chickpeas (shiro), meat, citrus fruits (mango, payaya, lemon, lime), bananas, pineapples, and avocadoes.[40] Coffee is a very important part of Ethiopian culture and typically consumed between meals two or three times per day in an elaborate ceremony with friends.[40] The only food that contains Vitamin D is eggs, which are eaten with a limited frequency. In addition, eggs contain roughly 50 IU of Vitamin D in their yolks only, which is not enough to satisfy the recommended 600 IU/d RDA with a reasonable daily consumption.[27,36] Clearly, foods that contain Vitamin D are not prevalent in the Ethiopian diet. This issue is compounded by the Orthodox requirement to abstain from animal products on Wednesdays and Fridays and during Lent. Additionally, during Ramadan, Muslims fast during daylight hours, which may limit the amounts and types of foods consumed.[40] There are no government programs such as the Women, Infants, and Children (WIC) program to provide supplements. This makes the majority of the population completely reliant on sun exposure for Vitamin D.[15,16] Breast milk is the least expensive and safest form of food for infants in Ethiopia and breastfeeding is practiced by most women.[16] Breast milk alone does not provide adequate Vitamin D for infants, particularly when mothers are already Vitamin D deficient and when mothers are dark-skinned.[2,6,18,20,29] Ethiopian infants whose mothers may not know the benefits of sun exposure and who do not consume foods rich in vitamin D are thus at risk.

Other Factors

Decreased sun exposure has been speculated to be a result of limited recreation time due both to rural responsibilities to sustain life and the increasing urbanization of some areas leading to increased indoor employment. It may also be due to housing conditions, access to media, and desire to avoid skin darkening, but there is little empirical data published regarding these factors. Sun exposure is required in places where adequate dietary Vitamin D cannot be obtained, begging the need for increased awareness of the benefits of sunbathing and a better balance between sun exposure and protection recommendations cross-culturally to maximize both Vitamin D synthesis and skin health.[7] This study hopes to describe some of these factors that may influence sun exposure behavior in more detail, or at least to identify their influence in Ethiopian culture.

METHODS

STUDY DESIGN

This study used a qualitative design to examine sociocultural influences on sun seeking behavior for rural and urban women and infants.

STUDY SETTING

The study took place in Hawassa, Ethiopia in the Southern Nations, Nationalities, and Peoples' Region (SNNPR). Six kebeles were selected for the study based on the willingness of health extension workers (HEWs) to screen participants and provide a meeting place. Three urban kebeles (Gabyadar, Dume, and Hogane) were from Hawassa town and three rural kebeles (Tula, Finchawoa, and Alamura) were selected from the greater Hawassa Zuria Woreda.

STUDY SUBJECTS

Women recruited for this study were over 18 years of age and residents of one of three urban (Gabyadar, Dume, and Hogane) or rural (Tula, Finchawoa, and Alamura) kebeles in Hawassa. Women were classified into one of three categories: 1) primipara women, 2) women who had a 1-2 year old child, or 3) grandmothers. A fourth in-depth interview group consisted of willing HEWs.

RECRUITMENT

Participants were recruited via purposive sampling by each kebele's HEW(s) to ensure clear communication of requirements and benefits from participation. Researchers first met with HEWs from nearby health posts around Hawassa and explained the research proposal in the local language (typically Amharic, but also included Sidamigna). Explanations were based on both written materials (English, see the *Appendix*) and researchers' knowledge of the study. HEWs who agreed to assist in screening and participant selection understood that both their participants and themselves would receive compensation for their participation (see *Compensation* below). Each focus group discussion (FGD) consisted of 5-10 participants. Some participants did not attend data collection sessions and some attended in excess of what was needed (**Tables 2** and **3**). Interviews with six HEWs were also conducted (**Table 3**).

COMPENSATION

Participants from urban kebeles received 100 ETB for their participation in this study. Participants from rural kebeles received one liter of cooking oil for their participation in the study. Upon completion of the questionnaires and in-depth interviews for each group of women, HEWs were compensated 500 ETB each for their participation.

DATA COLLECTION PROCEDURES

Discussion Setting. Locations for focus group discussions were arranged by HEWs. Hogane FGDs and interviews took place in a fenced-off community field in which the participants were the only individuals present. Dume FGDs and interviews took place in the home compound garden of one of the participants. Haikdar FGDs and interviews took place at a school compound on a weekend. Each rural FGD took place in the main room of the kebele's health post. Researchers provided snacks (bread and coffee) for participants during and after data collection.

Demographic Questionnaire. A short, semi-structured questionnaire was used to collect demographic data from study participants. A member of the research team administered the questionnaire in the local language to individual participants as they arrived at the discussion location. This ensured inter-participant confidentiality.

Focus Group Discussion (FGD). FGD questions were designed to obtain information about the women's sun exposure opportunities and preferences for themselves and their infants, cultural and religious beliefs regarding sunlight and sun exposure. Any other sociocultural factors affecting sun exposure that presented themselves also were discussed. There were 6-12 questions written for each

FGD participant group. The discussions were conducted in participants' local language and recorded by a handheld TASCAM DR-07 MKII Linear PCM Recorder. In urban groups, the head researcher (an American) was able to sit amongst group members and record the discussion. In rural kebeles, an Ethiopian member of the research team operated the recording device. The American researcher was not present during these rural discussions because the presence of an American was distracting and potentially uncomfortable for participants.

Timing of sun exposure was reported in a mixture of weeks, days, and months. We counted as one full week 4+ days into that week based on a week being 7 days. By this count, 7-10 days equaled 1 week, 11-17 days equaled 2 weeks, 18-24 days equaled 3 weeks, 25-31 days equaled 4 weeks, 32-38 days equaled 5 weeks, and 39-45 days equaled 6 weeks. One month equaled 4 weeks.

Consent. Prior to beginning the demographic questionnaire, participants were read the consent form for this study (see *Appendix*). Oral consent was obtained from participants and documented by the data collector in the presence of the HEW.

Data Collection Training. Focus group discussion training was conducted one week prior to data collection for one three-hour period. The training materials were adapted from the OMNI Toolkit for Conducting Focus Groups.

In-depth interviews. After demographic information and FGDs were completed, data collectors interviewed HEWs regarding their experiences, knowledge, and recommendations regarding sun exposure for their constituents and their own maternal practices.

ETHICAL CONSIDERATIONS

Ethical approval for the study was obtained from both the Oklahoma State University and Hawassa University Institutional Review Boards (IRB). The focus group leaders transcribed the discussions from the audio recordings. Audio files were permanently destroyed after completing transcription.

STATISTICAL ANALYSIS

Statistical analysis software (SAS, v. 9.3) was used to compile descriptive statistics from the demographic questionnaires. Numerical values are presented as percentages or means. Content analysis was used to analyze and compile qualitative data. Transcripts were analytically reduced through summaries and codes, which were then compiled into themes. Frequency counts were used to quantitatively represent relevant data.

FUNDING

This research was funded by a Wentz Research Grant from the Lew Wentz Foundation through the Henry Bellmon Office of Scholar Development and Undergraduate Research at Oklahoma State University, the Don and Cathy Humphreys Endowed Long-Term Study Abroad Grant through the Don and Cathey Humphreys Endowed Chair in the School of International Studies at Oklahoma State University, and the Thomas, Pauline, and Barbara Miller International Scholarship from the College of Human Sciences at Oklahoma State University. Support was also provided from the Nutracia Research Foundation.

RESULTS

DEMOGRAPHIC QUESTIONNAIRE

Urban. A total of 87 urban women participated in this study. Due to extra participants in the discussion, only 85 women filled out a demographic questionnaire. The average age of participants was 26 years old for current mothers, 52 years for grandmothers, and 22 years for pregnant women. About 54% of participants were Protestants and 40% were Ethiopian Orthodox, a reversal of the national statistics (19% and 44%, respectively). Only 6% identified as Muslim, also different from the national average of 34% of the population.[30] Regarding education, 18.5% of women had no formal schooling, 17% had a 1-5th grade education, 30% had a 6-8th grade education, 25% had a 9-12th grade education, and 10% had obtained a B.S. degree (**Table 4**). Approximately 55% of women were housewives not employed outside the home. The second highest group of women (21%) was employed in petty trade. No other employment had more than 10% of participants involved.

Current mothers and grandmothers had an average of 2.14 and 2.75 children, respectively. The average age of the youngest child for current mothers was 8 months. Current mothers observed their children first standing up at 9 months; however, only 18 of 85 participants provided responses. We did not ask the grandmothers this question because they likely would not remember the exact age at which their children began standing. The average pregnant mother was 6.65 months pregnant at the time this study was conducted.

A typical day for a woman in this population depended on their gravidity, but overall, common morning activities included making breakfast, washing clothes, commuting to work or friends' homes, or "no activities." This final category was most typical in pregnant women and rare in the other groups. General afternoon activities consisted mostly of traveling to and from the market or work and "walking around." Eighty two percent of women claimed these activities constituted a normal day.

The majority (95%) of homes had windows (54% wooden covers, 39% glass). This allows for sun exposure inside the home if desired; however, it must be noted that UVB cannot penetrate glass and thus, closed glass windows are just as much a barrier to vitamin D synthesis as closed shutters.

The three top sources of health information for the urban women were HEWs, television, and radio (**Table 5**). HEWs were a source of health information for 88% of participants. Of the 79% participants who had a television in their household, 70% used it to obtain health information, the highest percentage for health information gained via media. Although only 50.6% (n=43) total participants reported having a radio in their home, almost all of them (51% total participants, n=40) reported receiving health information via radio. While 76% participants had mobile phones, only 10% received health information via phone. Only 2% of urban participants reported gaining health information from schooling. Reasons for this could be lack of general education, lack of health information in elementary, middle, and high school, forgetfulness with time, or earning a B.S. in a non-health field.

A little over half of the participants had heard of vitamin D (51%). When asked to specify what they knew, 26 of 53 free responses listed by these women attributed vitamin D to sunlight. The remainder of free responses were few, but attributed vitamin D to "vegetables" (5 responses) and "foods" (4). Only one response cited eggs as a source of vitamin D, less than in rural women (see *Rural* below). These were free responses, not predetermined answers, so some participants may have given a correct answer alongside an incorrect one. Current mothers and pregnant women had greater knowledge of the source of vitamin D than grandmothers for all urban groups surveyed.

Two-thirds (n=56) of total participants reported having seen rickets in their lifetime. Of these, 39% "recently," 22% said "1-5 years ago," and 35% said "over 10 years ago." Of 104 free responses given when shown a picture of children with rickets, 52 responses attributed the condition pictured to "vitamin D deficiency", "lack of sunlight", or "rickets." Other responses included lack of vaccination (11 responses), malnutrition (10), disease (7), congenital anomaly (7), and lack of vitamins (4).

Approximately 92% of women reported rubbing their infant in some type of fat prior to sun exposure (usually oil, butter, paraffin, or lotion). Respondents included 48 grandmothers and current mothers out of 59 total current mothers and grandmothers. This statistic is difficult to compare because very few rural grandmothers answered this question (see *Rural* below). We asked the current mothers if they took their infant outside with them when they left their homes (n=28). Twenty-nine women provided responses, indicating an extra response. Two thirds of the women (66%) reported "never" taking their infant with them when they go outside the home, 17% reported "sometimes," 10% reported "often," and 7% reported "always." All pregnant women attended at least one monthly antenatal appointment, but only 27% attended >6 appointments (**Table 5**).

Rural. A total of 82 rural women participated in this study. All 82 women both filled out a demographic questionnaire and participated in a FGD. The average age of participants was 25 years for current mothers, 44 for grandmothers, and 20 for pregnant women. About 77% of the rural women were Protestant, and a relatively equal percentage was either Muslim or Ethiopian Orthodox (11% and 12%, respectively). Slightly over one third (36%) of rural women had no formal education, 36% had a 1-5th grade education, 25% had a 6-8th grade education, and only 4% had any high school education. No rural women reported completing high school beyond the 10th grade. The primary occupation of rural women was as housewives (83%). The second highest employment category was petty trade (9%). Only 5% of rural women reported farming as their primary occupation.

Current mothers and grandmothers had an average of 3.37 and 4.81 children, respectively. The average age of the youngest child was 6 months for current mothers. Current mothers observed their children first standing up at 14 months; however, only 8 of 82 participants provided responses, so this data is not representative. We did not ask the grandmothers this question because they likely would not remember the exact age at which their children began standing. The average pregnant mother was 6 months pregnant at the time this study was conducted.

A typical morning for a woman in this population consisted of farming, making food, fetching water, visiting neighbors and family, and visiting the health post. The typical afternoon activities were farming, commuting from work, the market, or friends' houses, and fetching water. Most (77%) of women claimed these activities constituted a normal day.

A little over half (57%, n=47) of homes had windows (85% wooden covers, 8% glass). Both closed shutters and panes pose a risk for increased vitamin D deficiency with post-partum avoidance of the outdoors. Half of the women surveyed claimed to possess poultry (n=42) with 20% having only 1 chicken, 45% having 2 chickens, 10% having 3 chickens, 7.5% each having 4, 5, and 6 chickens, and one participant having 9 chickens. This is relevant because egg yolks are one of the only available dietary sources of vitamin D to this population.

The three top sources of health information for the rural women were HEWs, radio, and friends/ neighbors (**Table 5**). HEWs were the source of health information for 96% of participants. All of the 23% participants who had a radio in their household used it to obtain health information. Only 15% of women reported gaining health information from friends and neighbors. No rural participants reported gaining health information from schooling.

Only 38% rural women reported having heard of vitamin D. Of these, only 2 of 70 free response categories listed by these women attributed vitamin D to sunlight. This was significantly less than the urban free response associations. The remainder of the free responses attributed vitamin D to potatoes (14 responses), carrots (10), and other vegetables. Six responses cited eggs as a source of vitamin D, which was more than in the urban women (**Table 6**). Only current mothers listed sunlight as a source of vitamin D, supporting slightly greater knowledge of vitamin D in this population than either pregnant women or grandmothers.

About half (48%, n=39) of all women reported having seen rickets before: 59% "recently," 15% "1-5 years ago," and 26% "over 10 years ago." Of 111 free responses given when shown a picture of children with rickets, 15 responses attributed the condition pictured to "vitamin D deficiency", "lack of sunlight", or "rickets." The most popular alternative response was "malnutrition" with 42 people mentioning it as a cause of the children's problem. Other responses included lack of sanitation, poor feeding practice in infancy, polio, and lack of vaccination. Identifying rickets from other problems in the region is a difficult task due to the high prevalence of all of these diseases, which manifest in similar ways.

Two-thirds (68%) rural women rubbed their baby with oil, butter, or another lubricant, predominantly oil (50%). However, only 31 out of the 54 current mothers and grandmothers surveyed answered this question, and most of these were current mothers. Thus, this statistic is not particularly useful in comparison to the urban participants and should not be used to draw definite conclusions, but rather, to suggest frequency trends between rural and urban women. Three fourths (77%) took their infants outside sometimes compared to 13% "never" and 10% "always" (n=31). Most women were in their second (37%) or third (44%) trimester of pregnancy.

Whereas all urban women had attended at least one antenatal appointment, 20% of rural women had not attended a single antenatal appointment. Roughly 36% attended 1-3 and 44% attended 4-6 appointments. No rural pregnant women attended more than 6 appointments.

FOCUS GROUP DISCUSSION

Appendix: Table 7

Urban. Reasons for limited exposure included cultural practice (mostly regarding timing and length of exposure) and concern for safety. Physiological barriers for mothers' own exposure included headaches, skin irritation, and lethargy in prevalence order, but this was only true for noonday sunlight. Mothers commonly used umbrellas to avoid this sunlight. The majority of pregnant women ceased employment and decreased travel and general motion during pregnancy. This seemed largely due to a desire to avoid discomfort rather than an aversion to sunlight specifically.

Reasons for limited infant sun exposure included avoidance of noon sun, fear of the evil eye, fear of sickness from "drafts", and a (albeit dying) cultural custom to stay at home for 30-45 days (1 month or 45 days specifically) postpartum. A number of mothers mentioned fear of the evil eye. Even if the mother stayed at home for 30-45 days, most women exposed their infants to sunlight after 1-2 weeks. A minority of mothers waited until 40-45 days postpartum to expose their infants. Mothers who stayed inside only 15 days seemed to place more emphasis on infant health. Mothers who stayed inside for one month placed more emphasis on their own health and recovery from delivery.

Participants exposed their infants to sunlight between 7-9 am for approximately 15-30 minutes daily. The prevalent feeling was that sunlight was very healthy for infants and nearly all participants mentioned something about why the sun was beneficial ("standing up and walking by himself," "vitamins," "avoid bow-shaped legs," "prevent rickets"; see Table 7 in the *Appendix*). Most participants using terms like "vitamin D" or "rickets" had some formal education. The others were just educated about sun's general benefits. General acceptance of benefits of sun exposure was more prevalent than education regarding the supporting science behind vitamin D metabolism.

Babies were not typically outside without their mothers, but if they were, it was with a grandparent or other family member. In general, mothers used umbrellas to protect their infants from sunlight when traveling in the afternoon, but did not seem concerned with sun exposure within the compound. Most concerns regarding infant coverage were based on comfort (covering their eyes during sun exposure). The majority of women did not rub infants with oil or butter prior to sun exposure, although most were aware of the practice. Generational changes were present in that women waited less time to expose infants than in the last generation. Sun exposure for infants was common and accepted behavior among all three groups of women in each urban kebele. HEWs, family members, and neighbors were the most common advocates for sun exposure mentioned by participants. There seemed to be a "common understanding" about the benefits of sun exposure amongst these women.

Rural. Reasons for limited exposure included cultural practice (again, regarding timing and length of exposure), concern for safety, and for pregnant women, daily responsibilities combined with safety. Physiological barriers for mothers' own exposure included headaches, general discomfort, and fear that sunlight during pregnancy "injures" the baby. Mechanism of action was not specified. Mothers used natural shade mostly to avoid the sun. Pregnant women seemed particularly likely to avoid sunlight due to great discomfort caused by laboring and traveling in the sunlight and fear that sunlight during pregnancy "injures" the baby.

The biggest influence on lack of sun exposure for infants seemed to be fear of sickness due to "air collisions" or "drafts" and fear of the evil eye. Despite this, women seemed to support the idea that sunlight makes their babies strong ("make his bone strong" "strong and healthy"; see Table 7 in the *Appendix*). Rural mothers seemed to know nothing about why sunlight is beneficial for their infant's health and their own. The majority of women reported waiting until 1-3 months postpartum to expose their infants to sunlight for roughly 30 minutes to 1 hour daily. Morning exposure was the common practice but why this was the case was not specified. Rubbing with oil or butter was more common in rural than in urban areas but still was not the prevalent practice.

Again, infants were never outside without their mothers. When mothers left their compounds, they reported covering their infants head to toe in clothes and using an umbrella to avoid sunlight exposure. Most of the current mothers did not expose their first children to sunlight but did expose subsequent children. Most grandmothers did not expose their infants and may have advocated against sun exposure for infants in the past, but now encourage it as reported by FGD grandmothers. There is a clear generational increase in acceptance and practice of infant sun exposure. Answers from the younger mothers suggested that HEWs seemed to encourage sun exposure while family members and neighbors may have discouraged it either through direct recommendation or general cultural acceptance.

HEW INTERVIEWS

Appendix: Table 8

Urban. Urban HEWs experienced the same discomfort, headaches, and skin irritation as their constituents and used umbrellas. One major difference between HEWs and community members was that HEWs practiced sun avoidance to keep their skin from changing color. Lighter skin is associated with beauty and higher status, hence, they avoided sunlight to avoid tanning, quite opposite to Western values. Most HEWs recommended the standard 45-day travel ban for new mothers to allow the mother to recover her strength and to preserve the health of the baby. HEWs do not often see mothers actively protecting their infants from sunlight. They had a good understanding that vitamin D is important to prevent rickets in children and recommended sunlight to their constituents. All HEWs interviewed promoted breastfeeding, which may not provide sufficient vitamin D deficiency particularly when the mother is already deficient or insufficient. One HEW mentioned using the government's "one-to-five network," a community education system to transfer knowledge from HEWs to community members. This program's goal is to "strengthen and accelerate social and behavioral changes" in a population.[31]

Rural HEWs. Rural HEWs experienced the same discomfort, headaches, and skin irritation as their constituents and used umbrellas. Again, skin lightening with sun exposure was a reason to avoid sunlight among this group as with the urban HEWs. HEWs report that rural women come to the health center at 45 days postpartum to get immunizations for their new infants. The avoidance of sunlight before 45 days is due to cultural practice and fear of infant illness and harm, similar to the urban women. One interesting difference is that the rural HEWs tended to expose their own infants to sunlight around 15 days postpartum similar to the urban women and HEWs. It is unclear what their actual recommendations were amongst their constituents. Additionally, one rural HEW cited fruits and vegetables as good sources of vitamin D, so the quality of rural HEW understanding of vitamin D sources and recommendations is questionable.

DISCUSSION

This study identified factors such as dress, culture, and health and safety affecting adequate sun exposure. These factors were relevant for Ethiopian mothers and infants from both rural and urban settings.

Observationally, clothing covering affects adequate sun exposure even for those who were not Muslim. While there are few strict clothing requirements in Orthodoxy and Protestantism, modesty is stressed and limbs are often covered regardless of Western or traditional clothing choices.[40] They typically wore long skirts and long sleeved shirts. Sometimes they bared their arms, but this was less common. Many women also wore a loosely-woven shawl over their heads, shoulders, and arms similar to an *abaya* worn by Muslims which further reduced sun exposure. Rural infants were protected more from the sun than their urban counterparts with blankets, clothes, back slings, hoods, scarves, and umbrellas when taken out of the house or the compound to travel. FGDs also revealed some clothing coverage practices for urban infants leaving their homes or compounds via umbrellas and general clothing coverage.

A combination of religious, cultural, and comfort factors may explain mothers' style of dress. Protestant and Ethiopian Orthodox religions both have more lax dress codes than Muslim culture, but may still be restrictive. Cultural traditions may account for this typical style of dress. Sun exposure decreased the comfort of both rural and urban women, a clear physiological barrier to sun exposure practices that certainly influences clothing coverage. Only HEWs mentioned skin lightening as a reason to avoid sun. There is little research discussing the desire for lighter skin in Ethiopian people, but possible reasons for HEWs to desire lighter skin speculatively include self-perceived higher status as government workers, greater education regarding Western beauty standards, or greater resource availability allowing them to focus on more vain pastimes. Specific, in-depth research into this subject is needed to understand why a desire for lighter skin would exist within this group of participants.

For infants, avoidance of noon sun exposure is related to fear of "drafts" and the evil eye. Initially, we were uncertain what role the evil eye might play in the sun exposure practices of the participants. Clearly, this belief is maintained by at least some rural residents in some capacity, although none explained much about the evil eye in detail. An anthropological report from the University of Pittsburg points out "original motives often disappear with institutionalization of the belief or custom, and in its place, habit becomes the primary source for the reinforcement of the pattern," which may be the case in this population.[38]

While mothers from both urban and rural kebeles acknowledged the general benefit of morning sun exposure for infants and practiced daily exposure for their infants, the length and timing of this sun exposure may not be sufficient to maintain serum levels based on previous studies. The literature on vitamin D provides varied recommendations for sun exposure to achieve adequate serum levels for different populations and even within populations. Most of these recommendations are based on studies with lighter skinned individuals. There are few studies that specify how much more sunlight is needed by darker skinned individuals to maximize health.[5,14] Thus, it is difficult to say how much sun exposure is needed in this Ethiopian population, particularly for infants.

Despite these barriers, both rural and urban women may actually be considered quite progressive in their infant sun exposure behavior compared to recommendations from the AAP, which discourages direct sun exposure for infants before 6 months of age. However, the AAP also recommends a 400 IU supplement for exclusively breastfed infants younger than 6 months. Women in this area exclusively breastfeed and have no access to such a supplement. Therefore, ensuring adequate sun exposure for their infants may be critical to achieve adequacy.

Unsurprisingly, many of those who had completed high school or higher education were much more accurate when discussing Vitamin D benefits and sources than those that did not complete high school. Urban and rural women both agreed that sunlight was beneficial for their babies but may not have known the reason why. Urban knowledge of the benefit of sunlight to bone health and strength demonstrated in the FGDs far outweighed that offered by rural participants in FGDs. This is likely due to general lack of formal education in the rural areas. It is possible that the efforts of certain NGO's and the WHO to introduce orange-fleshed sweet potatoes to rural kebeles to increase Vitamin A in the diets of these individuals have increased awareness of "vitamins" but not provided education to distinguish the different types and sources of these vitamins. The highest purported source of Vitamin D in the rural kebeles was potatoes, lending support to this theory. However, it is more important that participants understand the importance of sunlight in general than to be able to explain the biochemical basis of this recommendation. Therefore, it would not be vital to include specific biochemical knowledge in an educational program so much as to encourage sun exposure for its general benefits for bone health. While more rural than urban women identified eggs as a source of vitamin D, the data do not specify if this association was due to actual vitamin D knowledge. Instead, this may reflect an understanding that eggs contain many nutrients needed for health. Additionally, it was difficult to determine if the participants consumed the eggs their hens produced.

In general, current mothers had greater knowledge of vitamin D and sunlight exposure than either their pregnant or elder counterparts. One explanation for the disparity between pregnant and current mothers is that HEWs may not begin sunlight education until postpartum. One current mother from Gabyadar's community education program stated that sun exposure behavior "…is a common understanding and most women just know about it," suggesting success in the program but not offering much insight into the pregnant woman vs. current mother awareness disparity.

The lack of knowledge of Vitamin D benefits, sources, and the best time for sun exposure is likely influenced by the lack of formal education and resources to access medical care and information. Most rural and urban women receive their health information from their HEW (96.3% and 87.7%, respectively), so more focused education of the HEWs would result in greater education of their kebele members, particularly in the rural kebeles. Radio was a very effective method of communication, reaching half of urban participants and a little less than a fourth of rural participants. For both groups, all of those who had a radio used it to obtain health information. There is great potential to increase sun-seeking behavior via increasing and continuing existing radio health education broadcasts. Finally, 69.6% of urban mothers reported gaining health information from television; therefore, TV-based interventions similar to the avid oral rehydration salt campaign for diarrhea might benefit sun-seeking practices in urban women and thus improve vitamin D deficiency risk in this population. All women seemed very keen to implement the best recommendations for their infants' health, so an increase in education via these avenues presumably would greatly benefit mother and infant vitamin D levels.

Responses regarding whether mothers had rubbed their babies with lubricant suggest that the urban women practiced this actively and more than the rural women, but the FGD responses stated that this practice was more prevalent in past generations, not amongst the participants themselves. This disparity may be due to lack of clarity in the questionnaire wording and translator interpretation of the Amharic version of the question. It is also possible that only those who had practiced lubrication actually answered the demographic question, vastly skewing the data. Additionally, women in the FGDs may not have felt comfortable sharing this information with their peers or researchers if they thought the behavior was incorrect. Because of this large potential for error, more detailed data collection is needed for definite conclusions to be drawn regarding lubricant rubbing practices.

A clear generational change was observed in both the rural and urban populations. The fact that current mothers and pregnant women had a greater knowledge of vitamin D than grandmothers makes sense considering the generational changes seen in the FGD responses. One explanation is that health education has improved in the last generation in regards to vitamin D. Another explanation relates to the initiation of the National Nutrition Programme in 2008 which placed two HEWs in each kebele where before there had been only one.[31] This increase in staff and increased efforts to address nutritional deficiencies in Ethiopia may both have contributed to the increase in knowledge over the last generation of Ethiopian women.

Possible sociocultural interventions in this population would not need to address sun exposure acceptance because the participant consensus was that some sunlight exposure is beneficial for infants and mothers. Rather, an intervention might address the cultural fears surrounding the evil eye and the infeasibility of a baby catching a cold from a "draft" just by going outside in the sunlight.

Additionally, it might be beneficial to encourage sun exposure for mothers to ensure adequate vitamin D status before, during, and after pregnancy. This way, the potential and disputed risks of infant sun exposure may be reduced. This may be achieved by encouraging increased skin exposure during daily activities or individual sunbathing time. Additional research on the functions of vitamin D in this population and in infants is needed to validate such an intervention, however. Utilization of a "one-to-five network" as described in the NNP and in the Gabyadar HEW interview may increase efficiency of HEW efforts to spread education to constituents and decrease friend and family barriers to sun exposure practice via mass community awareness.

Windows in a home allow mothers to gain sun exposure without leaving home, provided they can open their windows wide enough, particularly in the case of the glass windows through which UVB does not penetrate. Urban homes had significantly more likelihood of having windows than rural homes. Those mothers without windows in their homes may be at increased risk for vitamin D deficiency due to staying indoors postpartum (particularly rural mothers, who have fewer windows and stay indoors for 1-3 months postpartum), while both rural and urban mothers with wooden shutters may not open them as much due to fear of "drafts." Since UVB does not travel through glass windows, those with wooden shutters may have a better chance to alter their vitamin D status because they are more likely to open their windows than a woman with glass windowpanes who gets sunlight but not the beneficial UVB rays. Using sunlight through open windows would be a beneficial behavior change to increase vitamin D synthesis in both mothers and infants who avoid the outdoors postpartum. Future interventions might explore this tactic to introduce sun exposure behavior acceptance in this population.

LIMITATIONS

Due to multiple researchers using the recording device, the FGD for Finchaowa Elders and Tulo Current Mothers were not properly recorded and, thus, were not available for transcription and analysis.

Some groups had extra participants (Gabaydar grandmothers and Tulo current mothers both had 11 total participants). Extra participants' demographic questionnaire answers were included in total analyses because of the other, smaller FGDs.

In the Dume kebele current mother group (the first group in which the study was conducted), literate women were allowed to fill out their own demographic questionnaires. This practice was discontinued for subsequent data collection so researchers could ensure questions were understood and properly answered. This may have confounded some of the quantitative data.

Due to the language barrier and anonymity of participants, some transcripts were not translated and transcribed exactly as recorded. Due to the distance and poor internet connection between the United States and Ethiopia, exact transcripts would have taken too long to request and receive. Therefore, some assumptions were made in the qualitative analysis of multiple participants supporting a statement made.

FGD questions were edited by the research team but were not tested on a pilot group of Ethiopian women. Additionally, inability of the head researcher to probe participants or provide suggestions for discussion leaders to probe participants due to the language barrier severely limited the depth of information obtained from FGDs. These factors may have negatively impacted the quality of answers gathered by research team members.

Some FGD participants may have known each other. All FGD participants knew their HEW. This may have blunted the truthfulness of reports of individual sun-seeking practices.

FGDs were analyzed three months post-collection. There were no immediate post-discussion summaries conducted by members of the research team to ensure impressions and answers from participants were interpreted in a similar manner. Analysis and interpretation was performed based on analysis of discussion transcripts and questionnaires only.

CONCLUSION

Overall, sociocultural factors affecting sunlight exposure are numerous and include dress, cultural practice, and fears of safety and discomfort. It is important to consider that referring to these factors as “barriers” represents a deficit-based approach when an asset or strength-based approach may be more useful in designing successful programs to increase sun exposure.

Knowledge of vitamin D benefits and sources is limited, particularly in rural populations and even among some HEWs. Ability to identify rickets is compromised by the prevalence of other diseases and conditions with similar presentation. However, general acceptance of the importance of sunlight for infant health is high. Common practice to expose infants in the morning for 30 minutes to one hour is likely beneficial for vitamin D synthesis. More research is needed on a global level to determine adequate time of day, length, and skin exposure needed to achieve ideal serum $25(OH)D_3$ levels. Although differences exist between urban and rural groups regarding initiation of sun exposure for infants, both can be considered progressive relative to vitamin D synthesis and the recommendations of the AAP regarding infant sun exposure. Grandmothers report a generational change towards acceptance of sun exposure behavior and now recommend it to family and neighbors. Before interventions are adopted, it would be beneficial to further explore the beliefs related to the evil eye and the potential for infant sickness due to “air collisions.” It may also be beneficial to utilize HEWs, radio, and television to communicate positive health messages regarding sun exposure and vitamin D as it relates to maternal and infant health. Again, further exploration should determine who would be the most influential in sharing such messages.

This study is meant to explore sociocultural factors affecting sun exposure related to potential vitamin D deficiencies in women from Awassa, Ethiopia. Such a study is supported by documented evidence of high vitamin D deficiency prevalence in the Middle East and sub-Saharan Africa in the last thirty years. Future studies may benefit by examining the practice of rubbing oil, butter, and other lubricants on infants, inquiring into reasons for dress, and examining the education curriculum of HEWs to determine where they may need to expand their lessons. Individual interviews instead of FGDs may also be beneficial for collecting accurate subjective data. More detailed probing in regards to questions asked in this study may also result in more enlightening responses.

Challenges to obtaining adequate vitamin D are exacerbated by skin color, clothing coverage, age, altitude, latitude, low dietary availability, among other moderators. Populations with low socioeconomic status may not have the ability to access vitamin supplements; thus, they rely on sun exposure for vitamin D adequacy. According to the Ethiopian Ministry of Health, 84% of the population is rural, making the tailoring of interventions to this population critical in order to maximize sun exposure health benefits.[31] Identifying factors affecting sun exposure in this population may assist in explaining historically low serum 25(OH)D_3 levels reported from countries with abundant sunlight and for the ethnicities residing therein. In addition, explaining these factors may help correct existing vitamin D deficiencies in these groups as interventions are developed to maximize sun exposure while respecting cultural practices and beliefs.

APPENDICES

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ANNEX 7: CURRICULUM VITA

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TABLES

Table 1: Differing Serum 25(OH)D_3 Recommendations

	IOM		Canadian Paediatric Society		US Endocrine Society	
Status	**nmol/L**	**ng/mL**	**nmol/L**	**ng/mL**	**nmol/L**	**ng/mL**
Deficient	<30	<12	<25	<10	<50	<20
Insufficient	30-50	12-20	25-75	10-30	52.5-75	21-29
Sufficient	50	20	75-225	30-90	75+	30+
UL	>125	>50	>225	>200	250 ??	100 ??

Table 2: Participant numbers by kebele

Kebele	Group	Participants
Gabyadar	Pregnant	9
	Current	10
	Grandmothers	11
Hogane	Pregnant	9
	Current	9
	Grandmothers	10
Dume	Pregnant	10
	Current	9
	Grandmothers	10
	Total Urban	**87**
Tulo	Pregnant	10
	Current	11
	Grandmothers	10
Alamura	Pregnant	8
	Current	8
	Grandmothers	8
Finchawoa	Pregnant	10
	Current	10
	Grandmothers	7
	Total Rural	**82**
Total Participants (n)		**169**

Table 3: HEWs interviewed by kebele

Kebele	HEWs Interviewed
Gabyadar	1
Dume	1
Hogane	1
Tulo	2
Finchawoa	0

Table 4: Highest education of participants (*n*=169)		
Grades Completed	**Urban Women (%)**	**Rural Women (%)**
No School (0)	18.5	36
Elementary (1-5)	17	36
Middle (6-8)	30	16
High (9-12)	25	2.5 *10th
College (15)	10	0

Table 5: Demographic characteristics of households (*n*=169)		
Characteristics	**Urban (%)**	**Rural (%)**
Housewife	55	83
Possession: Umbrella	59	23
Health Info Source	-	-
HEW	88	96
Elder	16	7
Friend/ Neighbor	35	15
TV	70	1
Radio	51	23
Heard of Vit D	51	38
Rubbed baby w/ fat?	92	68
# Antenatal Visits	-	-
0	0	20
1-3	13	36
4-6	60	44
6+	27	0

Table 6: Free association question responses: "Have you heard of vitamin D? Specify."		
	Urban (n=87)	**Rural (n=82)**
Heard of vit D	51% (n=43)	38% (n=31)
Specified	36 participants	32 participants
	# times mentioned	
Total responses	53	70
Sunlight	26	2
Potatoes	1	14
Carrots	-	10
Foods	4	1
Avocadoes	-	7
Egg	1	6
Beans	1	6
Vegetables	5	1

Table 7: FGD Response Summary

	Urban		Rural	
Question	Themes	Quotes	Themes	Quotes
While doing your daily activities outside, do you take precautions to avoid sunlight exposure? Why or why not?	Physical discomforts: Headache, skin irritation, general discomfort Umbrellas Only for heavy sunlight	"I avoid heavy sunlight at noontime. It is dangerous, affects my skin, and is generally not good ." DC	Physical discomforts: Headache, general discomfort Natural shade Time of day not specified	"I am very careful not to expose myself to sunlight. If the sun gets me, I will sweat and have a headache." TP
How have your activities changed since you became pregnant?	Reduction in travel and daily activities based on personal comfort level	"After I became pregnant, I stopped my work and just stay at home. I don't do all the household activities I used to ." DP	Severe reduction in outdoor activities and increase in sun avoidance behavior	"During pregnancy my outdoor activities are less because my baby will be injured by sunlight. " AP "I perform easy activities; if the sun gets me, I will become tired and sick." FP
Did you stay in the dark after you gave birth? For how long? Why?	45 days (1.5 months) Cultural tradition, recover mother's strength	"I am planning to stay at least two months inside the home because my body needs rest and recovery. But I am planning to get my baby out to the sunlight starting fifteen days after I give birth." DP	1-3 months Cultural tradition, fear of illness from "drafts"/ "air collisions" for both mother and infant	"…I am afraid that if sunlight gets me, I could have an air collision. Then if I breastfeed my baby, he will get sick." A "I am afraid to… get my son outside because I believe he could catch a cold." AP
Did you ever expose your infant to sunlight? Why and for how long?	~15 days or 2 weeks Fear of evil eye, illness from drafts	"I expose my baby to sunlight so he gets a good and normal body shape, especially straight legs." DC "Morning sun has vitamins totally from the sun. Sunlight makes my baby strong ." HE	1-3 months Fear of illness from "drafts", "air collisions", and the evil eye	"…want him to be strong and healthy…" FC
What is the best time during the day for an infant to be exposed to the sun? Why?	7-9 am, ~30 min	"After 9:00am, the sunlight becomes too strong for infants." DE "Exposing babies to the morning sunlight helps them to have a good body shape and…a straight leg…Babies who are not exposed to the morning sunlight will have bow-shaped legs." DC	Morning, 30 min-1 hr	"I took him for one hour because morning sunlight is important for his strength." FC
How do you dress your child when they will be outdoors? Why?	Depends on weather conditions (windy, cold, etc.) and time of day (strong sunlight) Less coverage when in the compound than when out in public	"I only dress my baby in clothes when I am in the compound; I do not use additional protection. When I go outside my compound, I use an umbrella." GP	Cover whole body with clothes, sling, umbrella	"When I take my son outside, I dress him well to prevent him from sunlight. I am also afraid that he could get a draft and become sick ." FP "I…cover his head, leg, and face because I am afraid of the evil eye." FP
Have you been told/ taught anything about sun exposure for your baby? Who told/ taught you these things? How do you feel about the advice you received?	HEWs, family and neighbors, formal education All mothers feel good about the advice they are given	"I have been taught about it from health extension workers and nurses… I feel this advice is very helpful and important." DC "My mom advised me, as did elders in my community. I feel happy and accepting towards this information; I am going to follow it." GP	HEWs encourage, family and neighbors may discourage All mothers feel good about the advice they are given	"I didn't take my first child for sunlight based on [my mother's] advice, but this [infant] gets sunlight because I am educated by professionals ." FC
Do you recommend sun exposure for your grandchildren or other mothers in the community? Where did you learn this?	Grandmothers cited a change towards acceptance and promotion of sun exposure behavior	"I am not only recommending but even showing [women in my community] how to properly expose their infants to sunlight and [teaching them] the benefits." DE	Most grandmothers did not expose, but now advocate exposure	"…after understanding the importance of sun light, I stopped advising others not to expose their babies to sunlight. I even expose my grandchildren to sun light." AE

Table 8: HEW Interview responses				
	Urban (n=3)		Rural (n=4)	
Question	Themes	Quotes	Themes	Quotes
While doing your daily activities outside, do you take precautions to avoid sunlight exposure? Why or why not?	Umbrella Physical discomforts: Headache, skin irritation, changes face color, general discomfort	"Our job involves moving outside from house to house and the sunlight changes out face color."	Umbrella Physical discomforts: Headaches, changes face color, general discomfort, skin irritation	"When I move house to house, the sunshine is dangerous and my face color changes."
Do mothers stay in the dark after they give birth? For how long? Why?	45 day travel ban, 15 days exposure Recover mother's strength, infant safety	"Children need vitamin D from sunshine to prevent rickets." "[Mothers] believe the child is not ready to be exposed to the sun before 15 days."	~45 days Vaccinations at health post at 45 days Culture, fear of infant harm/ illness	"It's culture; the child and mother have not enough strength to move after delivery." "If the child is exposed before 45 days, the baby can't tolerate [the sunlight]."
Do mothers expose their babies to the sunlight? How long after birth? Why and for how long? How does this compare with your own practices?	15 days postpartum until infant can walk	"Children get vitamin D from the sunshine to prevent rickets. They expose from the second week until 6 months."	45 days postpartum 15-30 min until infant can walk HEWs exposed earlier (1-2 wk postpartum)	"Yes; some of them do. Few of them know about the Vitamin D."
What is the best time during the day for an infant to be exposed to the sun? Why?	Morning is best Afternoon sun too strong	"The morning time because during this time, the sun is not too hot for the children."	Morning is best Afternoon sun too strong	"If the sunshine is too strong, that will damage the child."
Are there ways mothers protect their babies from the sun?	Most HEWs do not see mothers protecting their babies from the sun One mentioned umbrellas and clothes	n/a	Umbrellas, cover with clothes, natural shade	"They use umbrellas, blankets with hoods. They stay in the shade if they do not have umbrellas."
Do you teach mothers about vitamin D? What do you teach?	Teach source, benefits and dangers of deficiency Teach benefits of breastfeeding Gabyadar 30:1 model	"I teach about breastfeeding, eating a balanced diet, complementary foods, and vitamin D."	Teach source, benefits, and encourage exposure Encourage breastfeeding, but may recommend supplement with "Plumpnet" One HEW very uneducated (source F&V) (quoted)	"Yes; I told them the food they eat is must have a VD rich foods like fruit and vegetables."