

# Vitamin A deficiency in a Kenyan prison

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## Summary

**OBJECTIVE** To estimate the prevalence and causes of vitamin A deficiency disorders (VADD) in adult male prisoners in Nakuru, Kenya.

**METHODS** A total of 1048 male prisoners aged  $\geq 16$  years in Nakuru Government of Kenya prison in Nakuru, Kenya were examined by an ophthalmologist for signs of xerophthalmia. Two hundred and forty-one cases with xerophthalmia and 448 controls randomly selected from the remaining prison population were interviewed about risk factors for xerophthalmia and blood samples were taken to measure serum retinol and haemoglobin.

**RESULTS** 23.6% (95% CI = 21.1–26.3%) of examined inmates showed at least one sign of xerophthalmia, mostly night blindness (98.8% of cases). In the case-control study, the age-adjusted analyses showed that xerophthalmia was associated with age, length of imprisonment and previous imprisonment. Men with xerophthalmia were significantly more likely to be in poor health characterised by significant illness, recent hospital admission, persistent cough, diarrhoea, fever or chronic illness. After multivariate adjustment, duration of imprisonment remained strongly associated with xerophthalmia (OR comparing  $>4$  years with  $<6$  months = 20.1, 95% CI = 8.3–48.8). Previous imprisonment, fever, diarrhoea, hospital admission and chronic illness were also significant predictors. Serum retinol levels were significantly lower in cases than controls, while there was no difference in haemoglobin levels.

**CONCLUSION** Vitamin A deficiency was a significant public health problem among these Kenyan male prisoners, indicating that it may be important in vulnerable groups other than young children and pregnant or lactating women.

**keywords** vitamin A deficiency disorders, xerophthalmia, kenya, micronutrient

## Introduction

Increasing awareness of the role of vitamin A in human health has led to international efforts to eliminate vitamin A deficiency disorders (VADD) as a public health problem. VADD mainly occur in children and pregnant or lactating women in low-income countries, affecting 140 million preschool-aged children and over 7 million pregnant women and causing increased morbidity and mortality (World Health Organization 1995; West 2002). VADD may also occur in other vulnerable groups, such as refugees, displaced people and adult prisoners. Highly effective interventions exist for VADD, including food fortification, vitamin A supplementation and dietary diversification. (Sommer *et al.* 2002)

Kenya is classified by the World Health Organization (WHO) as having clinical VADD of public health significance (World Health Organization 1996), confirmed by the 1999 national survey (Mwaniki *et al.* 2002), and surveys in

children (Ngare *et al.* 2000; Munene *et al.* 2003; Siekmann *et al.* 2003; Nabakwe *et al.* 2005) and women (Etyang *et al.* 2003; Baeten *et al.* 2004). Few studies in Kenya have assessed the prevalence of VADD outside of these vulnerable groups, although high risk groups may exist (MacDonald *et al.* 2001; Mwaniki *et al.* 2002; Woodruff *et al.* 2006). Male adult prisoners may be a vulnerable group as they may have nutritionally inadequate diets and are at high-risk of diarrhoea and other illnesses. The aim of this study was to estimate the prevalence and causes of VADD among men interred in the Nakuru Government of Kenya (GK) prison.

## Methods

### Cross-sectional survey

All 1458 male inmates of Nakuru GK prison who were interred during April–May 2002 and were at least 16 years

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old were eligible for inclusion. Four hundred and ten men were excluded because they did not consent to examination (10%), were currently hospitalised (5%) or were on duties outside prison (85%). A total of 1048 adult male prisoners were included in the survey (72% response).

An ophthalmologist examined all participants for signs of xerophthalmia with an illuminated magnifying loupe. Participants were asked about the presence of night blindness, using the four question interview scheme recommended by the WHO (World Health Organization 1996). Xerophthalmia was categorised as: history of night blindness, conjunctival xerosis, Bitot's spots, corneal xerosis, corneal ulcers, corneal scars related to xerophthalmia or xerophthalmic fundus. Treatment records and the history were used to verify whether corneal scars were xerophthalmia-related.

#### Case-control study

All cases with xerophthalmia were interviewed about potential VADD risk factors, except for six who were unwilling or unable to participate. Controls were randomly selected from the remaining participants without xerophthalmia, matched by residential block, and were also interviewed. A blood sample was taken from all cases and controls that consented. Serum retinol was measured using standard high pressure liquid chromatography methods at the Kenya Medical Research Institute (KEMRI) laboratory. Haemoglobin was measured using a portable photometric haemoglobinometer.

#### Statistical analysis

Sample prevalence of xerophthalmia [and 95% confidence intervals (CI)] was estimated. Age-adjusted odds ratios (OR) (and 95% CI) were generated for the association between exposures and xerophthalmia through logistic regression modelling. A stepwise regression model was produced, retaining age in the model. Participants were classified by serum retinol level as: severely deficient ( $<0.35 \mu\text{mol/l}$ ), moderately deficient ( $0.35$  to  $<0.7 \mu\text{mol/l}$ ), mildly deficient ( $0.7$  to  $<1.05 \mu\text{mol/l}$ ) or normal ( $\geq 1.05 \mu\text{mol/l}$ ) (World Health Organization 1996). Sensitivity and specificity of xerophthalmia diagnosis was compared with the gold standard of deficient serum retinol levels.

#### Ethical approval

Ethical approval was obtained from the Prison authorities in Kenya, Ministry of Health, Division of Ophthalmologic Services, and KEMRI Ethical Committee. Participants gave

verbal consent. Subjects with xerophthalmia or low serum retinol levels were treated with high-dose vitamin A capsules. Subjects with low haemoglobin were given haematinics and referred to the medical clinic.

#### Results

Two hundred and forty-seven of the 1048 men examined (23.6%, 95% CI = 21.1–26.3%) showed at least one sign of xerophthalmia, of which night blindness was the most common ( $n = 244$ ; 23.2%, 95% CI = 20.8–26.0%).

Thirty men had Bitot's spots (2.9%, 95% CI = 2.0–4.1%), which were bilateral in 27 cases (2.6%, 95% CI = 1.7–3.8%). Five men had corneal scars, two of which were recent and three were old (0.5%, 95% CI = 0.2–1.2%).

In the case-control study, age-adjusted analyses showed that increasing age, longer duration of imprisonment and previous imprisonment were strongly associated with xerophthalmia (Table 1). Health-indicators were also significantly associated with xerophthalmia, including illness in prison, history of hospital admission in the last 30 days, persistent cough ( $\geq 2$  months), persistent diarrhoea ( $\geq 4$  motions per day for  $\geq 1$  week), persistent fever (lasting or recurring  $\geq 1$  month) or history of chronic illness ( $\geq 3$  months). Ethnicity and mid upper arm circumference were not associated with xerophthalmia, nor was receiving extra food – which was rare (2.8%). In the multivariate analyses, the strongest risk factor for xerophthalmia was duration of imprisonment (OR comparing  $>4$  years with  $\leq 6$  months of imprisonment = 20.1, 95% CI = 8.3–48.8). Previous imprisonment, fever, diarrhoea, hospital admission and illness in prison were significantly associated with xerophthalmia, while age, persistent cough and chronic illness were not.

Serum retinol and haemoglobin were measured in 87 cases and 64 controls. Serum retinol levels were significantly lower among cases (mean = 0.74, SE = 0.02) than controls (mean = 0.91, SE = 0.03) (mean difference = 0.17, 95% CI = 0.09–0.25,  $P < 0.001$ ). No participant had severe deficiency (i.e. retinol  $<0.35 \mu\text{mol/l}$ ), 35 cases and eight controls were moderately deficient ( $0.35$  to  $<0.7 \mu\text{mol/l}$ , prevalence = 28.5%, 95% CI = 21.6–36.5%), and 45 cases and 31 controls were mildly deficient ( $0.7$  to  $<1.05 \mu\text{mol/l}$ , prevalence = 57.0%, 95% CI = 48.7–64.9%). The age-adjusted OR for xerophthalmia comparing moderate deficiency to normal was 10.3 (95% CI = 3.0–35.5), and 2.4 (95% CI = 0.9–6.7) for mild deficiency. Using serum retinol as the gold standard, 35 xerophthalmia cases had low serum retinol (true positives) and eight men without xerophthalmia had low serum retinol (false negatives), producing a sensitivity of 81%. Fifty-six men without xerophthalmia had normal

**Table 1** Risk factors for xerophthalmia among 241 cases and 448 controls

	Case <i>n</i> (%)	Control <i>n</i> (%)	Age-adjusted OR (95% CI)	Multivariate- adjusted OR (95% CI)
<i>Demographic</i>				
Age (years)				
<20	7 (3)	38 (9)	Baseline	Baseline
20–24	43 (18)	115 (26)	2.0 (0.8–4.9)	1.2 (0.4–3.5)
25–29	62 (26)	93 (21)	3.6 (1.5–8.6)	1.5 (0.5–4.3)
30–34	45 (19)	89 (20)	2.8 (1.1–6.6)	1.3 (0.4–3.6)
35–39	25 (10)	45 (10)	3.0 (1.2–7.7)	0.7 (0.2–2.3)
40–49	29 (12)	43 (10)	3.7 (1.4–9.3)	1.3 (0.4–4.1)
50+	30 (12)	25 (6)	6.5 (2.5–17.1)	1.4 (0.4–4.5)
<i>P</i> for trend			<0.0001	0.82
<i>Prison-related variables</i>				
Previous imprisonment				
Yes	49 (20)	34 (8)	2.9 (1.8–4.7)	3.2 (1.8–5.8)
No	192 (80)	414 (92)	Baseline	Baseline
Duration of imprisonment (years)				
≤0.5	31 (13)	225 (50)	Baseline	Baseline
>0.5–1	64 (27)	107 (24)	4.4 (2.7–7.1)	4.6 (2.6–8.1)
>1–2	57 (24)	55 (12)	7.4 (4.3–12.7)	7.8 (4.2–14.5)
>2–4	62 (26)	48 (11)	9.0 (5.2–15.4)	11.5 (6.1–21.5)
>4	27 (11)	13 (3)	13.8 (6.3–30.3)	20.1 (8.3–48.8)
<i>P</i> for trend			<0.0001	<0.0001
<i>Health indicators</i>				
Illness in prison				
Yes	142 (59)	74 (17)	6.8 (4.7–9.8)	4.4 (2.7–7.3)
No	99 (41)	374 (84)	Baseline	Baseline
Recent hospital admission				
Yes	34 (14)	34 (8)	1.9 (1.2–3.2)	2.0 (1.0–3.8)
No	207 (86)	414 (92)	Baseline	Baseline
Persistent cough				
Yes	98 (41)	53 (12)	4.8 (3.3–7.1)	N.S.
No	143 (59)	395 (88)	Baseline	
Diarrhoea				
Yes	53 (22)	15 (3)	7.9 (4.3–14.5)	3.7 (1.8–7.5)
No	188 (78)	433 (97)	Baseline	Baseline
Fever				
Yes	85 (35)	42 (9)	5.0 (3.3–7.6)	2.2 (1.3–3.9)
No	156 (65)	406 (91)	Baseline	Baseline
Chronic illness				
Yes	35 (15)	34 (8)	2.0 (1.2–3.4)	N.S.
No	206 (86)	414 (92)	Baseline	

serum retinol (true negative) while a further 52 men with normal serum retinol had xerophthalmia (false positive), giving a specificity of 52%. Haemoglobin levels were lower in cases (mean = 15.66, SE = 0.23) than controls (mean = 16.25, SE = 0.25) though not significantly (mean difference = 0.59, 95% CI –0.07 to 1.25, *P* = 0.09).

## Discussion

Approximately one in four of the male prisoners had VADD, whether this was measured as the presence of

xerophthalmia or as moderately deficient serum retinol, showing that VADD was an important public health problem in this population (World Health Organization 1996). Men with VADD were more likely to have been imprisoned longer, imprisoned in the past and have poorer health. Illness, including diarrhoea and infection, may have been either a cause or a consequence of VADD, but the most likely culprit for the high prevalence of VADD was the prison diet. The prisoners received a ration of 500 g of food per day and although these meals were high in carbohydrate, they

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were very low in carotenoids and animal sources of retinol.

The 1999 national survey reported that VADD was common among Kenyan men (Mwaniki *et al.* 2002). High levels of VADD were also found in Kenyan adult men with high-risk sexual behaviour and genital ulcers (MacDonald *et al.* 2001), and among adolescent refugees in Kenya (Woodruff *et al.* 2006). These studies are not directly comparable, as a variety of methods were used for sampling subjects and measuring VADD. However, the results of the current study, together with these earlier reports, highlight the potential problem of VADD among adults in Kenya other than pregnant or lactating women.

There were strengths to the study. Both functional (xerophthalmia) and biochemical (serum retinol) indicators of VADD were assessed, using detailed ophthalmic examination and high pressure liquid chromatography. Ophthalmic examinations were undertaken by an experienced ophthalmologist. There were also limitations. The study was conducted in only one prison and the response rate was moderate, providing potential for selection bias. Diagnosis of night blindness was subjective, and there was no local word for night blindness. Xerophthalmia was a sensitive measure of serum retinol deficiency, but specificity was relatively poor. We could not measure serum retinol in all cases and controls.

### Public health implication

Vitamin A deficiency disorders is a problem of public health significance in this prison population (World Health Organization 1996). The prison authorities should ensure that the diet of the inmates is nutritionally adequate, including in vitamin A and provitamin A carotenoids. These prisoners would also benefit from periodic vitamin A supplementation to be instituted by the prison authorities. Food fortification and dietary diversification would also be beneficial, if feasible. These measures could reduce health care expenses for the inmates.

### Conclusion

Vitamin A deficiency disorders was highly prevalent among adult men in a Kenyan prison. Adult male prisoners may be another vulnerable group with respect to VADD and may need to be targeted with VADD interventions. Further surveys are needed to identify people at high risk of VADD outside of traditional vulnerable groups.

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#### Déficience en vitamine A dans une prison du Kenya

**OBJECTIF** Estimer la prévalence et les causes des troubles de déficience en vitamine A chez les prisonniers masculins adultes à Nakuru au Kenya.

**MÉTHODES** 1048 prisonniers masculins âgés de plus de 16 ans dans la prison gouvernementale de Nakuru au Kenya ont été examinés par un ophtalmologue pour des signes de xérophtalmie. 241 cas de xérophtalmie et 448 cas contrôles aléatoirement choisis dans le reste de la population carcérale, ont été interviewés au sujet des facteurs de risque pour la xérophtalmie. Des échantillons de sang ont été prélevés pour la mesure du taux de rétinol dans le sérum et de l'hémoglobine.

**RÉSULTATS** 23,6% (IC95%: 21,1-26,3) des détenus examinés présentaient au moins un signe de xérophtalmie, la plupart du temps de l'héméralopie (98,8% des cas). Dans l'étude cas/contrôle, les ajustements pour l'âge ont révélé une association de la xérophtalmie avec l'âge, la durée de l'emprisonnement et un emprisonnement précédent. Les hommes avec xérophtalmie étaient plus probables d'être de santé précaire caractérisée par des maladies sérieuses, une admission récente à l'hôpital, une toux persistante, de la diarrhée, de la fièvre ou une maladie chronique. Après un ajustement multivarié, la durée de l'emprisonnement restait fortement associée avec la xérophtalmie (OR = 20,1, IC95%: 8,3-48,8 pour la comparaison entre emprisonnement de plus de 4 années à celui de moins de 6 mois). Un emprisonnement précédent, la fièvre, la diarrhée, l'admission à l'hôpital et la maladie chronique étaient également des facteurs prédictifs importants. Les taux sériques de rétinol étaient significativement plus bas chez les cas que chez les contrôles alors qu'il n'y avait aucune différence dans les taux d'hémoglobine.

**CONCLUSION** La déficience en vitamine A est un problème important de santé publique chez ces prisonniers masculins kenyans, indiquant que cette déficience peut aussi être importante dans des groupes vulnérables autres que les jeunes enfants et les femmes enceintes ou allaitantes.

**mots clés** troubles de déficience en vitamine A, xérophtalmie, Kenya, micronutriments

#### Deficiencia de Vitamina A en una prisión en Kenia

**OBJETIVO** Estimar la prevalencia y las causas de los desórdenes por deficiencia de Vitamina A (DDVA) en hombres adultos, prisioneros en Nakuru, Kenia.

**MÉTODOS** 1048 prisioneros, con edad  $\geq 16$  años, internados en la prisión gubernamental de Nakuru, Kenia fueron examinados por un oftalmólogo en busca de signos de xeroftalmia. Se seleccionaron al azar 241 casos de xeroftalmia y 448 controles de entre la población carcelaria. Se les realizó una entrevista acerca de los factores de riesgo para xeroftalmia y se les tomó una muestra de sangre para cuantificar los niveles de retinol y hemoglobina en suero.

**RESULTADOS** 23.6% (95% IC = 21.1 a 26.3%) de los reclusos examinados tenían al menos un signo de xeroftalmia, principalmente ceguera nocturna (98.8% de los casos). En el estudio caso control, el análisis ajustado por edad mostró que la xeroftalmia estaba asociada con la edad, la duración del encarcelamiento y el haber estado previamente en prisión. Los hombres con xeroftalmia eran significativamente más propensos a tener una mala salud, caracterizada por enfermedades significantes, una admisión hospitalaria reciente, tos persistente, diarrea, fiebre o enfermedades crónicas. Después de un ajuste multivariado, la duración del encarcelamiento estaba fuertemente asociada a la xeroftalmia (OR comparando  $>4$  años a  $<6$  meses = 20.1, 95% IC = 8.3-48.8). El haber estado previamente en prisión, la fiebre, la diarrea, las admisiones hospitalarias y las enfermedades crónicas también eran predictores significativos. Los niveles de retinol en suero eran significativamente menores en los casos que en los controles, mientras que no había diferencia en los niveles de hemoglobina.

**CONCLUSIÓN** La deficiencia de Vitamina A era un problema de salud pública significativo entre estos prisioneros keniatas, indicando que esta patología podría ser importante en grupos vulnerables diferentes a los de niños pequeños y mujeres embarazadas o lactando.

**palabras clave** desórdenes deficiencia vitamina A, xeroftalmia, Kenia, micronutrientes