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Historical and practical uses of assessing night blindness as an indicator for vitamin A deficiency

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Abstract

The assessment of vitamin A status is critical for the planning, implementation, monitoring and evaluation of vitamin A deficiency prevention and treatment programmes. Determination of night blindness is one of the traditional methods of assessing vitamin A deficiency. A variety of subjective and objective methods have been used, however, reported night blindness, the most common method to assess poor dark adaptation, does not correlate strongly with biochemical indicators of vitamin A deficiency. Recently, more standardized field-based methods that utilize a standard stimulus to the eye have been developed, specifically the pupillary response test and the night vision threshold test. These low-cost, non-invasive methods have the potential to provide rapid assessment to determine whether the prevalence of vitamin A deficiency within a population is of public health significance or changes with an intervention.

Introduction

Vitamin A deficiency is of major public health significance in many parts of the world where poverty is extensive and resources are limited. The association between vitamin A deficiency and an increase in childhood prevalence and severity of infectious diseases, blindness and mortality has been well documented. Vitamin A deficiency in pregnant and breastfeeding women is also associated with poor maternal and infant outcomes. Much work has already been conducted to determine the social determinants that lead to vitamin A deficiency, including indicators of poverty, low education and social discrimination (*1*–*3*).

A number of methods have been used over the past century to assess vitamin A status, including dietary patterns, biomarkers, clinical examinations and histopathology (*4*). All these methods have their advantages and limitations for assessing vitamin A status both at the individual and at the community level. This review focuses on night blindness as a method for assessing vitamin A status. In the most restrictive sense, the measurement of night blindness is the ability to see at night, or synonymously in darkness or when light is of low intensity. A variety of methods have been developed to measure factors that relate to the biochemical, physiological and functional ability to see in darkness. However, the methods used to measure retinal physiology and the functional ability to see at night are fundamentally different, and although they provide mostly congruent findings, at times the results can be incongruent within an individual. One can measure objectively deterioration in the response of the eye to see in darkness, but a person may still be able to see and function at night. Night blindness is when a person is having trouble seeing in darkness and this takes into account the physiological responses to dark adaptation and either a cognitive recognition of the deficit or an objective measure of the functional deficit.

This paper reviews the most common measures of night blindness and their association with vitamin A status at the individual and at the community level as part of population-based assessments, and for monitoring and evaluation of vitamin A interventions. A brief background is provided on the physiological factors that bring together the role of vitamin A and measures of night blindness. Determining the presence of night blindness in the context of vitamin A deficiency addresses the logistical and practical aspects of conducting large-scale public health evaluations in resource-poor regions and countries of the world. Not all countries and programmes have the financial or laboratory resources to analyse serum vitamin A, to conduct elaborate retinol dose response measures, and to measure biochemical indicators of inflammation, poor protein status and/or other nutrients that affect serum vitamin A concentration. Assessment of night blindness avoids having to obtain blood from women and children. The costs associated with laboratory testing are lower and the results are available much more quickly than with laboratory analyses. It is also possible to repeat measurements in the field to improve accuracy. Often fewer people need to be trained to conduct night blindness testing, there are less consumable costs for such items as chemical reagents and for transportation of samples, and there is also less need for numerous personnel such as phlebotomists and laboratory technicians, and for laboratory supervision.

Night blindness and vitamin A

The physiological mechanisms that lead to night blindness have been elucidated from studies on genetic abnormalities related to the retina, as a result of diseases that interfere with fat absorption, liver metabolism and genetic mutations. These causes of night blindness are not comprehensively addressed in this paper since several reviews are already available (*5*–*7*).

Modern understanding about the role of vitamin A in vision was much enhanced by the work of Dowling and Wald (*8*, *9*) on the capacity for sight under variable levels of light. Their

studies elucidated the mechanism for night vision as a function of three integrative parts of the eye: the pupil, the rods and cones, and rhodopsin in the rods. The pupil acts as a filter that contracts and expands depending on the amount of light exposure. While the cone cells in the retina perceive colour in bright light, the rod cells perceive black and white images and work best in low light. Rhodopsin, a visual purple photopigment, is located in the rod cells in the outer periphery of the eye and is the key to night vision. When exposed to light, molecules of rhodopsin absorb photons and then split into the two chemicals, retinal and opsin. This allows the eye to perceive black and white images in a light environment but inhibits night vision. When exposed to darkness, retinal and opsin recombine to form rhodopsin once again, the chemical that promotes the capacity for night vision. These photoreceptors (cones and rods), are in the posterior of the retina next to the pigment epithelial cells while the nerve cells lie on the anterior surface of the retina.

Multiple nutrients are involved in the regeneration of rhodopsin, including protein, minerals, especially zinc, and vitamins that influence vitamin A metabolism and neuron transmission. Night blindness due to vitamin A deficiency is mostly associated with metabolic changes related to the regeneration of rhodopsin; the delay in recovery may also be due to anatomical changes in the rods, which take time to recover. Studies on rats have indicated that it might take 3–5 months for recovery in severe cases (*8*). At the point where all rod function is lost, rhodopsin levels remain at about two-thirds of normal and when deficiency continues, the cones are also affected (*10*). Anatomical changes on fundus examination have also been reported in humans with vitamin A deficiency, including the presence of yellow and white retinal spots (*11*, *12*). It is not known if the same anatomical relation exists with rhodopsin depletion in humans, but follow-up studies indicate that fundus anatomy fully recovers within 2–3 months (*11*).

Night blindness due to vitamin A deficiency also occurs secondary to medical interventions that lead to a decrease in fat absorption, such as bariatric surgery, and to other medical conditions leading to impaired liver function, such as in alcoholism and biliary cirrhosis (*13–15*). Additional knowledge about vitamin A and night blindness has been acquired from studying Sorsby's fundus dystrophy, a rare genetic defect that is characterized by a thickening of Bruch's membrane barrier between the photoreceptor and blood supply (choroid) due to abnormal lipid-containing deposits. Studies have suggested that the inhibition of blood flow with consequent vitamin A deficiency may be related to the night blindness in the early stages of development. In a small group of four family-related patients given 50 000 IU/day for 1 month, improvement occurred by the ninth day of treatment as measured by a shorter duration of the rod–cone break (*16*).

Current recommendations for using night blindness as a method to determine whether the prevalence of vitamin A deficiency is of public health significance

Several agencies and organizations have published recommendations regarding use of night blindness assessment to determine the public health significance of vitamin A deficiency in populations. Vitamin A deficiency has been defined as being of public health significance when it is present in ≥1.0% of children 24–71 months of age and is of severe significance when the prevalence is ≥5.0% (*4*, *17*). However, even in young children, prevalence of night blindness within the preschool years increases with age (*18–22*). The prevalence of night blindness may be greater among boys compared with girls within this age range and thus population studies must ensure that their sample contains a representative proportion of boys and girls. More recently, maternal night blindness has been suggested for assessing the vitamin A status at community level. This is determined as the proportion of women with a history of night blindness in a previous pregnancy that ended in a live birth in the past 3 years, and when possible using a local term for describing night blindness (*23*). Finally, a previous report by the World

Health Organization (WHO) has indicated that night blindness can be used for risk assessment, targeting programmes and evaluating effectiveness of vitamin A interventions (*4*).

Description of methods used to assess night blindness

Numerous tests and variations of standardized tests have been used to determine the presence of night blindness. This review focuses on the four tests that have been used most consistently in conjunction with other measures of vitamin A status. The most common tests involve having a person report about their current or past night blindness status and are based on dark adaptation (time it takes to respond to darkness) or the scoptic response to various light stimuli after dark adaptation. The other methods reviewed are: dark adaptometry, the papillary response test and the night vision threshold test. Other tests of night blindness include variations of the candle test, electroretinography and electro-oculography, but these tests either have not been standardized (candle test) or are very expensive for community-based programmes (electroretinography and electro-oculography).

Although there are several methods to measure night blindness, their association with vitamin A status may differ based on the measure of night blindness used, including the cut-points reported (*24*), the population under study and the season the assessments are conducted in. Night blindness is reported more frequently in older children, starting at 2 years of age, possibly due to post weaning, increases in exposure to other infectious diseases and illnesses, and easier reporting and observation by parents (*25*). Boys are affected more than girls in resource-poor areas probably due to more rapid growth and greater demand for vitamin A, and it may also occur more often when there is a local term for night blindness, but not always (*25*). In specific regard to pregnancy, night blindness is associated with gestation, age and parity (*26*).

Reported night blindness

Having someone report night blindness is the most common method to determine whether a child or an adult has night blindness. In countries where night blindness is common and severe there is often a local name for it: in Bangladesh the local names include *rat kana*, *alo andhari* and *krikana* (*27*), in the Terai (plains) region of Nepal *ratauni*, *ratundho* and *rataunji* (*28*) and in Indonesia *buta ayan* and *kotokeun* (*29*). Multiple terms are used for night blindness in Mali: in Dogon, *gire nama*, in Peul, *pinku* and in Bambara *surofinye* (*30*).

When a recall method is used for night blindness (either currently having night blindness or having had it in the past), a standardized sequence of questions is used. The questions need to distinguish between poor vision during the day and when there is less light, such as in the evening. In children it is advisable to find out whether the night vision is different from other children. Some studies have added questions about the functionality of a person when it is dark, such as their ability to perform certain tasks at night. In terms of identifying night blindness in young children, it is the mother who usually reports this condition and it will always require recall and/or observation of a child having problems functioning in the evening or having the child verbally tell the mother he or she cannot see. **Table A2.1.1** provides an example of a sequence of questions used to assess night vision.

Reported night blindness is considered the least invasive method to assess vitamin A deficiency. WHO has stated that a ≥5% prevalence rate of night blindness in children 24–71 months of age signifies that the vitamin A deficiency is of severe public health significance (*4*). However, the association between reported night blindness and biochemical indicators of vitamin A status has been inconsistent with regards to prevalence of low vitamin A status. **Table A2.1.2** presents the outcomes of 21 reports that include 33 matched data on the percentage of people with low serum vitamin A concentrations (<0.70 μmol/L) and the proportion of subjects who

Table A2.1.1
Questions used in the assessment of night blindness by recall during pregnancy

a. Do you/(does your child) usually have any difficulties seeing during the day? ☐ Yes ☐ No
b. Do you/(does your child) have any haziness or blankness in your vision in the evenings and/or at night? ☐ Yes ☐ No
c. Do you (does your child) have night blindness (using local term when available)? ☐ Yes ☐ No
d. Is your (does your child) ability to do things at night any different from others? ☐ Yes ☐ No

reported having night blindness. **Figure A2.1.1** indicates that there was no correlation between these values across the studies. Similarly, no associations were identified when the studies were restricted to only children, or only pregnant women or when the cut-point for deficiency was set at 0.35 µmol/L. Furthermore, a recent report (*46*) presenting national level data on the prevalence of xerophthalmia, found no correlation between the prevalence of this condition and the population with serum vitamin A concentrations <0.70 µmol/L (**Figure A2.1.2**).

Table A2.1.2
Reported night blindness and indicators of vitamin A status

Reference	Country	Population	N	% XN	Serum vitamin A concentrations	
					Total population	XN versus no XN
21	Ethiopia	Children 6–180 months	402	7.2%	8.2% <0.18 µmol/L 50.2% <0.35 µmol/L	NA
22	India	Children 1–5 years	8646	1.1%	54.7% <0.35 µmol/L	NA
36	United Republic of Tanzania	Preschool School age Women (pregnant or breastfeeding)	461 562 191	11.7% 9.1% 24.6%	Preschool 57.8% <0.35 µmol/L[a] 10.4% <0.18 µmol/L[a] School age 19.5% <0.35 µmol/L[a] 2.0% <0.18 µmol/L[a] Women 14.0% <0.35 µmol/L[a] 0.5% <0.18 µmol/L[a]	Preschool XN: 52.1% <0.35 µmol/L 4.2% <0.18 µmol/L No XN: 58.5% <0.35 µmol/L 11.3% <0.18 µmol/L School age XN: 14.6% <0.35 µmol/L 2.1% <0.18 µmol/L No XN: 20.0% <0.35 µmol/L 2.0% <0.18 µmol/L Women XN: 19.6% <0.35 µmol/L 2.2% <0.18 µmol/L No XN: 12.2% <0.35 µmol/L 0.0% <0.18 µmol/L
29	Indonesia	Children 0–6 years	5295	4.1%	18.5% <0.35 µmol/L[a] 3.5% <0.18 µmol/L[a]	XN: 33.6% <0.35 µmol/L 11.8% <0.18 µmol/L No XN: 17.8% <0.35 µmol/L 3.1% <0.18 µmol/L
4	Bangladesh	Children 0–15 years	5420	2.2%	43.7% <0.35 µmol/L[a] 4.4% <0.18 µmol/L[a]	XN: 60.9% <0.35 µmol/L 19.5%<0.18 µmol/L No XN: 43.3% <0.35 µmol/L 4.1% <0.18 µmol/L

Table A2.1.2 (*continued*)

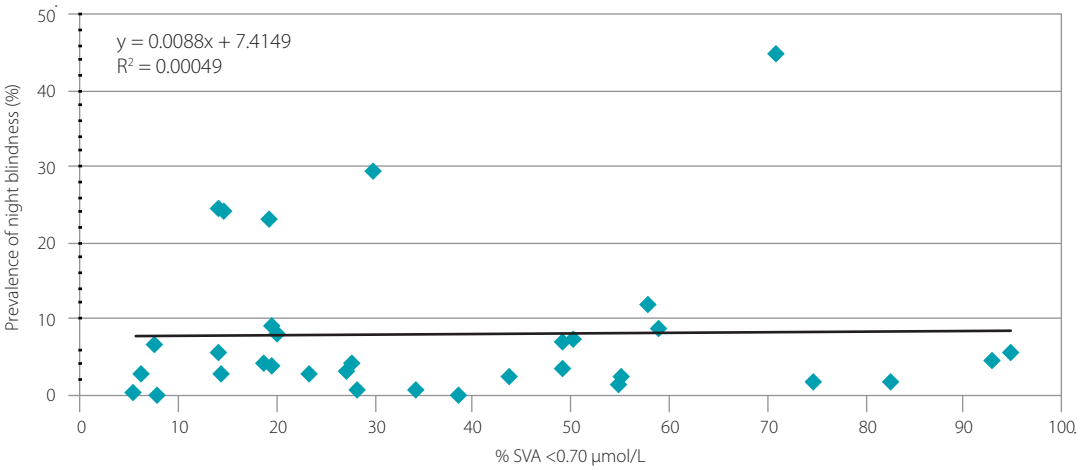
Reference	Country	Population	N	% XN	Serum vitamin A concentrations	
					Total population	XN versus no XN
37	Nigeria	Children 6 months – 6 years	213	1.5%	26.8% <0.18 µmol/L 74.6% <0.35 µmol/L	XN: 100% <0.35 µmol/L 100% <0.18 µmol/L No XN: 74.3% <0.35 µmol/L 26.0% <0.18 µmol/L
38	Mali	Children 6 months – 6 years	1510	4.3%	92.7% <0.35 µmol/L 43.8% <0.18 µmol/L	NA
31	Indonesia	Children 12–59 months (6 and 9 months post supplementation)	At 6 months 136 At 9 months 292	0% 2.42%	38.5% <0.35 µmol/L 55.1% <0.35 µmol/L	NA
25	Congo	Children 0–71 months	5048	0.7%	49.0% <0.35 µmol/L 18.1% <0.18 µmol/L (n=299)	NA
39	India	Children 6 months – 4 years	175	1.7%	82.4% <0.35 µmol/L 55.9% <0.18 µmol/L	NA
40	China	Children 0–61 months	1236	0.0%	7.8% <0.35 µmol/L 10.9% <0.35 µmol/L (rural) 4.9% <0.35 µmol/L (urban)	NA
32	India	Children 1–7 years	207	44.9%	India 70.8%<0.35 µmol/L	NA
30	Mali	Children 12–66 months	1997: 1510 1999: 1524	1997: 5.5% 1999: 3.3%	1997 (n=192) 94.8% <0.35 µmol/L 89.4% <0.18 µmol/L 1999 (n=251) 49.0% <0.35 µmol/L 39.9% <0.18 µmol/L	NA
41	Kenya Nepal	Adolescents 10–19 years	Kenya: 193 Nepal: 191	Kenya 24.0% Nepal 29.2%	Kenya 14.5% <0.35 µmol/L 1.6% <0.18 µmol/L Nepal 29.8% <0.35 µmol/L 1.0% <0.18 µmol/L	Total sample (Kenya and Nepal) XN: 22.9% <0.35 µmol/L No XN: 21.8% <0.35 µmol/L
42	India	Pregnant women	736	2.9%	27.0% <0.35 µmol/L 3.5% <0.18 µmol/L	NA
43	Kenya	Male prisoners ≥16 years	1048	23.2%	0.0% <0.18 µmol/L 19.1%<0.35 µmol/L[a]	XN: 40.2% <0.35 µmol/L No XN: 12.5% <0.35 µmol/L
44	Indonesia	Children 41–54 months	30	20.0%	36% <0.18 µmol/L	NA
45	Marshall Islands	Children 1–5 years	281	8.5%	58.7% <0.35 µmol/L	NA
34	Nepal (Kathmandu)	Pregnant women	1401	6.4%	7.5% <0.35 µmol/L[a] 1.1%<0.18 µmol/L[a]	XN: 10.6% <0.35 µmol/L 2.1% <0.18 µmol/L No XN: 7.3% <0.35 µmol/L 1.0% <0.18 µmol/L

Table A2.1.2 (*continued*)

Reference	Country	Population	N	% XN	Serum vitamin A concentrations	
					Total population	XN versus no XN
35	Nepal (Terai region)	Pregnant women	3531	5.4%	14.0%<0.35 µmol/L[a] 7.4% <0.18 µmol/L[a]	XN: 35.9% <0.35 µmol/L 7.7% <0.18 µmol/L No XN: 12.8% <0.35 µmol/L 2.5% <0.18 µmol/L
33	Nepal (Terai region)	Pregnant women	8764	8.0%	19.9%<0.35 µmol/L[a]	XN: 25.1% <0.35 µmol/L No XN: 19.5% <0.35 µmol/L

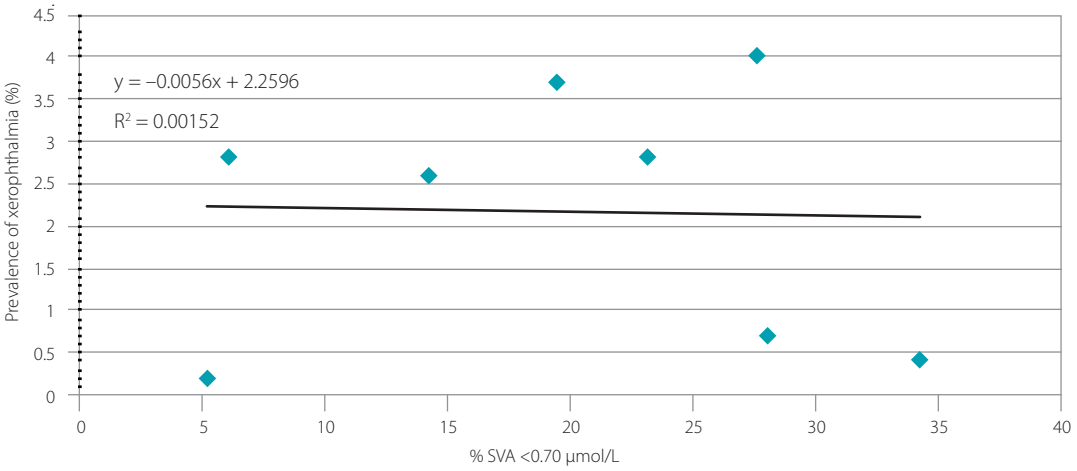
[a] Estimated from rates in cases and controls.
NA, not available; XN, xerophthalmia.

Figure A2.1.1
Relationship between xerophthalmia and serum vitamin A levels (SVA) <0.70 µmol/L (n = 21 studies) in the studies given in Table A2.1.2. Some papers reported results for more than one population.



Data from references (*4, 21, 22, 25, 29–45*).

Figure A2.1.2
Prevalence of xerophthalmia and percent serum vitamin A (SVA) <0.70 µmol/L using country data.



Data from reference (*45*).

Objective measures of night blindness

Several methods have been developed in the attempt to have an objective measure of night blindness. All of these methods are based on the scoptic response and thus have some similarities with regards to the environment in which measurements are taken, for example, all require dark adaptation. The most common time period is 10 minutes in a completely darken room. Training is required for taking measurements to decrease variability and intra- and inter-observer bias. Each method requires subject cooperation. Differences have been found within measurements made with the same method or different methods. Some researchers have bleached the eye (flashing a standardized light) to add uniformity to the measures. Other methods have looked at how quickly a person adapts to darkness whereas some methods determine the level of light that can be seen after dark adaptation. Some methods require dexterity and others a verbal response. The intensity of light that is used to stimulate the eye also varies between methods. This section reviews the most common methods that have been used to objectively measure night blindness.

The candle test

The candle test was one of the first objective measures of night blindness, and it requires only low-cost consumable materials. However, it has not been consistently used for evaluating vitamin A deficiency. The most common protocol for the candle test is to have the person dark-adapted, light a candle and determine whether the person can identify objects near the candle. The problem with the candle test is that all candles are not the same and thus the amount of stimulus provided to the rods is not known and this cannot be standardized. Often the standard has been the tester and if the tester can see the objects and the subject cannot, this leads to the diagnosis of night blindness (*47*). Furthermore, now that new technology is available, there is no advantage with this test compared with other assessment methods that can be standardized and have greater reproducibility for comparisons within and between populations.

Electroretinography

The electrophysiology of vision can be used for overall health assessment of the retina (*48*). Using a full field electroretinogram allows one to differentiate the rod and cone response to various levels of light stimuli against multiple intensities of background light. Historically, electroretinography have been used to measure scoptic response to brief light stimulus in patients with various ophthalmological conditions, including those that result in night blindness. Electroretinography has not been used in large-scale studies due to the associated costs and logistics. In order to conduct electroretinography, patients need to have their eyes dilated (e.g. using a combination of tropicamide 1.0% and phenylephrine hydrochloride 2.5%) prior to dark adaptation for 30 minutes. The eyes are then anaesthetized (tetracaine hydrochloride 0.5%) before placing contact lens electrodes, and children may need to be sedated. After dark adaptation, the scoptic response is elicited using a full field dome (e.g. Ganzfeld) by a dim flash of light and the amplitude and implicit times are recorded. A negative reaction to the dim flash supports poor rod response and later the combined rod–cone response can be measured using a bright flash. Calibration of the Ganzfeld dome is required and of the measures of the strength of the flashes, use of repeated flashes, background luminance and the electronic hardware and software that is used to measure amplitude and the implicit times.

Another method related to electroretinography is electro-oculography, which differs from the former in that it measures the continuous resting electrical potential of the retina compared with the transitory response measured by electroretinography. The equipment costs for these tests can exceed US$40 000 and the other costs for consumables and training of staff also make this test expensive and not suitable for large-scale community assessment, and monitor-

ing and evaluating of interventions in low-income countries. Studies in the past few decades have utilized electroretinography to identify night blindness in specific clinical cases that have resulted from vitamin A deficiency due to diseases interfering with fat absorption or iatrogenic outcomes following bariatric surgery (*49*).

Rapid dark adaptation test

The rapid dark adaptation test is based on the Purkinje shift, that is, the sensitivity of the retina to shift from the red to the blue end of the visual spectrum (*50*, *51*). The classical approach uses a Goldman-Weekers adaptometer. The eyes are first dilated to 7–8 mm with 1.0% tropicamide and then subjected to a consistent diffuse light of 3.13 log millilamberts luminance for 10 minutes followed immediately by the dark adaptation measurements while the subject is fixated on a 2 mm red light. The subject is then exposed to light flashes in ascending (first saw the test light) and descending order (ceased to see the test light), based on their responses, for 35–40 minutes until a plateau is reached. The logarithm of the light-perception threshold is then plotted as a function of time in darkness (*52*). The plot shifts upwards with increasing levels of night blindness, indicting a greater luminance level at the time the final plateau is reached. This method has been adapted using munsell coloured red (605 μm) and blue (475 μm) chips that were emitted at 6.8×10^3 candelas/m^2 after bleaching of the eye for 1 minute (*53*, *54*). The time taken by a subject to recognize and sort various coloured objects after bleaching is then used as a measure of the dark adaptation response. Studies have correlated night blindness with vitamin A status, but no standard cut-point has been recognized within any of the various applications to consider them useful in large-scale studies.

The pupillary response

Resurgence in creating a standardized objective measure of night blindness that could be implemented in low-income countries occurred with the development of the pupillary response test (*31*, *32*, *55*). The pupillary response is measured using an AC rechargeable battery-powered illuminator that emits light to one eye. There are 11 settings on the illuminator, separated by 0.4 log intervals. A subject places one eye fully over the illuminator while the other eye is focused at a space 2 m in distance while being exposed to a red light. The illuminator emits light in one eye while the pupillary response (contraction) in the opposite eye is monitored using a loupe with 2.5× magnification. A threshold used for impaired dark adaptation is a response to light greater than –1.11 log cd/m^2. This pupillary response test has been used in children and women. However, compliance with completing the pupillary response test is very low in children younger than 4 years of age (*31*). The pupillary response test has shown that the dark-adaptation threshold significantly improves after vitamin A supplementation in pregnant women, but not in postpartum women (*55*). Pregnant women who reported night blindness were very likely to fail the pupillary response test (80%); however, more importantly, 14.8% of women who did not report having night blindness failed the pupillary response test, suggesting that this test may be identifying earlier stages of night blindness that are not being recognized by the women themselves (*33*).

The night vision threshold test

The night vision threshold test (NVTT) instrument is a small, handheld, portable, battery-powered instrument that projects light of varying intensity onto a standardized matte projection screen that has a goniophotometer reflectance of 1.1. The list is 30 cm in diameter when the NVTT is 3.3 m from the screen (*34*, *56*, *57*). The amount of projected light is varied by changing the electrical current provided to a light-emitting diode (LED) through a series of switches. The NVTT instrument uses 6 V of energy for correct operation and is set up with six 1.5 V AA batteries (9 V). A low battery indicator light is activated when the battery power decreases to <7 V.

Light emission decreases linearly in degrees of illuminance on a log scale. An eighth switch provides a brighter training setting so that a subject can be instructed on how to respond in a lighted room before they are dark-adapted. The LED for the NVTT emits a light with a wavelength of 0.50–0.57 µm in the green spectrum. The illuminance of the NVTT ranges from 475 mlux at the brightest test setting to a minimum of 0.3 mlux in the dimmest setting. Each person is given a score relating to the dimmest light that they can see.

The NVTT test is administered after 10 minutes of dark adaptation. Subjects are then shown the dimmest light, and they need to indicate not just that they can see the light, but where the light is projected on the screen (left, centre, right). The placement of the light is done randomly so subjects are not able to identify a pattern as to where the light is projected. If the person is able to see the dimmest light, the test is halted. If the person is not able to see the dimmest light, the next brightest light is displayed. If the person is able to see this light, then the dimmer light is shown a second time. If the subject reports again they cannot see the light, the brighter light is shown again. This sequence is repeated with each increasing light until the tester identifies the dimmest light that a subject can see on two different occasions.

Initial studies using the NVTT to assess vitamin A status in children suggested that it was feasible and related to vitamin A status using the serum vitamin A concentration and the modified relative dose response as biochemical indicators (*56*). The NVTT was used to assess night blindness in pregnant women attending a prenatal clinic at the Maternity Hospital in Kathmandu, Nepal, and the results were compared with their serum retinol levels (*34*). Only 6% of women reported night blindness compared with 16% who failed the NVTT. More importantly, there was no significant differences in the mean serum concentrations or proportion of women who had concentrations <0.70 µmol/L between women who reported or did not report night blindness. However, the mean differences and the proportion with low values were significantly different between women who failed the NVTT compared with those who passed the test (**Table A2.1.3**). Similar results were reported from the Terai region of Nepal where the proportion of women who reported night blindness (5.4%) was nearly half that of women who failed the NVTT (9.3%) (*35*). Serum vitamin concentrations were lowest in women who had failed the NVTT and reported night blindness and greatest in women who passed the NVTT and did not report night blindness. However, serum vitamin A concentrations were lower in women who failed the NVTT and did not report night blindness compared with women who reported night blindness and passed the NVTT (**Table A2.1.4**), suggesting that the combination of both assessments may be a better method for screening for low vitamin A status. It is possible to use the proportion who have a low vitamin A concentration at the lowest level of light a woman can see and apply a probability approach to estimate the prevalence of vitamin A deficiency for a community (**Figure A2.1.3**). An important outcome in this later study was that the NVTT was able to indicate that response to four weekly doses of 25 000 IU of vitamin A for correcting

Table A2.1.3
Serum vitamin A concentration in women reporting night blindness and undergoing the night vision threshold test (NVTT).

	Reported night blindness		Failed NVTT score	
	Yes	No	Yes	No
(n)	47	303	177	173
Serum vitamin A (µmol/L)	1.25 ± 1.8[a]	1.24 ± 0.1	1.19 ± 0.1	1.29 ± 0.1
% <0.35 µmol/L	2.1	1.0	2.3[b]	0.0
% <0.70 µmol/L	10.6	7.3	11.3[b]	4.0

[a] Values are means ± SE.
[b] $P < 0.05$ (yes versus no)
Data from reference (*34*).

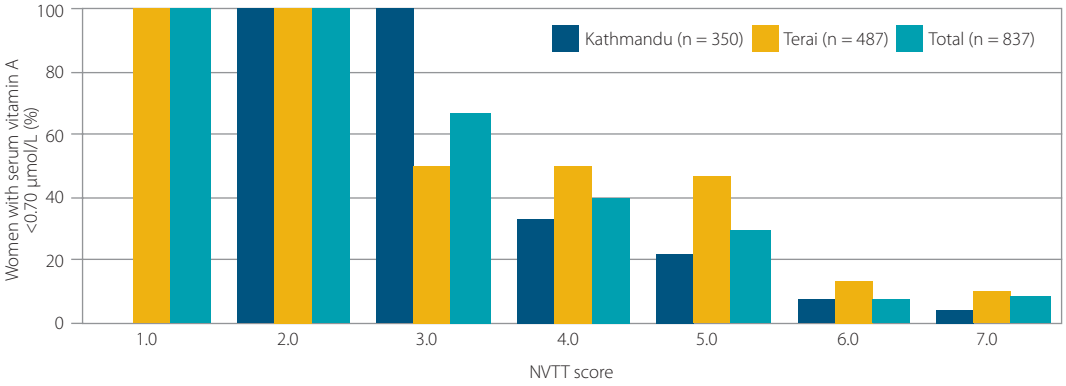
night blindness was dependent on the initial NVTT score (*58*), with fewer women recovering from night blindness when they could only see the brighter lights compared with women who could see the dimmer lights (**Figure A2.1.4**).

Table A2.1.4
Serum vitamin A concentration by reported night blindness (XN) and night vision threshold test (NVTT)

	Failed NVTT (n)	Passed NVTT (n)
Reported XN (n)	(21)	(3)
Serum vitamin A (µmol/L)	0.67 + 0.34[a]	1.09 + 0.16
% <0.70 µmol/L	55.0	0.0
% <0.35 µmol/L	28.6	0.0
Not reported XN (n)	(26)	(428)
Serum vitamin A (µmol/L)	0.96 + 0.57[a]	1.14 + 0.40
% <0.70 µmol/L	38.5	10.1
% <0.35 µmol/L	7.1	1.9

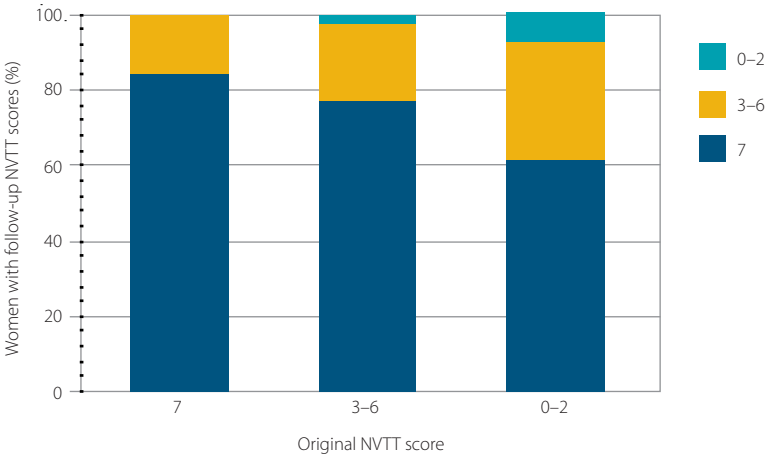
[a] Values are means ± SD
Date from reference (*35*).

Figure A2.1.3
Low serum vitamin A concentrations and night vision threshold test (NVTT) scores.



Data from references (*34*, *35*).

Figure A2.1.4
Night vision threshold test (NVTT) scores after four weekly prenatal doses of 25 000 IU vitamin A. Only women with original NVTT scores of 7 reported having night blindness.



Data from reference (*57*).

Discussion and conclusions

A history of night blindness remains the most frequently used indicator for the earliest and mildest expression of clinical xerophthalmia. The history of night blindness, however, is very subjective. In addition, it does not determine the degree or severity of dark adaptation and its accuracy is questionable. Certainly, reporting by parents will not detect subclinical vitamin A deficiency. Furthermore, there is a lack of evidence that reported night blindness correlates with population vitamin A status. This is of particular concern in young children, in whom proxy reports must be used.

Several methods are available to use for determining early defects in dark adaptation when financial resources are limited and vitamin A deficiency is prevalent. However, poor dark adaptation or night blindness should not be considered a dichotomous condition and the degree (severity) of night blindness within an individual and on a population level (prevalence) is dependent on the degree of vitamin A deficiency present. Methods to assess poor dark adaptation need more calibration to identify populations that are in greatest need of vitamin A interventions. Several criteria need to be considered when determining which method to use to assess night blindness as an indicator for vitamin A: cost, ease of administration under field conditions by people with limited education, and a high degree of sensitivity and specificity. **Table A2.1.5** compares the methods used to assess night blindness with several criteria that have been identified as important for indicators of nutritional status, that is, relevance, credibility, cost, comparability, time sensitivity and information use (*59*). Credibility refers to how well the indicator is accepted by the research community in terms of its theoretical and physiological evidence and its use in practice. In low-income countries, assessment methods need to be field-friendly, including being portable and able to function without the need to access electricity over an extended period of time.

Table A2.1.5
Field methods to assess night blindness

Assessment method	Relevance	Credibility	Cost	Comparability	Timeliness	Information use
Report night Blindness	Low	Moderate	Very low	Moderate	Moderate	Moderate
Candle test	Low	Low	Very low	Low	Low	Low
Electroretinography	High	High	Very high	High	High	High
Rapid dark adaptation	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Pupillary response	Moderate	High	High	Moderate	High	High
Night vision threshold	Moderate	High	Low	Moderate	High	High

In conclusion, currently there is a need for an objective, non-invasive measure of vitamin A status and an objective measure of night blindness, or more appropriately, poor dark adaptation, may fulfil this role. Affordable assessment methods are available and can provide rapid results for assessing populations so that programmes can target populations that are most in need of vitamin A interventions (*60*). Several of the objective measures available may identify anomalies of dark adaptation before people themselves are cognizant of a decrease in function. On a population basis, algorithms can be created with these methods to estimate the prevalence of night blindness once a method has been calibrated with an acceptable biochemical indicator of vitamin A status. This will allow determination of the public health significance of vitamin A deficiency within a population in a timely manner for programme planning and evaluation.

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