



**Chapter 3**  
*How big is the problem?*

# Chapter 3: How big is the problem?

This chapter assesses the global burden of acute malnutrition in infants <6m. It summarises the analysis of country level datasets and examines the potential impact of a transition from the use of the National Centre for Health Statistics Child Growth Reference (NCHS) to the 2006 WHO growth standards (WHO-GS).

## 3.1 Why population burden of disease matters

Well defined disease burden epidemiology is important. If poorly defined, populations risk being marginalised. This chapter addresses a prevailing assumption that malnutrition in infants <6m is uncommon relative to older age groups.<sup>96</sup> The 1995 WHO 'Field Guide to Nutrition Assessment', for example, states that "children under 6 months of age, apart from being more difficult to measure, are often still breast-fed and therefore satisfactorily nourished".<sup>97</sup> These notions lead to the exclusion of infants <6m in many nutrition surveys.<sup>98,99</sup> Yet without population data, effectively tackling infant <6m malnutrition is difficult. Programmes will not know whether actual admissions reflect community disease burden, which management strategies are most appropriate and the extent of public health impact.

Efforts to improve understanding of the epidemiology of acute malnutrition in infants <6m are therefore critical. This includes estimating the potential impact of recent changes in case definitions (see Section 2.4.2). Studies examining the 2006 WHO growth standards (WHO-GS) for diagnosing wasting in children consistently show greater numbers labelled as wasted than with old NCHS references.<sup>100,101,102</sup> A recent international consultation reviewed and endorsed the use of WHO-GS for selective feeding programmes<sup>103</sup> but did not address infants <6m. This chapter includes an assessment of the effect of WHO-GS-based diagnosis in this area. Key policy and research implications of findings are discussed.

## 3.2 Aims

This chapter aims to:

- Describe the prevalence of wasting amongst infant <6m in nutritionally vulnerable settings
- Examine how new case definitions based on WHO-GS affect the burden of disease
- Explore key characteristics of wasted infants <6m

Wasting (weight-for-height <-2 z-scores) was described rather than global acute malnutrition (weight-for-height <-2z and/or bilateral oedema) since analysis was conducted on Demographic & Health Survey (DHS) datasets that do not gather data on oedematous malnutrition.

## 3.3 Methods of determining population burden of disease

### 3.3.1 Study design, setting and population

Secondary analysis was conducted of 21 DHS country datasets.<sup>104</sup> Datasets were selected from a reference population of 36 countries identified in the 2008 Lancet 'Maternal and Child Undernutrition' series as accounting for over 90% of global malnutrition.<sup>105</sup> The 21 datasets selected were those with available anthropometric data collected in the last ten years and those considered representative of nutritionally vulnerable populations. Data were available for a total of 163,228 children 0 to 59 months (mean 7,773 per country; range 1,710 to 45,398) and included 15,534 infants <6m.

### 3.3.2 Data handling

Permission to download DHS datasets was obtained from <http://www.measuredhs.com/accesssurveys/search/start.cfm>. Data management and main analyses used SPSSv.15 (© SPSS Inc USA). Weight for height Z scores (WHZ) (using both NCHS references and WHO-GS), were calculated from weight, height/length, sex and age using ENA for SMART software (version October 2007).<sup>106</sup> Cases with extreme values were cleaned according to standard criteria.<sup>107</sup> These exclude individuals with:

- Weight-for-height z-score (WHZ) WHZ (NCHS) <-4 or > +6 or
- Weight-for-age z-score (WAZ) WAZ (NCHS) <-6 or >+6 or
- Height-for-age z-score (HAZ) HAZ (NCHS) <-6 or >+6 or
- Incompatible combinations of HAZ & WHZ (HAZ >3.09 and WHZ <-3.09) or (HAZ <-3.09 and WHZ >3.09)

To ensure a balanced comparison, if a child's z-scores were valid by these NCHS criteria, then the same child's WHZ(WHO) was considered valid.

### 3.3.3 Data analysis

Prevalence of malnutrition was described by wasting using standard criteria applied to both NCHS and WHO-GS:

- Wasting = WHZ <-2,
- Severe wasting = WHZ <-3
- Moderate wasting = WHZ  $\geq$ -3 to <-2

Four major analyses examined age-specific effects:

- a) Prevalence of wasting by country:** To aid analysis, countries were classified using the internationally recognised 'Integrated Food Security Phase Classification' (IPC).<sup>108</sup> IPC considers food security, nutrition and livelihood information to determine the severity of an emergency and guide the need for interventions. It considers >3% to <10% prevalence of acute malnutrition as moderately food insecure; 10-15% as an acute food and livelihood crisis; >15% as a humanitarian emergency; >30% as famine/humanitarian catastrophe. We emphasize that IPC is not normally applied to single age groups, nor to anthropometric indicators alone; it serves here only to illustrate the relative magnitudes of infant/child and NCHS/WHO differences.
- b) Changes in country prevalence of wasting using WHO-GS:** Change in prevalence of moderate and severe wasting using the WHO-GS v NCHS was examined using scatter plots and simple linear regression.
- c) Caseload implications for treatment programmes:** Any changes in clinical caseloads of infant <6m and children in selective feeding programmes using NCHS v WHO-GS were investigated. For our analysis, we assumed that all eligible patients would be identified and appropriately admitted.
- d) Characteristics of wasted infants <6m:** Preliminary analysis was undertaken of key characteristics of wasted infants <6m with reference to other variables available in the DHS datasets but detailed analysis was beyond the scope of the MAMI Project. As a priority this should be explored in more detail in future work.

Data is presented for all wasted children rather than by country. The focus is on severe wasting, since mortality and morbidity risks are highest in this group.

Z-score wasting cut-offs are graphically compared for different age groups using NCHS and WHO growth norms. Reference data were derived from published NCHS<sup>109</sup> and WHO tables.<sup>110</sup> The length range of 49.0 cm to 79.0 cm was used for comparison, since 49.0 cm is the lowest length included in the NCHS reference weight for height index, and 79 cm is just above the median for one year old children.

### 3.4 Results

#### 3.4.1 Country prevalence of infant <6m and child wasting: is it an emergency?

Wasting was prevalent in the countries examined, but there were large age-group and inter-country variations (see Figure 9).

Figure 9a shows infant <6m wasting. Countries are ordered by increasing infant <6m wasting prevalence (NCHS). Prevalence is lowest using NCHS growth references. Even so, only 7/21 countries have acceptably low infant <6m wasting prevalence (<3% by the IPC classification). One has prevalence of >15% and is therefore defined a 'humanitarian emergency'. Using WHO-GS for diagnosis, the prevalence of infant <6m wasting increases markedly: only 1/21 countries remain with an acceptably low <3% prevalence and 11/21 are in the 'humanitarian emergency' class.

Figure 9b, shows that NCHS/WHO changes amongst children aged six to 59 months are minimal. With NCHS-based diagnosis, 3/21 countries have a low <3% prevalence of child wasting. Two have a high 'humanitarian emergency' level. Using WHO-GS based diagnosis, the IPC classification of countries does not change.

Figure 9: Country prevalence of wasting (WHZ <-2) as defined by NCHS and WHO-GS

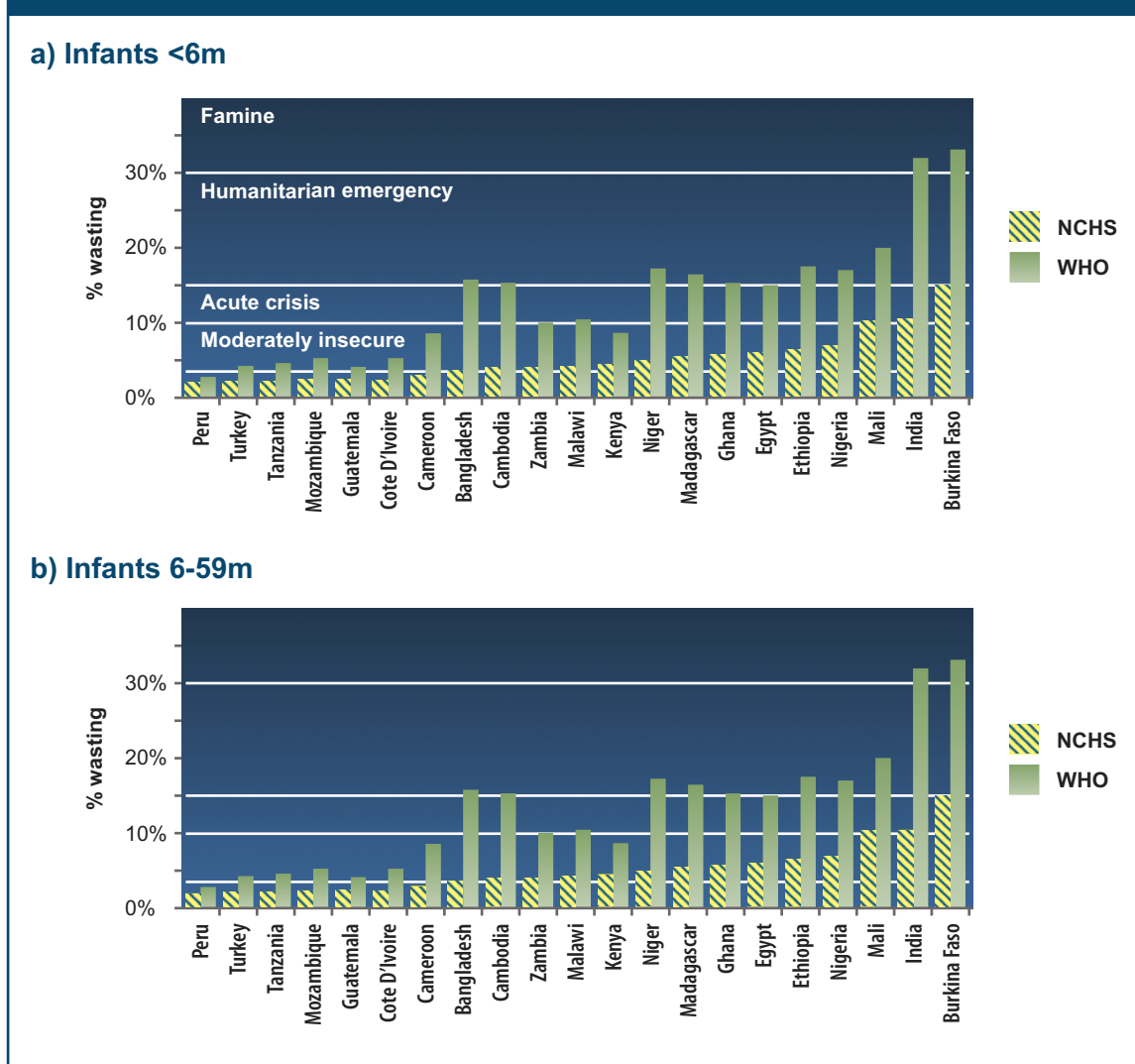


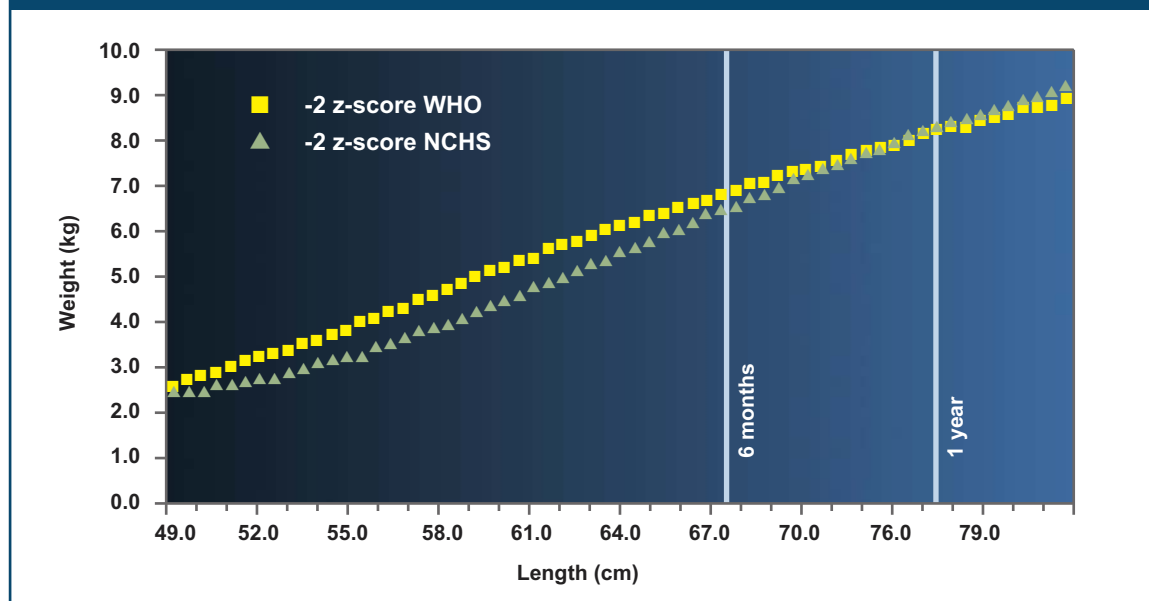
Figure key: NCHS – striped bars, WHO-GS – solid bars.

## 3.4 Results

### 3.4.2 NCHS and WHO 'cut-off curves' defining wasting

Figure 10 helps explain the age related effects seen in Figure 9. Vertical dotted lines show median lengths at age six months and one year for boys. The girl's chart follows a similar pattern and so is not included. For younger, shorter infants <6m, there is a large discrepancy between WHZ-NCHS and WHZ-WHO <-2 cut-off values. WHO-GS cut-off values are consistently higher, increasing the numbers of infant <6m diagnosed as wasted. These differences narrow as infants approach one year of age. The patterns for moderate and severe wasting are similar and are therefore not shown.

Figure 10: Weight cut-offs used to define wasting by either NCHS or WHO-GS criteria (boys)



### 3.4.3 Differences in severe and moderate wasting

Differences in severe and moderate wasting to overall wasting prevalence are shown in two scatter plots (Figures 11a) and 11b). Use of WHO-GS increases the prevalence of severe wasting in both infants <6m and children. The magnitude of increase is consistently greater for infants <6m. Moderate wasting similarly increases in the infant <6m age group. In contrast, prevalence of moderate wasting in children decreases when using WHO-GS.

### 3.4 Results

**Figure 11: Scatter plots of country prevalence (NCHS v WHO) of severe and moderate wasting**

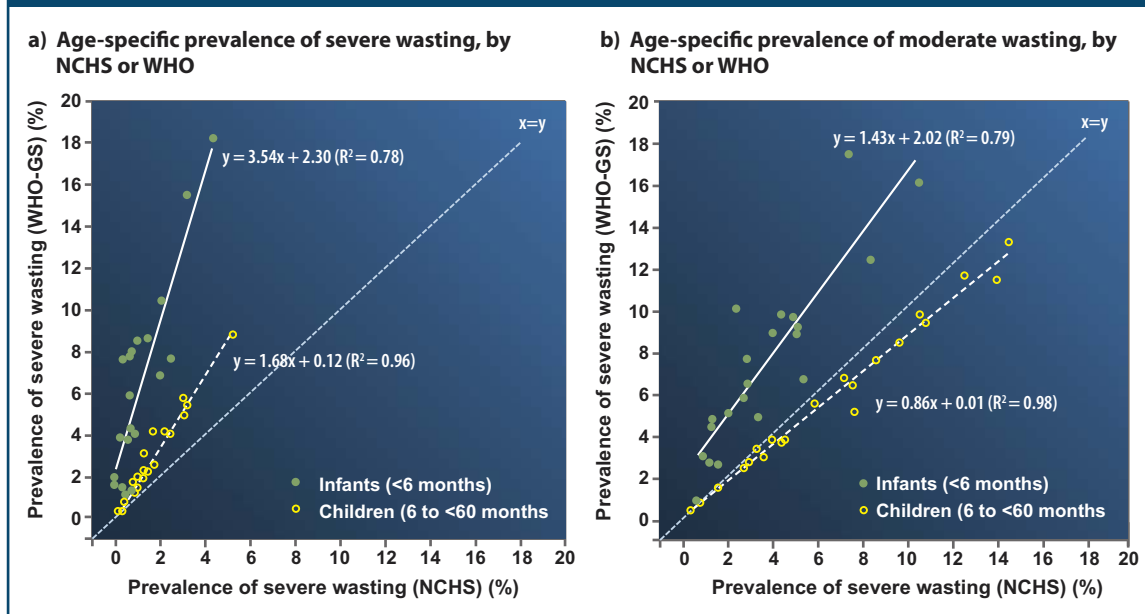


Figure key: Regression and identity lines are shown. Each country survey is represented by one filled and one unfilled circle.

#### 3.4.4 Implications of prevalence changes for treatment programmes

The use of WHZ-WHO-GS rather than WHZ-NCHS to diagnose wasting may be expected to result in large increases in the proportion of therapeutic feeding (TFP) and supplementary feeding programme (SFP) admissions who are infants <6m (see Figure 12). For TFP treatment of severe wasting (Figure 12a), there is not a clear linear trend, but nonetheless, a dramatic upward shift in the percentage of infants <6m who are eligible for admission. For SFP treatment of moderate wasting (Figure 12b) there is a significant trend with an expected increase of 1.59 fold in the percentage of admissions who are infants < 6m.

**Figure 12: Scatter plot on effect of switch from NCHS to WHO-GS on age profile of selective feeding programme admissions**

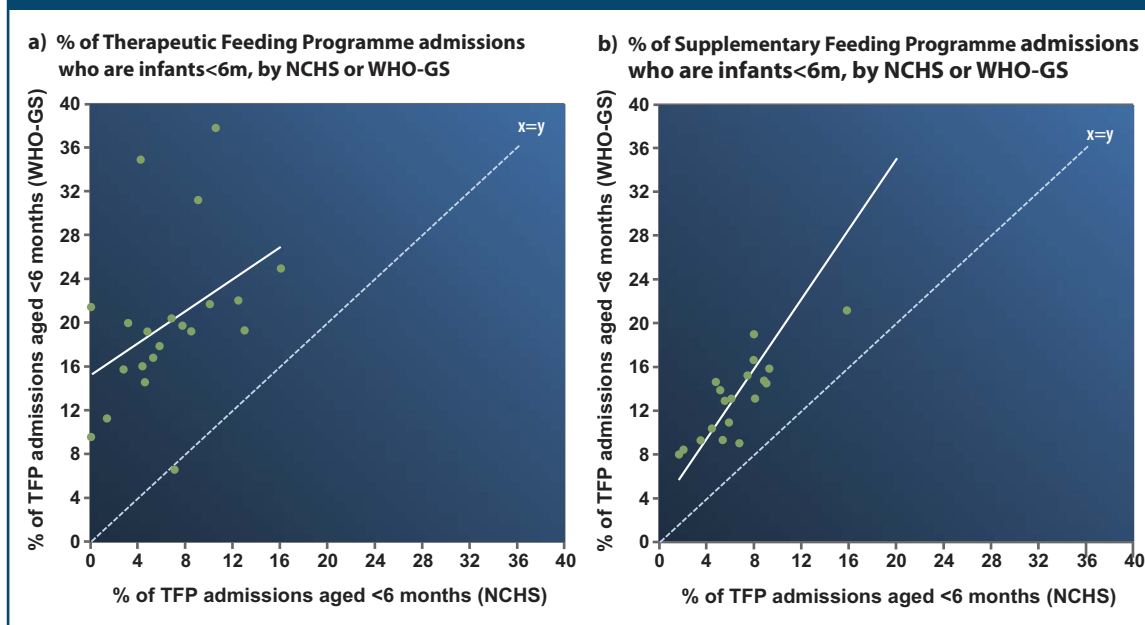


Figure key: Regression and identity lines are shown. Each circle represents one country survey.

### 3.4 Results

#### 3.4.5 Summary of NCHS-WHO regression line equations

Linear regression relationships illustrated in the previous sections are detailed in Table 4. The larger b values, representing the slopes of the regression lines, emphasize that NCHS/WHO z-score changes are greater for the infant <6m group than for children.

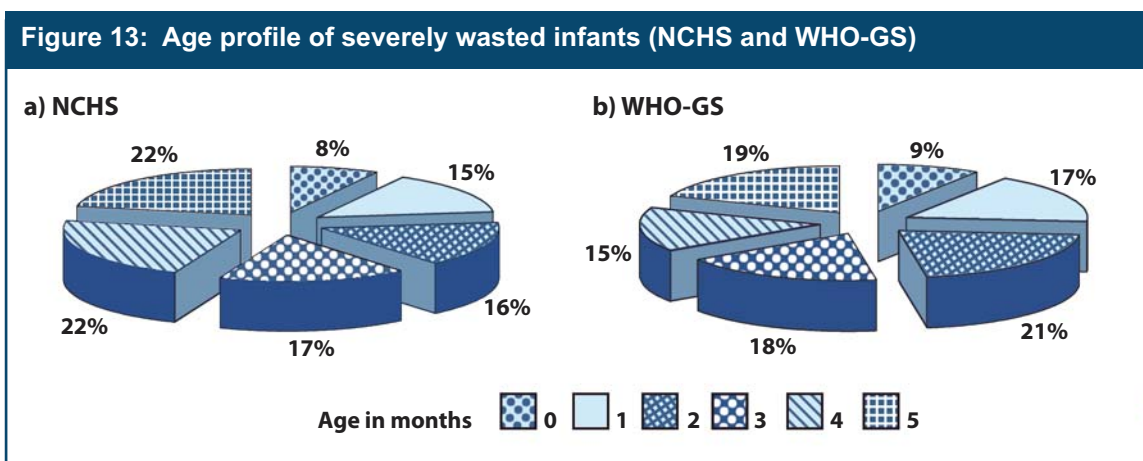
Table 4: Linear regression models showing relationships between key variables					
a) Infant wasting from child wasting prevalence					
To predict	From		(95% C.I.)	Constant	r <sup>2</sup>
Infant <6m wasting (NCHS)	Child wasting (NCHS)	0.56	(0.37 – 0.75)	0.23	0.66
Infant <6m wasting (WHO-GS)	Child wasting (WHO-GS)	1.42	(1.14 – 1.72)	1.53	0.84
b) Change in wasting prevalence					
To predict	From		(95% C.I.)	Constant	r <sup>2</sup>
Severe infant <6m wasting (WHO-GS)	Severe infant <6m wasting (NCHS)	3.54	(2.63 – 4.44)	2.30	0.78
Severe child wasting (WHO-GS)	Severe child wasting (NCHS)	1.68	(1.51 – 1.84)	0.12	0.96
Moderate infant <6m wasting (WHO-GS)	Moderate infant <6m wasting (NCHS)	1.43	(1.08 – 1.79)	2.02	0.79
Moderate child wasting (WHO-GS)	Moderate child wasting (NCHS)	0.73	(-0.05 – 1.51)	15.28	0.17
c) Change in admissions for feeding programmes treating wasting					
To predict	From		(95% C.I.)	Constant	r <sup>2</sup>
% infant <6m in TFP (WHO-GS)	% infant <6m in TFP (NCHS)	0.73	(-0.05 – 1.51)	15.28	0.17
% infant <6m in SFP (WHO-GS)	% infant <6m in SFP (NCHS)	1.59	(1.21 – 1.96)	3.31	0.80

NCHS: National Centre for Health Statistics references; WHO-GS: World Health Organisation growth standards.

#### 3.4.6 Basic demographic profile of severely wasted infants

##### a) Age profile

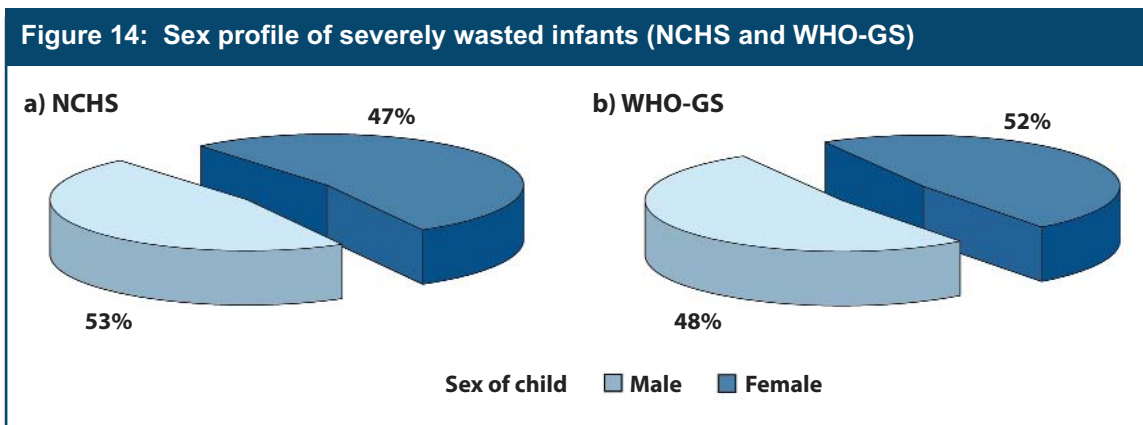
Figure 13 shows the detailed age profile of severely wasted infants <6m, classified using NCHS (n=257) and WHO-GS (n=1337). Using WHO-GS, the age bands are more evenly spread, whereas with NCHS, 44% of infants <6m are four or five months old. Patterns for moderate wasting are similar and are not shown.



### 3.4 Results

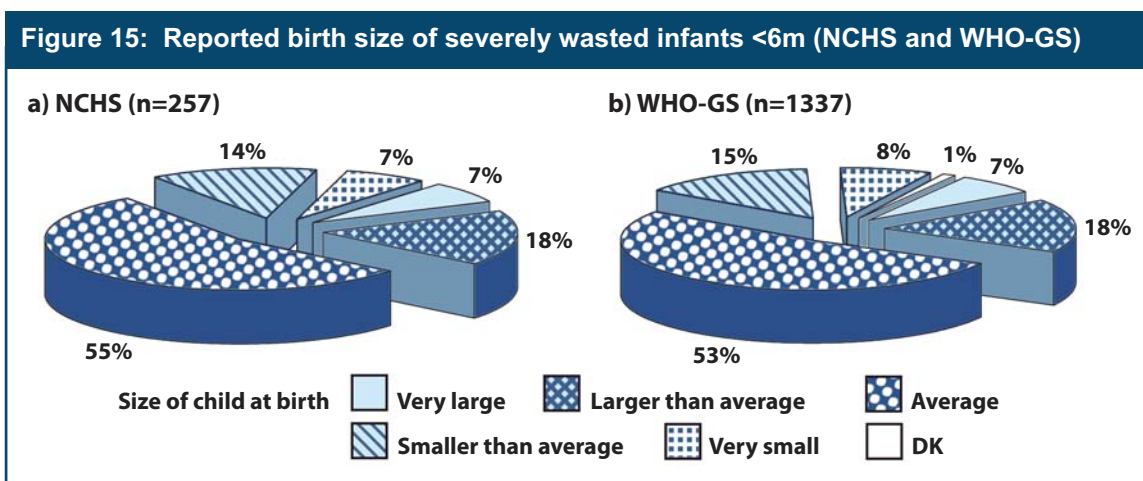
#### b) Sex profile

Male: female ratio of severely wasted infants is reasonably balanced (Figure 14), but differs according to the growth norm used. WHZ-NCHS has a slight excess in females and WHZ-WHO an excess in males.



#### 3.4.7 Size at birth and infant <6m wasting

Figure 15 shows the reported birth size of severely wasted infants <6m based on NCHS (15a) and WHO-GS (15b). There are negligible NCHS/WHO differences. Using either case definition, over 50% of wasted infants are reported as being normal size at birth. Only a modest proportion is ex-low birth weight (LBW). Patterns with moderate wasting are again similar so are not shown.



Although LBW does not underlie the majority of cases of infant <6m wasting, LBW infants do appear to have elevated risk of subsequently developing both severe and moderate wasting compared to normal birth weight infants (see Figures 16 and 17). Interestingly, this is most pronounced in those under six months and when using WHO-GS diagnostic criteria.



3.4 Results

Figure 16: Prevalence of severe wasting by reported birth weight category

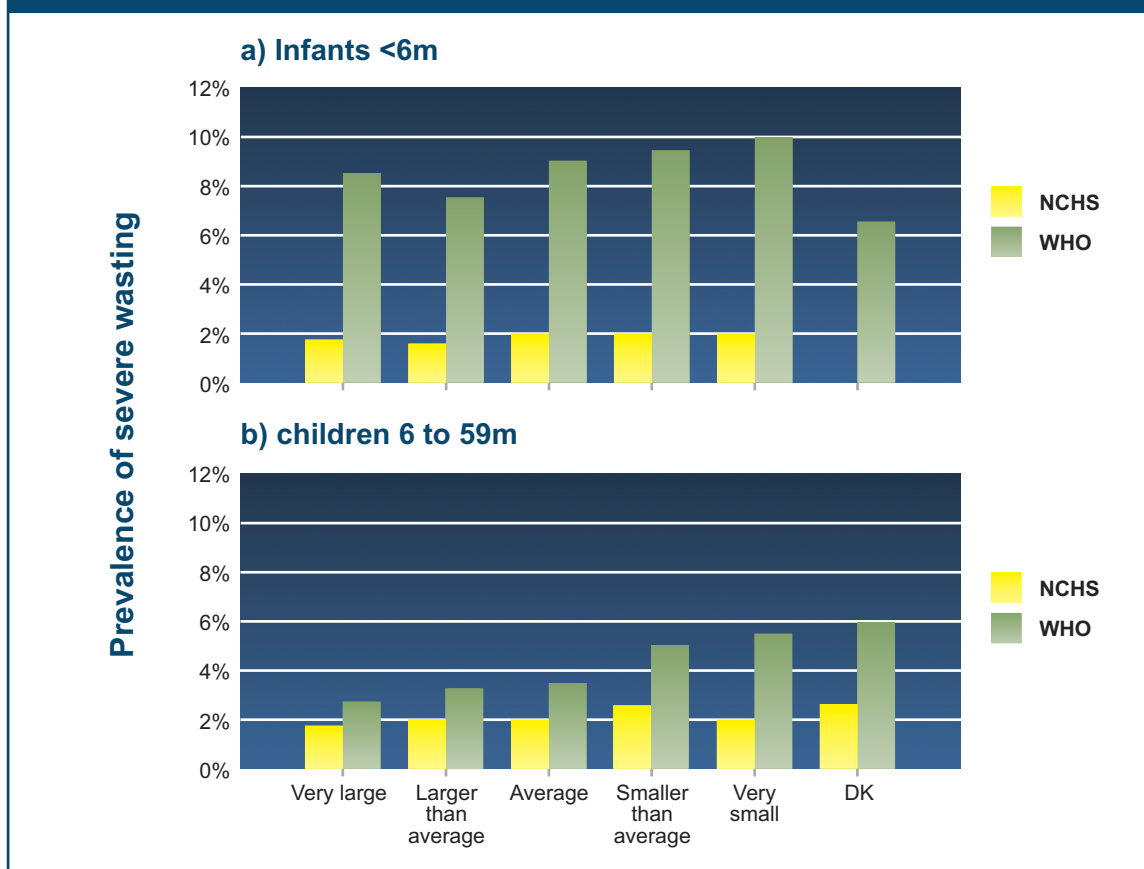
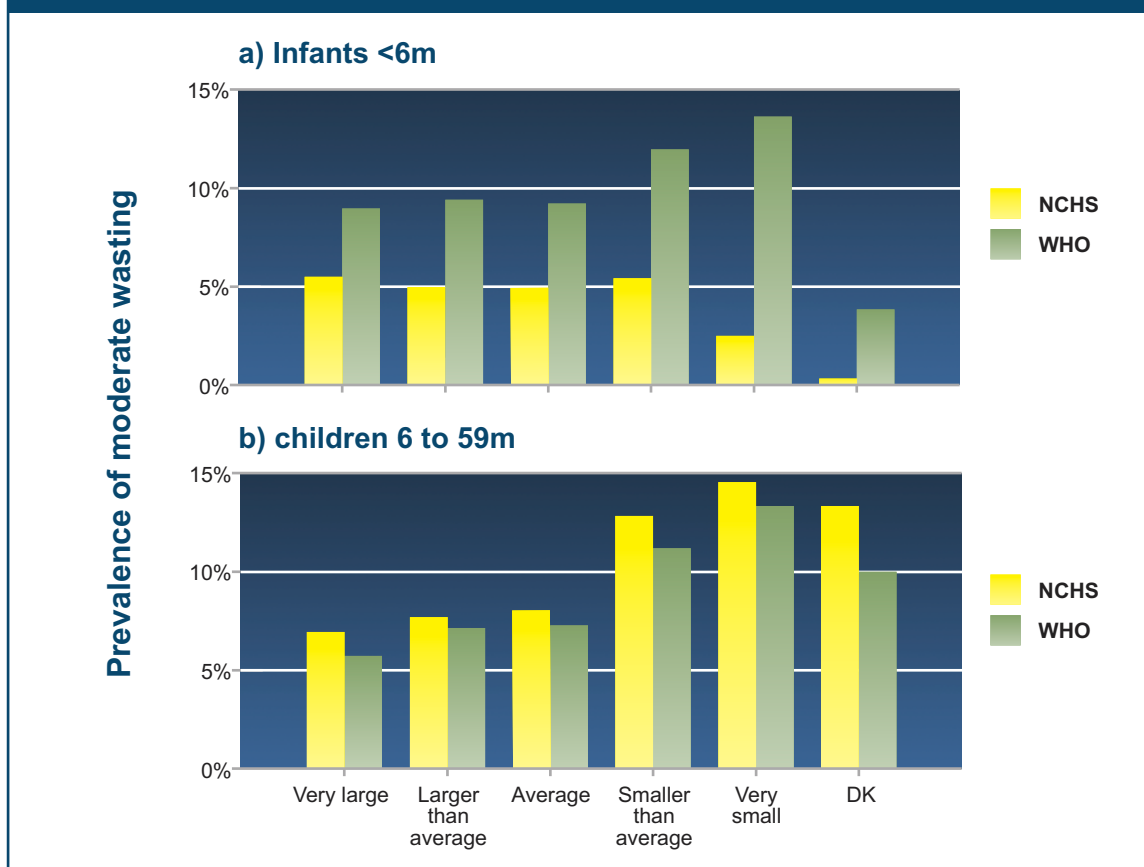


Figure 17: Prevalence of moderate wasting by reported birth-weight category



## 3.5 Discussion

The analysis shows that wasting among infants <6m is a prevalent public health problem. The prevalence of wasting in infants <6m is significant using both NCHS and WHO-GS. Disease burden is greatest, however, using WHO-GS for diagnosis. With forthcoming international rollout of WHO-GS for feeding programmes in emergency and other nutritionally vulnerable settings urgent follow-on work is needed to explore the reasons for and implications of our observations. Some initial ideas follow.

### 3.5.1 Explaining differences in NCHS v WHO-GS

We hypothesise two possible, likely co-existing, factors underlying observed NCHS/WHO differences. First, being a 'gold standard', WHO-GS are simply better at reflecting the true magnitude of population malnutrition. Exclusive breastfeeding, maternal health services, child health services and food security all impact wasting and are all known to be suboptimal in many settings.<sup>111 112</sup>

Second, the methods used to construct WHO growth curves play a role. The WHO-GS technical document states that *"to avoid the influence of unhealthy weights for length/height, observations falling above +3 SD and below -3 SD of the sample median were excluded prior to constructing the standards"*.<sup>113</sup> Given that the individuals on whom WHO-GS are based were already pre-selected from a much larger number screened to exclude health, environmental or suboptimal breastfeeding constraints to growth, small but healthy children might have been further excluded and the variation in the 'standards' greatly reduced. This may have resulted in the WHO-GS measurements having relatively small standard deviations and the z-score based thresholds identifying relatively large numbers of infants and children as malnourished.

A further consideration may be errors in anthropometric assessment. This issue has broad implications beyond NCHS/WHO-GS assessment, irrespective of which norm is used. With regard to assessment of weight, weighing scales measuring to the nearest 100g are common,<sup>114</sup> and this is a relatively large percentage of infant total body weight. Random errors either side of the true value are likely to lead to misclassification of malnutrition. Small errors can make a big difference in weight-for-height z-score. An evaluation of anthropometric training of emergency nutrition staff found that, while 88% of national nursing and nutritional staff said they felt very competent at undertaking weight measurements for children aged between six months and five years, this fell to 29% for infants less than six months<sup>115</sup>.

The assessment of length may prove even more challenging for this age group. New WHO training materials note, *"it is not possible to straighten the knees of newborns to the same degree as older children. Their knees are fragile and could be injured easily, so apply minimum pressure"*.<sup>116</sup> Since height would therefore be underestimated, weight-for-height would be falsely increased and true wasting prevalence underestimated.

### 3.5.2 Clinical profile differences in infants <6m in NCHS v WHO-GS

There are minor differences in clinical history between infants <6m diagnosed by NCHS and WHO-GS. The clinical implications of this are uncertain. High wasting prevalence does not appear to be explained just by LBW as has sometimes been postulated. Though individual risks of subsequent wasting do appear higher in ex-LBW infants, they do not contribute so significantly to total numbers wasted. Interventions targeted at minimising LBW (e.g. maternal micronutrients) would not therefore be alone sufficient to tackle infant <6m wasting.

The month-by-month age distribution of wasting is relatively even. Significant developmental changes during this time mean that age-tailored interventions and guidelines might have a role to play. What might be appropriate and useful for a five month old might be inappropriate for a two month old. Since different infants mature at different rates, clinical expertise and flexibility to manage individuals on a case-by-case basis would be useful.

### 3.5.3 Policy implications

There are several immediate policy implications of these findings:

*a) Nutrition surveys should more routinely include infants <6m*

Using simple regression analysis, we have shown that high infant <6m wasting prevalence correlates strongly with high child wasting prevalence. Extrapolations and estimations are not a replacement for direct surveys, however, and infants <6m should be included routinely in surveys where this is feasible. This would require training specific to assessment in this age group to ensure data quality; equipment such as weighing scales should also be reviewed for suitability.

*b) Feeding programmes should more actively consider likely prevalence of infant <6m wasting*

Results offer useful interim estimates of infant/child and NCHS/WHO-GS wasting prevalence trends until wider validation is possible. Findings can be generalised, if cautiously, for a number of reasons. Countries were chosen as representative of nutritionally vulnerable settings, a full range of high prevalence to low prevalence countries were included, the strength of correlation was mostly high ( $R^2 > 0.5$ ), overall trends were consistent for all countries, trends and absolute numbers are consistent with other research,<sup>117 118 119 120</sup> and trends coherent with NCHS and WHO-GS cut-offs.

*c) Formal discussion of infant <6m wasting data in local, national and international fora*

Appropriate planning is necessary to optimise the rollout of WHO-GS. We have shown that the introduction of WHO-GS lead to large increases in estimates of infants <6m eligible for admission to selective feeding programmes. The risk-benefit balance of this for infants <6m should be considered separately to that of older children. For example, the risks of more 6 to 59 month children enrolling into selective feeding programmes are minimal, but benefits likely. Focus on outpatient treatment for most children means that inpatient capacity is no longer a major constraint.<sup>121</sup> Assuming adequate resources, scale up of community-based TFPs and SFPs should be possible.

In contrast, the risks of increasing admissions of infants <6m are potentially serious. MAMI is currently inpatient focused<sup>122</sup> and therefore the increase in admissions has serious resource implications. Labelling infants <6m as malnourished at the community level may introduce further risk, for example, by encouraging introduction of 'top up' foods or breastmilk substitutes to exclusively or predominantly breastfed infants.<sup>123 124 125</sup> The potential benefits of more admissions are tempered by a weak evidence base underlying current treatments for infants <6m.<sup>126</sup> Skilled breastfeeding support is often scarce in facility and community based programmes. Inpatient management is resource intensive and cannot be easily scaled-up. SFP strategies for infant <6m with moderate wasting are not well developed and at present focus on feeding the breastfeeding mother, the efficacy of which is unknown.

Linear growth is more informative than one-off measures of nutritional status.<sup>127 128</sup> However, serial growth monitoring is often lacking in infants <6m that present to selective feeding programmes; treatment protocols rely on current size rather than growth monitoring. Research is urgently needed on how caregivers and healthcare workers in resource limited settings manage and interpret growth assessment using NCHS v WHO-GS.

### 3.5.4 Limitations

Future work is needed to address the limitations of data presented in this chapter. TFPs admit cases of severe wasting *and/or* oedematous malnutrition. This analysis looks at wasting alone since DHS data do not include oedema. Thus the full implications for TFP admissions are not reflected here.

There is no data on the timing or nature of the observed wasting to strategise on interventions, e.g. the contribution of HIV to malnutrition in this age group. It is important to repeat these analyses in different settings to explore their wider generalisability. Age-specific effects may be very situation dependent. Further investigation is also needed into how accurately anthropometric measurement in infants <6m is conducted in routine surveys, such as DHS.

It is critical to note that these analyses have focused on z score comparisons. Z-scores are the international standard for surveys reporting on the prevalence of wasting and results are used to plan programmes. However, many selective feeding programmes use a closely related but not identical weight-for-height % of median (WHM) indicator (<70% WHM = severe wasting; 70 to <80% WHM = moderate wasting). Both z-

## 3.6 Summary findings and recommendations

scores (NCHS) and % of median (NCHS) are recognized in current WHO protocols for the management of acute malnutrition.<sup>129</sup> In contrast, tables using WHO-GS only present z-scores. The magnitude of WHM-NCHS to WHZ-WHO changes may differ from WHZ-NCHS to WHZ-WHO changes. This urgently needs to be explored to determine more accurately how the shift to WHZ-WHO will manifest at 'field level' for infants <6m.

Lastly, it is important to establish how well different anthropometric indicators predict mortality and which indicator(s) best identifies infants <6m who will benefit from selective feeding programme admission. It is also important to know the nature of the risk profile; whether there is a linear increase in mortality risk with decreasing weight, or whether there is a 'threshold' beyond which there are marked risk increases.

## 3.6 Summary findings and recommendations

### Summary findings

Wasting in infants <6m is a prevalent public health problem. Infant <6m wasting is strongly and positively correlated with child 6 to 59m wasting and is significant using both NCHS and WHO-GS.

Use of WHO-GS increases the prevalence of severe wasting in both infants <6m and children, but the increase is greater for infants <6m. Moderate wasting in children decreases when using WHO-GS, but increases in the <6m age group.

There are minor differences in clinical profile between infants <6m diagnosed by NCHS and WHO-GS. Wasted infants <6m are not predominantly ex-LBW and include a relatively even distribution of ages from 0 to five months.

Selective feeding programme treatment protocols generally rely on current size rather than growth assessment. Used in this way, WHO-GS result in particularly large increases in estimates of the numbers of infants <6m eligible for admission to selective feeding programmes. This comparison is based on the use of WHZ; many selective feeding programmes currently use case definitions based on weight-for-height % of the median (WHM).

### Summary recommendations

A risk-benefit analysis of a potential large increase in infants <6m presenting to selective feeding programmes is needed. A priority investigation is how single and serial growth measures and chart position is interpreted by health workers using NCHS v WHO-GS based charts.

Feeding programmes should more actively consider likely prevalence of infant <6m wasting, for example, nutrition surveys should more routinely include infants <6m to establish local burden of disease. This requires training specific to assessment in this age group and appropriate equipment.

The MAMI analysis could be used to *approximate* infant <6m wasting prevalence. This should only be done as a stop gap measure where there is complete absence of other information. Further validation is needed before this could be considered a reliable or precise approach.

The implications of moving from WHM using NCHS to WHZ based on WHO-GS urgently needs to be explored to determine more accurately how the shift to WHO-GS will affect individual diagnosis and outcomes for infants <6m in pre-existing programmes.

Further research is also needed into the prevalence of oedematous infant <6m SAM, whether WHZ is the best indicator for this age, how well different anthropometric indicators predict mortality, and the clinical profile of malnourished infants <6m.

## Endnotes

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