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HEALTH STAFF UNDERSTANDING, APPLICATION, AND INTERPRETATION OF GROWTH CHARTS IN NIGERIA

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CMW conceived the study design and ANM piloted and developed this further. IOE adapted the design for use in this study, created the questionnaire, collected the data, undertook the initial analyses, and produced the first draft of the paper. CMW and ALG helped plan the study and supervised the analyses. SNI supervised data collection in Nigeria. CMW undertook further analyses and drafting of the paper. All authors contributed to successive drafts, and have approved the final draft.

Abstract

We aimed to compare plotting accuracy and interpretation of weight gain patterns in average and small infants on Road-to-Health (RTH) and the new WHO growth charts in Enugu, Nigeria. Child health staff plotted standard weights on both formats. Twelve plotted charts were created, permutating 3 different weight trajectories (fast, steady, slow) ending at two attained weights (average, small), with each plotted on both chart formats. Respondents were shown four of these charts and asked to describe the weight gain pattern shown and what action this pattern would prompt. There were 222 respondents, of whom 78% were hospital-based; 54% were nurses, 32% medical doctors, and 13% nutritionists. Plotting accuracy was good on both the WHO and RTH charts, but rating of weight gain was generally poor. On the RTH chart, slow weight gain was correctly recognised in only 19% average and 35% small infants and responses were not significantly associated with the pattern shown. On the WHO charts, slow weight gain was correctly recognised in 40% average and 65% small infants ($p=0.002$ and <0.001), but they were also more likely to rate small children with normal growth as slow weight gain. In a logistic regression model, final weight predicted a slow weight gain rating more strongly (OR=2.4; 1.8 to 3.2) than an actual slow weight gain pattern (OR 1.8; 1.1 to 1.6). Health staff seemed unable to recognize slow weight gain and were influenced more by current weight than actual weight gain pattern, though the new WHO format improved recognition.

Key words: growth monitoring, undernutrition, health professional, infant, anthropometry, Nigeria

Key Messages

- Health staff mainly plotted charts accurately but seemed unable to interpret weight trajectory
- Slow weight gain was better recognised on the new WHO chart format than the RTH chart
- Interpretations were more strongly influenced by the child's current weight than the weight gain pattern

Introduction

Growth is an important indicator of child health, nutritional status, and overall well-being (Tanner, 1976). In early infancy, growth is rapid and disturbances in health and feeding soon result in undernutrition. Growth monitoring is therefore undertaken universally during infancy with the use of growth charts which provide a visual representation of child growth (Ashworth, Shrimpton, & Jamil, 2008). The effectiveness of growth charts in the diagnosis of undernutrition is dependent on how well they are plotted and interpreted. Health staff must therefore know how to plot charts accurately and interpret the growth patterns displayed (Sachs, Dykes, & Carter, 2006).

Several studies have suggested that health practitioners' skills in plotting, application and interpretation of growth patterns are ineffective. Ruel found that health staff in Lesotho had poor knowledge and skills in growth chart use (Ruel et al., 1991), and a survey of experienced primary care nurses found they had poor knowledge of growth monitoring (Kitenge & Govender, 2014). A study in community clinics in Kenya found substantial age and weight plotting inaccuracies (Mutoro & Wright, 2013). Furthermore, a study in Somalia found misclassification and underestimation of undernutrition in infants among maternal and child health clinic workers (Qayad, 2005).

Potentially the most challenging aspect of chart use is interpreting the weight gain trajectory. A UK survey found that less than two-thirds of the paediatricians felt competent in detecting abnormal growth (Wallace & Kosmala-Anderson, 2006) and a multi-country survey by the WHO multi centre growth reference study (MGRS) found that difficulty in interpreting the child's growth curves was the commonest problem encountered (de Onis, Wijnhoven, & Onyango, 2004). However, little research on interpretation of plotting has been done in countries with higher prevalence of undernutrition.

The Road-to-Health (RTH) growth chart is a simple, parent-held chart which is still widely used in developing countries and is usually included in cards that also act as mobile databanks, with relevant records on the child's important health events (Tarwa & de Villiers, 2007). This chart shows only two weight reference curves, based on the US NCHS reference, the 50th and the 3rd centile (Figure 1A, 2A). The space between the two curves is deemed the "road to health" zone of normality for most children in the population. Although the RTH charts are widely used for growth monitoring in Nigeria, there is little information on how well child health professionals plot and interpret them.

Since 2006, many countries have adopted the WHO growth standard and charts (WHO Multicentre Growth Reference Study Group & de Onis, 2006). Recognition of the deficiency of previous formats guided the construction of the new WHO charts (de Onis et al., 2004) which show 5 centiles or z score lines (Figures 1B, 2B) and their implementation is supported by standardised training programmes. Although the validity of these new charts has been explored, the extent to which health practitioners understand them and can use them effectively is not clear. The layout and format of the chart may be important; a study in the UK demonstrated that changing the chart format improved the precision of judgment made about slow weight gain in infancy (Wright, Avery, Epstein, Birks, & Croft, 1998).

The prevalence of undernutrition in Nigerian infants and children is still high, particularly in the rural areas: undernutrition (based on z-scores below -2 for weight-for-age, length-for-age, and body-mass-index-for-age) was found to be prevalent (13.8% of underweight, 30.8% for stunting and 10.0% for wasting) in the first three months of life (Olusanya, Wirz, & Renner, 2010). While detecting true undernutrition is important, misinterpretation of normal growth patterns as abnormal in children below 6 months also risk as it can interfere with exclusive breastfeeding (Ahmad et al., 2014). Therefore, as part

of a programme of work on weight gain and undernutrition in infants under 6 months, we set out to test:

- plotting accuracy on RTH charts compared to the new WHO format growth charts
- how well different growth patterns are recognised on the two formats
- the hypothesis that the final weight shown on a chart was more influential than the actual weight trajectory in determining the recognition of slow weight gain.

Method

This cross-sectional, observational study was conducted in two teaching hospitals and the four largest government-owned health centres in Enugu city, Nigeria, from February to July 2012. All medical doctors, dietitians/nutritionists, nursing officers, and community medical staff actively involved in growth monitoring and working in these centres were invited to take part. Recruitment took place at the teaching hospitals' during weekly paediatric mortality conferences as well as child health clinics in health centres. Ethical approval was obtained from the College of Medicine Ethics Committee at the University of Glasgow and the Medical Research Ethics Committee of the University of Nigeria Teaching Hospital (UNTH), Enugu.

A structured self-completion questionnaire adapted from a previous pilot study in Kenya (Mutoro, 2011) was used for data collection. The first sections contained questions about how often respondents plotted and interpreted charts and used them to identifying or treat undernutrition. This was followed by plotting exercises on the RTH and WHO charts using the following weight data:

1) Age of 2 months with a weight of 4.7 kg
2) Age of 4 months with a weight of 5.9 kg
3) Age of 6 months with a weight of 7.5 kg

In the last section, respondents were asked to interpret growth patterns presented on RTH and WHO charts, designed to allow the influence of weight trajectory to be considered independently of final weight and chart type. Twelve plotted charts were created that permutated 3 different weight trajectories (fast, steady, slow) ending at two attained weights (average, small). Each of these was plotted on both chart formats (see Figures 1 and 2). These were then presented in 3 versions of the questionnaire (as shown in supplementary table)

handed out to respondents in strict rotation, with no respondent viewing the same growth pattern more than once plotted on either chart format.

For each chart, respondents were asked to assess the weight pattern shown on a 5 point scale, from very slow (1) to very rapid (5) and specify their next step out of three options:

1) Not worried, reduce level of care/continue current care
2) Monitor more closely
3) Refer out /offer further assessment

SPSS version 22 was used for the analysis. For the plotting exercise each individual plot was checked for accuracy of both plotted age and weight. Each was coded as incorrect if they were more than 200 g or 0.2 month away from the true value and the difference from the true value was recorded. The total number of correct plots per respondent was then summed. For the chart interpretation, the unit of measurement was the chart rating not the respondent. The four rated charts were extracted in to a per-chart data file including information about each scenario and the respondent, with one line per scenario response. The researcher received the impression that not all staff members were taking the survey seriously, so possible 'gaming' of the ratings was investigated by comparing responses within individual respondents. If exactly the same rating was given to all 4 charts presented, that respondent's ratings were classified as invalid.

Logistic regression was used to determine independent effects of the three factors (size, weight gain and chart type) on rating as slow weight gain or clinical concern (further monitoring or referral out). The ratings of weight gain patterns and proposed actions were re-coded by interpretation accuracy (correct or incorrect) for the individual scenarios and combined to give a 3 category summary (both incorrect, one correct, both correct) which was used to compare overall interpretation accuracy between professional subgroups (Table 2).

Results

Out of the 233 staff approached, (222, 95%) completed the questionnaire. Most (172, 78%) worked in hospitals, 121 (54%) were nurses 72 (32%) were medical doctors and 29 (13%) dietitians/nutritionists. Nearly half (102, 45.9%) had more than 10 years, 59 (27%) had 5-10 years and 61 (28%) less than 5 years of experience. Most respondents (195; 88%) often interpreted charts, but only a third (71, 32%) often plotted them. Half the respondents often diagnosed (112, 50.5%) or treated undernutrition (113, 50.9%), and 197 (88.7%) felt confident in the use of charts.

Most of the respondents plotted charts accurately, but mistakes were least common on the WHO chart than the RTH chart (Table 1). Although mistakes were rare, in some instances they were substantial, with age plots as high as 5 months and two kilograms from the true value. There was no difference in accuracy by facility type (hospital or health centre). Plotting errors were however more common among doctors (51, 71%) and dietitians (20, 69%) than nurses (57, 47%; p=0.002). Staff with more than 10 years' experience tended to make more mistakes than those with less experience, especially when plotting age [34 (33%) versus (17%) p=0.004].

Each respondent rated 4 charts, yielding 888 chart ratings. Eight respondents gave the same rating to all 4 charts presented to them suggesting that they were not cooperating with the experiment ("gaming") and their ratings were excluded, which left 856 ratings, with 68-74 ratings per permutation. On the RTH, chart respondents rated only between 19-35% charts correctly and the concordance of their responses and the true patterns shown was so poor that this did not achieve statistical significance (p=0.097, p=0.180; see Table 2). Only a minority of respondents felt the slow weight gain pattern merited referral or closer monitoring. On the WHO charts, slow weight gain was generally better recognised, though this was still more

likely in a small (65%) than an average (40%) infants, and recognition of fast weight gain was still weak.

Respondents were twice as likely to correctly recognise slow weight gain on the WHO as on the RTH charts, but were also slightly more likely to incorrectly rate small children with normal growth as slow weight gain when plotted on the WHO chart format (Table 3). In small children respondents were twice as likely to correctly recognise the need for clinical action when plotted on WHO format and also slightly more likely to incorrectly propose further action in children with healthy weight gain, but for average children there was no difference between chart types (Table 3).

In a binary logistic regression model, into which final weight, weight gain pattern and chart type were all entered, the respondents were twice as likely to rate weight gain as slow or have clinical concern on the WHO chart type as the RTH. Small final size was a stronger predictor of whether a pattern was rated as slow weight gain than the actual weight gain pattern shown. For clinical concern, the actual pattern was the strongest predictor, but small size was also strongly predictive (Table 4).

Using the summary interpretation measure 213 (24.9%) charts were rated wrongly for weight gain and proposed actions (both incorrect), 299 (34.9%) were both correct while 344 (40.8%) were part correct. This was not related to the type of health facility or profession, but 40.8% of charts rated by less experienced staff (<5 years) were both correct compared to 36.4% for 5-10 years and 30.4% for >10years (χ^2 trend p=0.023).

Discussion

This study set out to assess plotting and interpretation accuracy on the RTH and the new WHO charts among health staff in Nigeria. The use of a factorial permutated design allowed us to consider how much the previous weight gain pattern and chart type modified judgements compared to the current weight of the infant. Overall, there was poor recognition of weight gain patterns on both charts but the recognition of slow weight gain was more accurate on the WHO charts. Health staff depended more on final weight rather than growth trajectory in determining future management.

The accurate plotting of growth charts appears to be a challenge, as high levels of inaccuracy have been reported by other studies (Cooney, Pathak, & Watson, 1994; de Onis et al., 2004). Our earlier study, using the same plotting exercise with primary care staff in Kenya found that weight was often plotted well above the true level, which might reflect an unconscious wish to present a child's growth positively(Mutoro & Wright, 2013). Charlton and colleagues also reported poor plotting accuracy in Zambia, but reported that this was greatly improved by training (Charlton, Kawana, & Hendricks, 2009). It is not clear if the better plotting in the current study relates to a different health care system or the fact that most of this sample were hospital staff, who were possibly better trained. Overall, the respondents tended to plot the ages and weights best on the RTH, probably due to familiarity, since the RTH was in use Nigeria at the time of data collection. Plotting was more accurate on the RTH charts and among nurses and less experienced staff. The possible reason for this unexpected finding is that the less experienced health staff would have been more recently trained with more-up-to-date robust training materials (for example the WHO training materials) and the more experienced health staff tend to be less clinically active. This suggests the need for health staff continuing professional development, particularly with

increase in years of service, to avoid redundancy in healthcare practice resulting from getting more involved in administrative duties.

The interpretation of growth patterns displayed on charts is difficult even for postgraduate doctors and is expected to pose a technical challenge for health care workers as well (Morley, 1994). Similar to our findings, poor understanding of the weight trend has been previously described, but testing the use and understanding of growth charts in clinical settings is challenging. Standardised chart plotting and interpretation exercises are therefore more practical, but these exercises need to be valid and, most importantly, relevant for clinical management.

In Malawi, a randomized cross over study assessed health staff response to the plotted chart of a small but clinically well infant aged below 6 months using both WHO and NCHS growth standards. Health staff were significantly more concerned about the infant when looking at the WHO charts than NCHS standards and this made them more likely to interfere with exclusive breastfeeding, particularly the less experienced staff (Ahmad et al., 2014). Ahmad demonstrated that, similar to our findings, health workers did not consider the growth trend when assessing infants (Ahmad et al., 2014). However, that study presented only one normal growth pattern in a small child. One of the strengths of our study is the use of multiple plotted examples of growth patterns in infants, including ones who would be a cause for concern, rather than clear cases where the centile was very low, or there was obvious weight loss. However, this may have meant that the charts did not have enough relevance for the hospital staff surveyed, as they did not show the severe patterns commonly seen. Another strength of this study was its large scale and the range of staff taking part, but a limitation was that only a minority were working in primary care, where growth charts are commonly used for surveillance. This was largely pragmatic - based on the existing local

clinical connections - but the group surveyed did, by their own account, assess nutritional status and used charts a lot and no difference was found between these two categories of staff either in their plotting or in interpretation. The patterns shown were in very young infants who are rarely admitted to nutrition programmes, which may also be why respondents tended not to recognise the need for follow up in an infant with slow weight gain.

In the current study, the ratings of weight gain were strikingly inaccurate. One possible explanation for this was poor cooperation. The questionnaire was quite long and the chart ratings came after respondents had already undertaken the plotting exercise. This was clearly identified in eight respondents who gave the same rating to all four charts presented to them, but there may have been others who just entered random arbitrary responses. However, this could not have been the case for all, because the accuracy of ratings was consistently better on the WHO charts, which were viewed last.

A higher proportion of staff recognised the need for further intervention when looking at the WHO chart. This may reflect the benefit of a clearer chart format. The RTH shows only the 50th centile and below, which sets an intrinsically low standard for 'normality'. In contrast, the WHO format shows the full normal range. However, it should also be taken into consideration that under 6 months the same weights plotted on the WHO charts will appear to be on a lower centile than when plotted on the RTH charts (see figures 1 and 2). This reflects the fact that the NCHS reference, on which the RTH is based, under-represented healthy weight gain in the first weeks of life as it was based on bottle fed infants (Whitehead, Paul, & Cole, 1989). Thus the RTH chart will always tend to offer false reassurance about small infants. The WHO chart was much more likely to lead to correct recognition of slow weight gain, but also, in small children more likely to lead to the mislabelling of children with healthy weight gain, as was seen in the paper describe earlier(Ahmad et al., 2014). However,

even for small, weight-faltering infants plotted on the WHO chart, less than half of the respondents recognised the need for closer monitoring or referral. This is in accordance with the WHO MGRS multi-country survey which found that while charts were widely used, only a minority of health facilities reported that their staff responded to chart abnormalities by closer follow-up of growth performance or investigation of the causes of growth faltering (de Onis et al., 2004).

The permutated design clearly illustrated that small infants generated more anxiety than average sized infants, even when growing well, and that size was more influential on rating a chart as slow weight gain than the actual weight gain trajectory. This suggests that health staff either fail to consider the previous growth pattern, or do not understand its significance. In settings with few resources and high levels of malnutrition, not considering the previous trajectory will rarely make any difference as the most recent weight will be by far the best predictor of future risk (Bairagi, Koenig, & Mazumder, 1993; Briend & Bari, 1989). However, as the prevalence of severe malnutrition falls with demographic transition, more sophisticated approaches, such as trajectory will become important. There will be a need to identify less obvious cases, such as a child dropping through the normal range, but not yet below it and in small but healthy children, misinterpretation of growth patterns in children below 6 months can increase inappropriate referrals and risk of offering feeding advice that could interrupt exclusive breastfeeding. (Ahmad et al., 2014).

Conclusions

These findings suggest that implementation of the WHO 2006 growth charts might enhance recognition of slow weight gain patterns. However, the interpretation of weights plotted over time is still very poor and more research is needed to develop effective training strategies, if charts are to be used effectively. For example, pre-service training on plotting and interpreting growth measures, with supportive supervision to reinforce effective use of acquired skills. In addition, a significant barrier to effective use of growth charts is lack of appropriate policy. towards periodic quality training for health staff on growth monitoring.

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Figure 1

Example of a plotted chart for slow weight gain in a small-sized infant shown on (A) RTH and (B) WHO growth charts and in an average-sized infant shown on (C) RTH and (D) WHO growth charts

Figure 2

The six weight gain patterns used in the questionnaire

Table 1

Accuracy of age and weight plotting on both the Road-to-Health (RTH) and World Health Organisation (WHO) charts

	RTH Chart (N, %)			WHO Chart (N, %)			
Plotting category	**Below true value**	**All correct plotting**	**Above true value**	**Below true value**	**All correct plotting**	**Above true value**	**Chi^2 P-value**
Age (months)							
2	8 (3.6)	203 (91.4)	11 (5.0)	6 (2.7)	207 (93.2)	9 (4.1)	1.00
4	10 (4.5)	201 (90.5)	11 (5.0)	7 (3.2)	206 (92.8)	9 (4.1)	0.87
6	6 (2.7)	201 (90.5)	15 (6.8)	8 (3.6)	200 (90.1)	14 (6.3)	0.66
All correct	190 (85.6)			187 (84.2)			0.42
Weight (kg)							
4.7	7 (3.2)	212 (95.5)	3 (1.4)	23 (10.4)	188 (84.7)	11 (5.0)	0.25
5.9	21 (9.5)	199 (89.6)	2 (0.9)	29 (13.1)	190 (85.6)	3 (1.4)	0.30
7.5	2 (0.9)	216 (97.3)	4 (1.8)	18 (8.1)	186 (83.8)	18 (8.1)	0.77
All correct	189 (85.1)			162 (73.0)			<0.001

Table 2

How ratings of chart patterns related to actual weight gain patterns shown to respondents (*Values in* ***bold*** *are correct answers)*

	Actual pattern shown			**Respondent description of weight gain pattern (% within each pattern shown)**				**% who would monitor more / refer out**	
Chart type	**Final size on chart**	**Growth pattern on chart**	**Number of ratings**	**Slow**	**Steady**	**Fast**	**P***		**P***
RTH	Small	Slow	74	**35.1**	36.5	28.4	0.58	**23.0**	0.07
		Steady	74	24.3	**36.5**	39.2		14.9	
		Fast	68	32.4	50.0	**17.6**		11.8	
	Average	Slow	68	**19.1**	32.4	48.5	0.17	**19.1**	0.03
		Steady	72	20.8	**37.5**	41.7		12.5	
		Fast	72	6.9	40.3	**52.8**		6.9	
WHO	Small	Slow	68	**64.7**	27.9	7.4	0.046	**45.6**	0.09
		Steady	68	32.4	**30.9**	36.8		16.2	
		Fast	72	52.8	23.6	23.6		31.9	
	Average	Slow	72	**40.3**	27.8	31.9	<0.001	**23.6**	0.002
		Steady	74	29.7	**39.2**	31.1		13.5	
		Fast	74	14.9	29.7	**55.4**		5.4	

*Chi^2 trend

Table 3

Percentage of charts rated correctly as slow or normal weight gain or requiring further action, broken down by final size and chart type

Final size on chart	Weight gain	Number of charts rated	% rated as slow weight gain			% Requiring further action		
			RTH chart	WHO chart	P	RTH chart	WHO chart	P
Small	Slow	142	35.1	64.7	0.001	23.0	45.6	0.005
	Normal	282	71.8	57.1	0.013	86.6	75.7	0.014
Average	Slow	140	19.1	40.3	0.009	19.1	23.6	0.33
	Normal	292	86.1	77.7	0.069	90.3	90.5	0.55

Table 4

Results of logistic regression of the mutually adjusted predictive effect of size, weight gain and chart type on: Model A: rating as slow weight gain and Model B: clinical concern (further monitoring or referral out)

		A: Rating as slow weight gain		B: Clinical concern	
Chart feature		Odds ratio	95% confidence intervals	Odds ratio	95% confidence intervals
Final weight	Average	Reference		Reference	
	Small	2.51	1.84 - 3.41	2.08	1.45 – 2.99
	P	<0.001		<0.001	
Actual weight gain	Steady/rapid	Reference		Reference	
	Slow	1.89	1.38 - 2.59	2.38	1.67 – 3.4
	P	0.001		<0.001	
Chart type	RTH	Reference		Reference	
	WHO	2.26	1.66 -3.06	1.75	1.22 – 2.51
	P	<0.001		0.002	