Coverage of vitamin A supplementation, deworming and immunisations: Associations with nutritional status among urban children younger than 5 years in Nelson Mandela Bay, Eastern Cape Province, South Africa

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Background. Even though immunisation coverage is tracked through the district health system in South Africa (SA), limited information is available regarding interventions linked to the Expanded Programme on Immunisation (EPI) and the impact on the nutritional status of children <5 years of age.
Objectives. To describe coverage of immunisations, vitamin A supplementation and deworming among children <5 years old in an urban area of Nelson Mandela Bay, Eastern Cape Province, SA. A secondary objective was to investigate whether a history of missed immunisations, vitamin A supplementation or deworming was associated with wasting or stunting in children.
Methods. A descriptive study was conducted between September 2015 and February 2016, where cross-sectional anthropometrical data were collected from 1 513 children in 32 pre-schools, together with a retrospective analysis of the participants' Road-to-Health/clinic cards to collect data on immunisation, vitamin A and deworming. Participants were categorised into 3-month age intervals to facilitate data analysis. Ethical approval was obtained from the Nelson Mandela University Research Ethics Committee (Human).
Results. Data of 1 496 children were included in the analysis. The prevalence of underweight was 2.5% (n=37), while 11.2% (n=167) were stunted and 1.1% (n=16) were wasted. There were associations between age category and delayed vitamin A supplementation (χ^2=32.105; df=19; n=836; p=0.03) and deworming (χ^2= 45.257; df=17; n=558; p<0.001), but there was no association between delayed vaccinations and age category. There were no significant differences in anthropometrical indicators for children with delayed vitamin A supplementation, deworming and vaccinations compared with children in this sample who were up to date regarding the relevant indicators. However, weight-for-age, height-for-age and weight-for-height z-scores and stunting risk were associated with low birthweight (LBW) (odds ratio (OR) 4.658; p<0.001).
Conclusion. Coverage of vitamin A supplementation and deworming but not immunisations was poorer among children in older age categories. A history of delayed vitamin A, deworming and vaccinations was not associated with the anthropometrical status of children. Children with LBW should be considered for more rigorous follow-up, as they are at higher risk of stunting.

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Sub-Saharan Africa accounts for one-third of all undernourished children globally, with ~39% stunted, 10% wasted and 25% underweight children <5 years of age.[1] Despite a decline in the global prevalence of stunting, the absolute number of stunted children in the African region has increased from 46.3 million in 1990 to 57.4 million in 2020.[1]

Conventional approaches to understanding the causes of childhood malnutrition have focused on infant- and young child-feeding practices and food security, with stunting perceived to be a result of chronic undernutrition.[2] Raiten and Bremer[2] have challenged this conventional approach, and recently more attention has been paid to wider contextual factors that result in childhood malnutrition, including intrauterine growth restriction, poor nutritional status among pregnant and breastfeeding women and factors related to women's empowerment, including education and access to resources. Furthermore, there is increasing interest in environmental enteric dysfunction in the aetiology of stunting.[3] Environmental enteric dysfunction refers to a subclinical state of intestinal inflammation, which results in poor nutrient absorption.[4] Budge *et al*.[4] suggest that poor sanitation and stunting may be causally linked via environmental enteric dysfunction. Vitamin A deficiency results in poor epithelial cell differentiation, which has an impact on gut mucosal integrity and nutrient absorption. Vitamin A deficiency and rotavirus infection are among the leading causes of diarrhoea in children.[5] Soil-transmitted helminth infestation, which may cause anaemia, diarrhoea and reduced appetite, can negatively affect the nutritional intake, growth and development of children, even in urban areas.[6]

The Expanded Programme on Immunisation (EPI), which commenced in 1974, is considered one of the world's most successful public health programmes.[7] As the EPI is a platform from which it is possible to deliver additional health interventions, other primary healthcare services such as deworming, as well as vitamin A supplementation and growth monitoring, were integrated to coincide with immunisation where possible, as a strategy to increase coverage of these maternal and child health (MCH) interventions. Recovery from childhood stunting has been associated with timely child

immunisation,[8] suggesting that prevention of childhood illnesses is an important component of preventing childhood malnutrition.

As children require less frequent vaccinations as they get older, visits to primary healthcare services may decline. Countries with constrained health resources therefore have to consider strategies, such as outreach visits to community pre-schools and crèches, to ensure adequate coverage of these interventions. Although vaccination rates in Nelson Mandela Bay, Eastern Cape Province, South Africa (SA) have been improving,[9] the rate of childhood morbidity and mortality remains high.[10] Limited information was available at the time of the study with regard to coverage of vitamin A supplementation and deworming.

The objective of the study was to describe coverage of immunisations, vitamin A supplementation and deworming among children <5 years of age in an urban area of Nelson Mandela Bay. A secondary objective was to investigate whether a history of missed immunisations, vitamin A supplementation or deworming was associated with wasting or stunting in children. There is previous evidence of stunting being associated with low birthweight (LBW) in this population;[11] therefore, the authors investigated whether a similar relationship could be observed in this larger sample and whether a significant relationship existed, controlling for LBW when the data were analysed.

Methods

A cross-sectional study was conducted between September 2015 and February 2016 in children from 32 pre-schools or crèches.

Weight and height or length were measured by supervised trained fieldworkers, using standardised techniques[12] and calibrated equipment. Weight was measured in kg to the nearest 0.01 kg using a calibrated Seca electronic scale (Model 874) (Seca, Germany), height was measured in cm to the nearest 0.1 cm using a Seca stadiometer (Model 217) for children >24 months old, and length was measured recumbently in cm to the nearest 0.1 cm using a Seca 210 mobile measuring mat for children <24 months of age. Date of birth, date of visit, sex of the child, last date of vitamin A supplementation, last date of deworming and vaccination records were collected from participants' clinic cards. Data collection tools were piloted prior to the study, and data were recorded onto an electronic database.

Weight-for-age *z*-scores (WAZ), height-for-age *z*-scores (HAZ), weight-for-height *z*-scores (WHZ) (for children <60 months of age) and body mass index (BMI)-for-age *z*-scores (BAZ) were subsequently generated using the National Center for Health Statistics/World Health Organization (WHO) reference with the WHO Anthro and WHO AnthroPlus programs (version 1.0.4)[13] to determine stunting (HAZ <-2 standard deviation (SD)), wasting (WHZ <-2 SD) and overweight (WHZ >+2 SD) for children up to 60 months or BAZ >+1 SD for children >60 months of age. Data were cleaned according to WHO[14] criteria. Deworming and vitamin A supplementation given >7 months before the assessment date were considered to be delayed. Immunisation that was due at the appropriate age at the time of assessment, but >30 days late according to the clinic card, was considered to be a missed vaccination. For the purpose of data analysis, the participants were split into age categories in 3-month intervals.

Data were analysed using SPSS version 26 (IBM Corp., USA).[15] Descriptive statistics including frequencies and percentages were used to describe outcomes of categorical data. Inferential statistics included *t*-tests to compare anthropometrical data from different vitamin A, deworming, vaccination and birthweight categories. Children were categorised into 3-month age intervals to represent dynamic growth and to facilitate data analysis. Associations between delayed vaccination, vitamin A and deworming and age categories were analysed using χ^2 statistics. Significance was set at α=0.05. Binomial regression analysis was used to assess stunting risk associated with birthweight for age categories, and multinomial regression analysis was used to explore risk factors for stunting. The odds ratio (OR), 95% confidence interval (CI) and *p*-values were calculated using the model. The significance level was set at α<0.05.

Ethics approval

Ethics approval (ref. no. H15-HEA-DIET-003) was obtained from the Nelson Mandela University Research Ethics Committee (Human) and institutional permission was obtained from the Eastern Cape Department (ECD) of Education, as well as principals and teachers from all the schools. Parents of the children in the classes of the ECD practitioners received a letter explaining the purpose of the research and inviting them to provide informed, written consent for the children to participate in the study. Parents were requested to send their children's clinic cards to the pre-school. A convenience sample was obtained including all children with signed informed consent letters, clinic cards and consent to undergo the anthropometrical measurements on the day of data collection. All schools included in the sample fell under the no-fee-paying school category.

Results

Data of 1 513 children were collected. There were 1 496 children in the analysis, as 17 children had implausible *z*-scores. The mean age of participants (*n*=1 496) was 34.4 (SD 17.93) months and 50.0% of the sample was male (*n*=748). The mean birthweight was 3 062 (577) g and according to the clinic cards 14.0% (*n*=170) of the children had an LBW. The mean WAZ was 0.12 (1.16), with 2.5% (*n*=37) being underweight. The mean HAZ was -0.63 (1.23) and 8.3% (*n*=126) were moderately stunted, with a further 2.7% (*n*=41) severely stunted. The mean WHZ was 0.69 (1.17). According to the WHO (2006) definitions, 0.3% (*n*=4) were severely wasted and 0.8% (*n*=12) were moderately wasted. Due to missing clinic cards or cards that were re-issued, vaccination data were only available for 840 participants, of whom 13.8% (*n*=116) were not up to date with their vaccinations. Deworming data were available for 558 children, while 39.6% (*n*=221) of these children were not up to date with their deworming treatment. Data on vitamin A were available for 836 children, and 38.5% (*n*=322) had missed their last vitamin A dose.

Trends in vaccination, vitamin A and deworming coverage

Trends in vaccination, vitamin A and deworming are shown in Fig. 1. There was no relationship between the age category of children and vaccinations being up to date (χ^2=23.79; *df*=19; *n*=840; *p*=0.204). However, a significant relationship was observed between delayed vitamin A supplementation and age category (χ^2=32.105; *df*=19; *n*=836; *p*=0.03), as well as between delayed deworming and age category (χ^2=45.257; *df*=17; *n*=558; *p*<0.001).

Relationship between nutritional status and coverage

No significant differences in anthropometrical indicators (WAZ, HAZ and WHZ) were observed for children who had received vitamin A but missed the most recent dose (Table 1). Similar trends were observed for up-to-date vaccinations and up-to-date deworming v. interventions that were late. Significant differences in WAZ, HAZ and WHZ were observed for LBW children compared with those born with a normal birthweight.

Low birthweight and nutritional status

Children with LBW were at an increased risk of stunting (OR 4.658; *p*<0.001) (Table 2). Among children <12 months of age, there was an increased risk of being stunted, given an LBW history (OR 29.318;

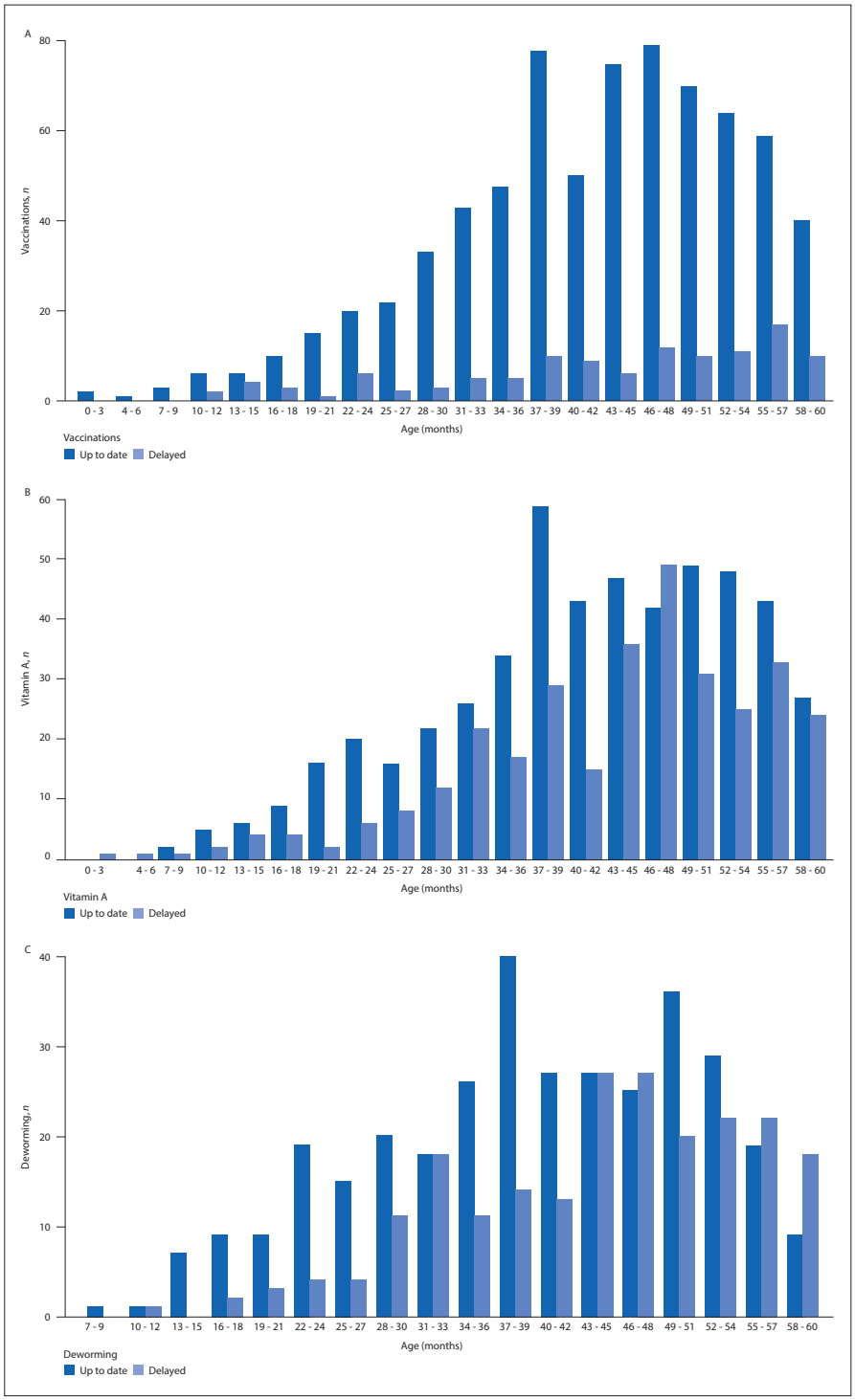

Fig. 1. Delayed v. up-to-date: (A) vaccination; (B) vitamin A supplementation; and (C) deworming by age (n=840).

$p<0.001$); however, among children with a history of LBW who were >48 months old, the odds of being stunted were not significant (OR 0.911; $p=0.885$).

LBW (OR 5.603; $p<0.001$) was a significant risk factor for stunting among children. Vitamin A, deworming and vaccinations were not significant factors for stunting risk (Table 3).

Discussion

This study aimed to describe the coverage of immunisations, vitamin A supplementation and deworming among children <5 years old in an urban area of Nelson Mandela Bay. Approximately a third of children with completed clinic cards had missed vitamin A and deworming treatments, whereas <15% were not up to date with their vaccination schedules. It was also found that there was a relationship between missed vitamin A and deworming treatments and age category. Most immunisation doses under the EPI schedule take place within the first 18 months of life. The EPI schedule may provide an opportunity for vitamin A and deworming through routine visits to clinics and mobile clinics. However, Comley *et al*.[16] suggested that vitamin A distribution needs re-evaluation in SA communities, as there is a large discrepancy between vitamin A and vaccination uptake. This is supported by our finding that vitamin A supplementation uptake is poorer when children are older and require less frequent vaccinations.

A secondary objective was to investigate whether a history of missed immunisations, vitamin A supplementation or deworming was associated with wasting or stunting in children. The WHO has made a strong recommendation for providing vitamin A supplementation in communities at risk of deficiency, as there is good evidence of effectiveness of vitamin A supplementation in reducing childhood mortality.[17] However, the evidence for effectiveness in other indicators of child health such as growth is weaker.[17] No significant differences in anthropometrical indicators (WAZ, HAZ and WHZ) were observed for children who had received vitamin A and missed the most recent dose. The findings of this study suggest that children are likely to miss doses of deworming medications, putting them at higher risk of re-infection and undermining the effectiveness of the intervention. However, in this sample, poorer coverage of vaccination and deworming did not affect the nutritional status of participating children. Other researchers indicate that academic achievement is poorer among children infected with soil-transmitted helminths.[18] Stunting is associated with poorer cognitive development.[19] However, regularly treating children with deworming medications does not appear to improve weight, height, stunting prevalence, school performance, iron status or mortality outcomes.[20,21] Water, sanitation and hygiene (WaSH) strategies, including improved sanitation, wearing shoes, washing hands before eating and after defaecating, could instead be prioritised as long-term interventions to prevent helminth infestation and associated negative outcomes, as frequent re-infection may undermine chemotherapeutic strategies to address soil-transmitted helminths.[22]

Since 2003, basic staple foods have been fortified with vitamin A in SA.[23] Faber *et al*.[24] found that fortified bread and maize products contributed to the majority of vitamin A

Table 1. Vitamin A, deworming, vaccination and birthweight categories for anthropometrical indicators of nutritional status

Nutrition variable	Vitamin A	*n*	Mean (SD)	Difference	*t*	*df*	*p*-value
WAZ	Up to date	513	-0.01 (1.12)	0.036	0.458	833	0.647
	Delayed	322	-0.05 (1.075)				
HAZ	Up to date	514	-0.815 (1.14)	0.019	0.244	834	0.807
	Delayed	322	-0.834 (1.041)				
WHZ	Up to date	513	0.652 (1.17)	0.025	0.313	833	0.754
	Delayed	322	0.625 (1.16)				
Nutrition variable	**Deworming**	***n***	**Mean (SD)**	**Difference**	***t***	***df***	***p*-value**
WAZ	Up to date	337	0.16 (1.09)	0.119	1.242	556	0.215
	Delayed	221	0.04 (1.13)				
HAZ	Up to date	337	-0.743 (1.17)	0.033	-0.341	556	0.733
	Delayed	221	-0.77 (1.11)				
WHZ	Up to date	337	0.843 (1.11)	0.119	1.2	556	0.231
	Delayed	221	0.723 (1.21)				
Nutrition variable	**Vaccinations**	***n***	**Mean (SD)**	**Difference**	***t***	***df***	***p*-value**
WAZ	Up to date	723	-0.0427 (1.11)	-0.065	-0.588	837	0.557
	Delayed	116	0.0227 (1.11)				
HAZ	Up to date	724	-0.826 (1.11)	0.0265	0.240	838	0.810
	Delayed	116	-0.852 (0.99)				
WHZ	Up to date	723	0.6284 (1.16)	-0.0938	-0.799	837	0.424
	Delayed	116	0.722 (1.24)				
Nutrition variable	**Birthweight**	***n***	**Mean (SD)**	**Difference**	***t***	***df***	***p*-value**
WAZ	LBW	170	-0.635 (1.13)	-0.857	-9.150	1 207	<0.001
	NBW	1 039	0.222 (1.13)				
HAZ	LBW	170	-1.44 (1.19)	-0.917	-9.582	1 208	<0.001
	NBW	1 040	-0.535 (1.16)				
WHZ	LBW	170	0.325 (1.29)	-0.424	-4.301	1 207	<0.001
	LBW	1 039	0.749 (1.17)				

SD = standard deviation; WAZ = weight-for-age *z*-scores; HAZ = height-for-age *z*-scores; WHZ = weight-for-height *z*-scores; LBW = low birthweight; NBW = normal birthweight.

Table 2. Binomial regression analysis of stunting risk for low-birthweight children at any age, 12 months and 48 months

Risk factor	OR	95% CI	*p*-value
Stunted at follow-up (any age) (*n*=1 223)			
Low birthweight†	4.658	3.132 - 6.927	<0.001*
Stunted at <12 months (*n*=261)			
Low birthweight†	29.318	10.542 - 81.534	<0.001*
Stunted at >48 months (*n*=299)			
Low birthweight†	0.911	0.257 - 3.226	0.885

OR = odds ratio; CI = confidence interval.
*Statistically significant at $p<0.05$.
†Reference category is normal birthweight.

Table 3. Multinomial regression analysis for stunting risk (*n*=530)

Risk factor	OR	95% CI	*p*-value
Deworming delayed†	1.601	0.766 - 3.344	0.211
Vitamin A delayed‡	1.223	0.577 - 2.593	0.600
Vaccinations delayed§	1.081	0.415 - 2.499	0.969
Low birthweight¶	5.603	2.987 - 10.512	<0.001*
Male sex‖	1.668	0.964 - 2.867	0.067

OR = odds ratio; CI = confidence interval.
*Statistically significant at $p<0.05$.
†Reference category deworming up to date.
‡Reference category vitamin A up to date.
§Reference category vaccinations up to date.
¶Reference category normal birthweight.
‖Reference category female sex.

intake in urban children in SA and that while vitamin A supplementation rates were poor, the prevalence of vitamin A deficiency was lower in urban areas compared with national estimates. Therefore, the value of high-dose vitamin A supplementation may be reduced in urban environments in the context of higher intakes of vitamin A-fortified staple foods. This may in part explain why no associations could be demonstrated between poor vitamin A coverage and a compromised nutritional status.

Previous research from this community revealed that access to child support grants and household food security are associated with stunting risk until LBW is considered as a co-factor.[11] When LBW was considered, food security and access to grants were no longer significantly associated with anthropometrical indicators of nutritional status in children. In the current study, significant differences in WAZ, HAZ and WHZ were observed for LBW children compared with those with a normal birthweight, and children with LBW were at an increased risk of stunting. Children with an LBW were more likely to have a HAZ

<-2 in the first 12 months of life, but children with an LBW in older age categories were not significantly more at risk of stunting, which suggests that children with LBW may eventually experience catch-up growth. However, the reasons for this recovery were not accounted for in the present study. The results of the multinomial regression analysis indicate that gender, delayed vitamin A, delayed deworming and delayed vaccinations are not associated with stunting risk, but LBW is a significant risk factor for stunting. There was no evidence that delayed vitamin A, deworming and vaccinations contributed to stunting and wasting in this sample, and that LBW was likely to be corrected without these interventions. Longitudinal evidence from India shows that childhood immunisations are associated with recovery from stunting between 5 and 8 years of age.[25] Faye *et al*.[8] found that timely child immunisation along with age at stunting, household economic status and mother's parity were among the factors associated with recovery from stunting before a child's fifth birthday in Kenya.

Data were collected from children attending crèches and therefore the results cannot be generalised to the wider population. The study used a cross-sectional design, which is not ideal for describing the factors associated with the dynamic growth patterns in children. Data on vitamin A, deworming and vaccination history were limited to the last dose and did not account for the full vitamin A, deworming and vaccination history. It was not investigated whether children in this sample with delayed deworming were infected with soil-transmitted helminths. Data were not collected on potential confounding factors, including HIV and other illnesses. Morbidity and mortality were not assessed in this study, limiting the interpretations of the effectiveness of vitamin A, deworming and vaccinations regarding their effects on anthropometrical status. Birthweight was recorded but not gestational age; therefore, no distinction was made between LBW and children born prematurely. This study made use of gold-standard anthropometrical methods for data collection.

Conclusion

Coverage of vitamin A and deworming but not immunisations was poor among children in this population. One-third of children had missed vitamin A or deworming treatment. The National Department of Health should invest in strategies to improve coverage of these interventions. History of delayed vitamin A, deworming and vaccinations was not associated with anthropometrical status of children. LBW was the only factor significantly associated with stunting risk. Children with LBW should be considered for more rigorous follow-up, as they are at higher risk of stunting.

Declaration. None.

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Conflicts of interest. None.

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