Wasting Stunting Technical Interest Group (WaSt TIG) Sub-Working Group Meeting

Revisiting mortality and anthropometric deficits/reconsidering 'risk'

9th December 2019, London

Contents

Participants

Participants: André Briend, Bob Black, Heather Stobaugh, Jay Berkley, Mark Myatt, Marko Kerac, Martha Mwangome, Tanya Khara and Carmel Dolan.

Remote participants: Kevin Phelan, Andrew Mertens, Erin Boyd, Sheila Isanaka, Sunita Taneja (PI India cohort)

ENN support team: Natalie Sessions (rapporteur), Charlotte Barton (administration)

Apologies: Catherine Swinger, Christine McDonald, Paluku Bahwere, Kieran O'Brien, Natasha Lelijveld, Jaden Bendabenda, Simon Schoenbuchner, Michel Garenne, Keith West (PI Nepal cohort)

Meeting Objectives & Introductions

To take stock of the WaSt TIG mortality analysis, reflecting on key outcomes of the analysis

- To jointly consider and discuss the mortality analysis in light of other analyses
- To discuss the implications of the analysis for programmes, policies and research
- To agree on the next steps for this body of work (including additional data, further analysis, journal, timing and authorship)

The meeting started with a run through the agenda and introductions. Specific thanks were made to the Principle Investigators of the mortality cohorts used in this analysis for allowing ENN to use the data for this work. Thanks were also extended to OFDA/USAID for funding this important analysis and also to Irish Aid for co-funding this meeting.

WaSt TIG Analysis

Presentation 1: Background to the WaSt TIG Mortality Analysis (Tanya Khara)

https://www.dropbox.com/s/29x8yd01jocsp1o/p1-WaSt-MA%20meeting-background.pdf?dl=0

The work exploring the relationship between wasting and stunting was originally conceived when ENN examined the landscape for scaling up CMAM financing in 2013 which highlighted the separation between funding for wasting and stunting. Subsequent conversations ENN had, both internally and externally, highlighted the separation between these two forms of undernutrition in terms of policy, programming and research. Thus, the Wasting Stunting (WaSt) Technical Interest Group (TIG) was established to bring together a wide range of expertise (around 40 members) to deepen our understanding of the relationship between these two forms of undernutrition and explore whether this separation was the most effective way of addressing them.

As the first step, a (non-systematic) literature review was conducted in 2013 which highlighted that little is known of the relationship between wasting and stunting, particularly the degree of overlap between these manifestations of undernutrition and the implications. This was followed by a research prioritisation exercise which highlighted the priority research gaps. The WaSt TIG agreed that there was the potential to use existing data to answer some of these priority questions and a number of sub-working groups (SWGs) were set up to explore different data sources and questions. In particular set of questions came from the McDonald et al (2013) paper which looked at mortality risk amongst untreated children in 10 contexts and which highlighted the elevated mortality risk associated with multiple anthropometric deficits (defined as wasted, stunted and underweight). Questions that remained in relation to the McDonald analysis were;

1. would the risk of death associated with multiple deficits be reduced if underweight children were excluded?
2. What proportion of children do experience wasting and stunting at the same time?
3. Are these children being reached currently, and could we do better?

A 'SMART' working group was set up to examine these questions beginning with the analysis of an existing database of SMART surveys from 51 countries from 1992 to 2015, over 1.8 million children. The main finding was that all children with concurrent wasting and stunting (WaSt) are also underweight and thus, the multiple deficit category in the McDonald paper is same as concurrent wasting and stunting. At the same time, an analysis of national datasets (MICS and DHS) was conducted to explore the prevalence and burden of children who were concurrently wasted and stunted. This analysis, of 84 countries, noted that some countries have a concurrent prevalence of over 5%, although a large range was noted. Although this study used national data so caveats to these findings are important, this was the first time such an analysis was conducted and there was a subsequent call for people to routinely report on concurrent prevalence, particularly given the McDonald findings in relation to mortality risk. The GNR is now updating these figures on a yearly basis, with the 2018 GNR noting a global burden of around 16 million children. Both analyses found that WaSt children were more likely to be younger and more likely to be boys.

Further SMART data analysis to understand how to detect these at-risk WaSt children found that WAZ and MUAC detected with good sensitivity and specificity (WAZ <-2.6 was very good at detecting WaSt and MUAC<133mm was okay). However, the conversation within the group shifted to who

were the most critical children to identify with WaSt, i.e. those most at risk of dying. Access, via Michel Garenne to mortality cohort data collected in the 1980s in Niakhar, Senegal, enabled the group to conduct further analysis of risk. Analysis of this data published by the SWG in 2019 found that a combination of MUAC<115mm (an existing standard CMAM criteria) and WAZ<-2.8 identifies all deaths associated with WHZ <-3 and WaSt. Thus, a combination of MUAC<115mm and WAZ <-2.8 can identify children with severe anthropometric deficits at highest risk of death, including WaSt children. As WFA is already used in Growth Monitoring Programmes (GMP), potential was seen to explore how an existing platform to identify children with low WFA could be utilised. In the January 2018 WaSt TIG meeting, the need to explore whether or not the same pattern is found elsewhere and to explore the optimal WAZ cut off for detecting high-risk children missed by MUAC <115mm but avoiding overloading programmes was identified. It was agreed that the group would attempt to secure all 10 original mortality cohorts from the McDonald paper to re-run the analysis and further explore cut-offs, work that has occupied the SWG since then.

Presentation 2: WaSt TIG multiple-cohort mortality analysis (Mark Myatt)

https://www.dropbox.com/s/0xsqbg9j5jrfmzf/p2-WaSt-MA%20meeting-analysis%20MM.pdf?dl=0

This analysis explores which anthropometric case definitions **best** identify children at high short-term risk of mortality using multiple mortality cohorts. Mark noted that as this was the first face-to-face presentation of the results, the presentation was intended to provide 'something to kick against' and discuss. The analysis presented used 11 cohort datasets from 11 countries from 1977- 1997. Three of these cohorts include measurement of MUAC alongside weight, height and age measurements. The additional mortality cohort was obtained from Democratic Republic of Congo (DRC) and secured through Catherine Schwinger. It was noted that 'best' anthropometric measure needed to include consideration of: sensitivity (relative to alternatives), specificity (greater than 85%), informedness (how much better are we than chance), face validity (given that not all severe anthropometric deficits can be solved through nutrition interventions, the measure needs to make sense on face value), inclusivity (this is critical as people are invested in the status quo of using both MUAC and WFH measures and a number of people in the international nutrition community feel strongly that shifting to MUAC only programming excludes children who are wasted based on WFH and who may go on to die) and compatibility with existing practices and tools (practicability). It was noted that this last criterion requires that the anthropometric measure be familiar and compatible with current platforms being used at national level i.e. IMCI, MCH, CMAM, GMP, etc.

10 case definitions were used for analysis (HAZ <-3, WAZ<-3, WHZ <-3, WHZ <-2 , MUAC <115mm, MUAC <120mm, MUAC <125mm, WHZ <-2 and HAZ <-2 (i.e. concurrent wasting and stunting), MUAC <115mm and/or WHZ<-3, MUAC <115mm and/or WAZ<-3). Three of these had too low specificity (i.e. too low to avoid flooding programs with too many false positive cases). These included HAZ<-3 and MUAC <125mm. When examining informedness, Youden's Index (a measure combining both sensitivity and specificity) was used and MUAC< 115 or WAZ <-3 was found to be the most 'informed' index to use. MUAC<125mm was noted to have high sensitivity but low specificity- this means that while MUAC only programmes capture high numbers of children with anthropometric deficit, they may also capture children who do not need to be part of the programme. In terms of inclusivity, there were some differences between the cohorts. In Bangladesh, Ghana, Guinea Bissau, India, and Philippines, WAZ identified all deaths. In the DRC, all WHZ and WaSt deaths were detected by MUAC and/or WAZ (this cohort had a very high number of deaths) and in Nepal, two cases were not detected by MUAC and/or WAZ and in Indonesia, two WaSt cases were not detected. In Peru, WaSt deaths were detected through MUAC and WAZ (although there were very few deaths in this cohort). In Senegal, almost all WHZ<-3 and WaSt

deaths were predicted using MUAC <115mm and/or WAZ<-3. In summary, in terms of inclusivity, the case definition of MUAC< 115 and/or WAZ<-3 predicted all, or nearly all, deaths associated with WHZ<-3 and WaSt. WAZ <-3 alone was also found to predict most of these deaths. Both MUAC<115mm and WAZ<-3 also do well when assessed for face validity (i.e. both are severe anthropormetric deficits) and compatibility with existing tools and practices.

When examining children based on MUAC< 115 and/ or WAZ< -3. Three possible groups emerge:

1. MUAC<115mm AND WAZ<-3: These children would already be admitted to therapeutic care
2. MUAC<115mm AND WAZ>-3: These children would already be admitted to therapeutic care
3. WAZ< -3 AND MUAC>115mm: The question of what to do with these children remains.

It was explained that the study that ENN is leading (preparations currently underway in Nigeria) with funding from OFDA/USAID is designed to explore how to treat the third category.

Pooled risk ratio's of the three possible groups (as well as for all children with MUAC< 115), were calculated and the so-called 'new' group (those WAZ< -3 but MUAC>115), was found to have lower risk of mortality than the other groups. This indicates that it might be possible to treat these children with a less intensive programme than the others. Very few children fell into the MUAC <115mm but WAZ>-3 category and the mortality risk greatly varied by cohort, so conclusions are harder to draw. When broken down further into age groups (as requested previously by the SWG), the patterns emerging are very similar. Mark noted that currently GMP is still widespread but often 'It is simply measuring children for the sake of measuring them' and thus, using it to identify children at most risk and linking with CMAM could leverage an underutilised service. Linking CMAM and GMP however, will have caseload and workload implications. In this regard, if compared to a therapeutic programme admitting based on MUAC<115mm, analysis presented suggested that adding in children with WAZ<-3 could increase caseloads by a factor of four. However, workload might increase to a lesser extent if less intensive treatment is an option with the new group of childen. In terms of the types of additional children being admitted to programmes - they would likely be older, more underweight and slightly more wasted. Such considerations will be trialled with the Nigeria study, using the ComPAS dosage charts (see study summary available online). It was also noted that a SWG is in place for the study - a number of members of which overlap with this SWG for the mortality analysis.

Presentation 3: Optimising the detection of children who died with a severe anthropometric deficit (André Briend)

https://www.dropbox.com/s/fe8mzfeh8dupwy7/p3-WaSt-MA%20meeting-analysis%20AB.pdf?dl=0

André noted that there is a lot of overlap with the conclusions coming out of the overall cohort mortality analysis and further analysis that he presents on the three of the ten cohorts where MUAC measurements are present (Senegal, Nepal and DRC).

Focussing firstly on data on deaths within 6 months of follow-up, André presented the analysis of ROC curves for all deaths in the 3 cohorts for the different indicators (MUAC, WHZ, WAZ, HAZ). WAZ< -3 was the most sensitive among simple indices of severe deficits. MUAC, WAZ and WFH RoC curves were all very similar in the high specificity range. Two questions remain however, first, do we miss some children if we use only one index to identify high-risk children and second i.e. can we just increase the existing MUAC cut-off and identify more of these deaths? Rather than adding in another indicator.

André clarified a concern he has with raising a MUAC cut-off to <125mm. Using MUAC for age standards he illustrated that around 15% of girls are below 125 mm MUAC at 6 months of age in a well-nourished population - the measure will therefore identify a large proportion of children who

will not benefit from treatment. This is a lesser problem with a 120mm cut off as very few children in a well-nourished population are identified.

Looking at the 3 mortality cohorts where MUAC measurements are present, the analysis illustrates that a combination of WAZ <-3 and MUAC <115mm represented most deaths associated with a severe anthropometric deficit defined as WAZ or WHZ <-3 or MUAC <115mm or WaSt (87% of deaths associated with a severe anthropometric deficit identified with WAZ< -3 **and 97%** identified with MUAC<115 combined with WAZ< -3). 9% of these deaths were identified by WHZ and not by MUAC and 27% were identified by MUAC and not WHZ which indicates that even at MUAC <115mm, MUAC misses few children. If the MUAC cut-off is adjusted to <120, 25 additional deaths are identified, however alone MUAC<120mm only identifies 57% of the deaths associated with a severe anthropometric deficit, but in combination with WAZ<-3 **97%** - as above), Separate analysis by country resulted in similar patterns. Through this analysis, it is clear that WAZ <-3 is the most sensitive index, that MUAC used alone does predict increasing number of deaths with a higher cut-off but that large numbers of deaths associated with WAZ<-3 would still be missed if WAZ were not used.

A second analysis was performed on the same cohorts but looking at different periods of follow up (1 month, 3 months, 6 months), and a significant improvement of detection of high-risk children was seen at 1 month follow up in all but HAZ measurements. WAZ <-3 was able to predict all deaths with a high degree of sensitivity and specificity with some improvement at 1 month follow up. WHZ and MUAC showed improvement (higher sensitivity) at 1 month follow up. At one month follow up, MUAC and WHZ RoC curves were noted to be very similar at high specificity levels.

When exploring child deaths at one month follow up, 53% of deaths associated with a severe anthropometric deficit at assessment are captured by MUAC<115. WHZ<-3 only added an additional 5% (compared with 9% at 6 months of follow-up) indicating that with increased frequency of measurement the discrepancy between WHZ and MUAC decreases. Comparably the addition of WAZ<-3 adds substantial number of deaths leading to a total of 95% of these deaths identified for this indicator when combined with MUAC<115mm. In conclusion, André noted that frequent screening will improve case detection and monthly screening is preferable (The "Family MUAC" model is very effective in enabling monthly follow up). With monthly screening, very few deaths with WHZ <-3 are missed by MUAC, even MUAC <115. However, a substantial number of deaths associated with WAZ <-3 are missed.

Plenary discussions and reflections

Several important reflections were noted by group discussions following on from the three presentations. These included:

Terminology and analysis:

- The terminology of acute malnutrition is extremely unhelpful as wasting itself very rarely occurs acutely. The aim of the WaSt project is to start to enable us to look at malnutrition in an integrated way
- There is a problem with Youden's Index as that it gives equal weighting to specificity (false positives) and sensitivity (false negatives). Questions were raised as to whether we should be weighting sensitivity and specificity equally given the public health costs involved. Given that specificity was set at 85%, they were not necessarily equal in the analysis but it was agreed that the explanation for using 85% needs to be highlighted further within the analysis. André identified a paper which details the reasoning for balancing sensitivity and specificity and not giving them a priori identical weighting that could help in this explanation:

https://www.nejm.org/doi/full/10.1056/NEJM197507312930501 McNeil BJ. Primer on Certain Elements of Medical Decision Making. N Engl J Med 1975; 293:211-215.

- There is a need to understand what is driving stunting within WaSt children, particularly considering whether they were born small and/or where they are born (Africa/Asia). This leads to the more fundamental and recurring question of whether global anthropometric standards really apply to all populations. Whether this is raised in the mortality paper remains to be discussed during write-up.
- While it is important to focus on mortality, a lot of children won't die and wouldn't die in the absence of programmes but that doesn't mean they won't suffer detrimental effects. We should, therefore, be mindful of other potential positive effects of "false positive" cases receiving treatment, as well as the potential detrimental effects (costs) of treating those who are not going to die. For example, research has shown that their neurodevelopment is greatly affected during undernutrition, and cognitive outcomes could be considered, particularly in the younger age categories as we know from biological data that plasticity (the ability of the brain to modify its connections or re-wire itself) develops early in life. We do not have data to explore this fully but a literature review so that we can represent the wider evidence in this area in our discussion may be needed.
- Because low WAZ might be driven more by the level of wasting or the level of stunting in different children, it is likely there will be different outcomes from treatment accordingly e.g. we might see greater response (in terms of catch-up) from the more wasted children and less response from the more stunted children (as height gain is less likely). However, we may be treating some of the things that the stunting is a marker for and in this case, it would be good to look beyond anthropometric measures at outcomes like broader health implications/morbidity etc. (particularly relevant for the WaSt study in Nigeria).

Context analysis

- It might be useful to consider the context/background of the datasets dividing them into endemic and epidemic settings to see if there is a difference in the patterns. We already have the individual country Venn diagrams to be able to do this. Endemic settings are where the vast majority of malnutrition cases occur, but epidemic settings often get more attention when emergency programmes are run by INGOs generating a lot of data.
- Correlation doesn't imply causation and there may be lots of confounders in relation to low MUAC/ WAZ leading to death, it might be useful to work out some causal diagrams for endemic v. epidemic settings.

Modelling of workload and feasibility

- It might be useful to examine MUAC<125mm or MUAC<120mm, in addition to MUAC<115mm in workload comparisons as while we know MAM treatment isn't widespread, it might not be a fair to compare workload for SAM treatment in isolation against the new proposed inclusion of WAZ<-3. A better comparison might be with other 'expanded criteria' options.
- There is a need to consider whether the taking of WAZ measurements in government health facilities is really possible. Often scales don't work or are not correctly calibrated, children are not undressed when weighed (which overestimates the weight) or are dehydrated (which underestimates the weight) and age is often not accurate. There are risks in using specific WAZ calculations and it is worth considering the practicalities, particularly in government-funded institutions.
- Using GMPs as an entry point might be useful to bringing programmes to scale, it would be an opportunity to make GMPs more believable and useful (moving beyond the notion that if you measure it, it will improve). Although awareness of MUAC at GMPs is very low and a strategy

would be needed to introduce MUAC (though it is was noted that Mothers MUAC is gaining popularity). It might be valuable to map the extent of GMPs as a starting point to examine this.
- Again, when examining integration with GMPs we need to separate the optimal versus the practical, we need to examine what compromises we are prepared to make to integrate with GMPs, particularly in areas where GMPs are of low coverage.

Interpretation and implications of the analysis

- When talking about WHZ, we must bear in mind that people are very invested in the status quo and we need to nuance the communication of our findings with this in mind to successfully shift the conversation. The findings presented do suggest that we need to move the debate from MUAC vs WHZ to MUAC and WAZ. However in our analysis we need to be clear we are not discounting deaths associated with WHZ - rather that we are concerned about identifying and treating them. Our analysis shows that the combination of MUAC<115mm and <-3 WAZ catches and those children with WHZ<-3 most likely to die. It indicates there is no additional benefit in the use of the height measure. At the same time, we can also be clear that length and height are not currently part of IMCI, so it is often a measure that is not compatible with national programmes.
- If we recommend treatment based on low WAZ, what would the discharge criteria be? This will be examined in the Nigeria study as we don't have much knowledge of what response to treatment looks like for the additional group of children. As part of the background to the Nigeria study data from the ComPAS trial have been examined in order to gain some understanding of response for children with Low WAZ (paper in preparation - Bailey et al). During the Nigeria study growth charts will be used to track catch-up growth and identify when weight gain levels off - this will be a sign to trigger discharge. At the very minimum, not being in an at-risk category (MUAC above 115, WAZ above -3) will be a necessary discharge criterion. It was noted that it would be useful to also collect illness data and frequency of illnesses as this would be an important criterion, i.e. those exiting the programme need to be at lower risk of morbidity than those entering the programme.
- The analysis suggests it would be useful to shift to measurements every month for identification of new cases at high mortality risk. There was considerable discussion on the feasibility and practicality of monthly measures, particularly in government-run settings. Kevin noted ALIMA's work on Family MUAC which has found monthly measures by carers to be possible and results in earlier detection, including earlier detection of relapse. Even in Government-run settings (e.g. MoH run facilities in Niger) positive impacts were noted. Shelia also noted her work examining the feasibility of giving MUAC bands to mothers in Niger and Nigeria and noted that caregiver training can increase knowledge and confidence to measure MUAC at home but does seem to decrease with time (up to 3 months after treatment discharge), She also noted anecdotally that mothers do tend to lose MUAC bands (hence the need for refresher training and additional MUAC bands being made available),

Consideration of wasting and stunting in the Gates analyses

Presentation 4: Highlights from Gates analysis (Andrew Mertens)

(presentation not sharable at this time as findings are being prepared for publication)

We were joined remotely by Andrew who noted that the Knowledge Integration project within the Gates Foundation aimed to study patterns in child growth failure with a focus on understanding longitudinal patterns in age-specific incidence, causes, and consequences of wasting and stunting. Using aggregated data from 35 cohorts and trials, pooled analyses were conducted. Inclusion criteria for a subset analysis were weight and height measurements between birth and 24 months

of age, conducted in low and middle-income countries, looked at both healthy and sick children, enrolled at least 200 children and collected measurements bi-annually, quarterly, or monthly. In total there was data for 108,336 children although not every cohort was measured from birth or until 24 months and every cohort measured a different set of covariates. The majority of the cohorts were from South Asia and data from key regions (such as East Asia and the Middle East) were missing.

When looking at the key ages when growth failure was at its highest and how this varies by region and time of year, the analysis found that wasting prevalence peaked around one year of age, stunting prevalence peaked at 18-21 months, and that both were highest in South Asia. compared to sub-Saharan Africa and Latin America. The analysis also found a high incidence of both wasting and stunting at birth and in the first 6 months of life. Concurrent wasting and stunting increase with age and again was highest in South Asia. Andrew noted that very few children are only wasted i.e. most wasted children were also found to be underweight or wasted and stunted (therefore as demonstrated in previous analysis of the WaSt group - also underweight by definition). A larger proportion of children are only stunted but about half of stunted children at 24 months are both stunted and wasted. The analysis found that over half of children recover from wasting within 90 days though it is not known how many of these were treated as cohort-specific referral guidelines were not known. As would be expected, the analysis shows that most stunting cases do not recover to above -2 HAZ by two years of age. There was a strong seasonality component to wasting (coinciding with rainfall) found in the data including that season of birth affected both at-birth WHZ and the WHZ trajectory over the first 2 years of life. The question remains if whether mortality risk has a similar component of seasonality.

Characteristics (child, parental, household) of those at highest risk of growth failure were examined. Parental and at-birth anthropometry were strong predictors of both WHZ and HAZ. Birth order, maternal education and household size were also found to be important. Seasonality was found to be an important predictor of WHZ but not HAZ.

The analysis found that children born wasted do not fully recover (on average, born-wasted children's WHZ increases rapidly after birth). Children who recover from at-birth wasting have a higher cumulative incidence of wasting, WaSt and persistent wasting (defined as >= 50% of measurements of WHZ < -2) between 6-24 months. The analysis also found that a lower WHZ precedes slower linear growth velocity. Furthermore, children who were persistently wasted under 6 months had the highest risk of being persistently wasted after 6 months of age. This was followed by children who are moderately underweight and moderately wasted. Children who were moderately underweight under 6 months had the highest risk of concurrent wasting and stunting at 18 months. This was followed by children concurrently wasted and stunted under 6 months and children severely underweight. In terms of risk of mortality, children who were severely underweight under 6 months and children concurrently wasted and stunted under 6 months had the highest risk of mortality before 2 years (relative risk ≈ 4.8 for both conditions). This was followed by children persistently wasted. Children persistently wasted under 24 months had the highest risk of mortality among measures of growth failure occurring before 24 months. Except for persistent wasting, all measures of growth failure had stronger associations with mortality when occurring under 6 months of age, compared to the same measures occurring from 6-24 months.

Andrew noted some limitations to the analysis including the lack of population-based randomised samples, geographic imbalances in the data available, differences between the cohorts in timing and frequency of measurements, very few cohorts including MUAC measurements, lack of information on treatment of wasting, and the likely impact of residual confounders. In addition, the anthropometric measures are not adjusted for gestational age (although in studies where this was done, only a marginal difference was noted). Critically as wasting and stunting are rare outcomes,

even with large amounts of data, it is difficult to draw conclusions. Despite these limitations, key conclusions can be drawn. These include:

- Two distinct peaks in wasting were seen: at 1 year and at or shortly after birth (driven primarily from cohorts from South Asia)
- Stunting had the highest prevalence at 18-21 months but the highest incidence in the first three months, and stunting was higher in South Asia.
- Wasting is highly seasonal, suggesting it is important to develop targeted interventions to prevent the onset of seasonal wasting
- The characteristics most strongly associated with wasting and stunting are not easily modifiable, but they could be useful for screening children at high risk of growth failure after 6 months.
- Severely underweight children and children both wasted and stunted had the highest risk of death.
- WAZ may be a better metric than WHZ for screening children under 6 months.
- Early growth faltering also had strong associations with later concurrent wasting and stunting and later persistent wasting highlighting the importance of targeting that early period for intervention.
- Measures of growth failure under 6 months had a stronger association with mortality than the same measures under 24 months.

Plenary discussion and reflections

The group were struck by how the findings of the Gates analysis do mirror findings from the WaSt work to date, the analysis of the MRC Gambia longitudinal cohort data in particular (periods of wasting affecting linear growth and wasting leading to higher vulnerability to more wasting in particular), and also findings of analyses carried out by the MAMI (management of malnutrition in mothers and infants) group in relation to infants.

Specifically, a number of points/questions were raised by members of the SWG:

- It would be good to examine the under 6-month age group further. Seasonality has been observed a few times and it would be good to explore length velocity further in terms of stunting reversal in this age group. Andrew noted that they hadn't explored this in detail.
- There is a need to further understand seasonality, particularly examining this phenomenon in contexts where there was no variation in food availability. In Kenya, Jay reported that in Dadaab refugee camp the population seem to experience the same seasonal patterns of wasting as are found elsewhere in Kenya, despite receiving non-varying rations, suggesting that food security is not the major driver. Infectious disease may be a high driver of seasonality changes, but this varies in different countries and contexts.
- In terms of wasting recovery rates, was it possible to understand which cohorts had access to treatment and which did not? Andrew responded that they were not able to get this information, and this highlights another limitation of this analysis - that we don't know the proportion of the wasted children who are experiencing spontaneous recovery v. being treated.
- A question was raised on whether there were differences in the mortality and anthropometry associations between regions. Andrew noted that only 10 cohorts included mortality data so strong conclusions can't be drawn. However, there were not consistent or strong differences in the strength of associations between measures of early growth failure and mortality between South Asian and African cohorts
- It might be valuable to explore the distribution of size at birth (low birth weight, premature children etc.). Andrew noted that some studies reported gestational age so that pre-term and LBW babies could be separated, but the numbers are very small so challenging to analyse.

- A question was raised on whether the datasets recorded oedema. Andrew noted that some did, and those datasets contributed to the overall dataset.

Agreement of next steps for the WaSt mortality analysis:

Further analysis

- Strengthen the background on the 85% specificity for the paper and show clearly that we have considered costs of false positives and false negatives - in line with paper shared by André (above)
- Add to the analysis risk ratios for MUAC<120mm and for MUAC<125mm to allow comparison of risk across other 'extended protocol' options.
- For the examination of implications for caseload and cost: add some additional comparisons /scenarios, including other expanded protocols for MAM, and unpack those scenarios (including different intensities of treatment) and the resulting implications a bit more. As a next step the ENN team together with Mark will sketch out some scenarios to compare to the theoretical WAZ model and start a 'round robin discussion' to agree on which to use. Additional information of coverage achieved under some of the expanded protocols for MAM will also be sought. As write-up progresses the co-author group will take a view on what can be done for the main paper and what might require an additional paper. Andrew noted that his team has developed a machine-learning estimation tool to estimate the distribution of mortality reduction if different coverages of child screening could be achieved - he shared this for review by the WaSt team. https://tlverse.org/acic2019-workshop/stochastic-treatment-regimes.html
- Include in the paper the additional analysis presented by André which models the options of increasing the MUAC cut-off and the implications of this for identification of deaths.

A number of additional suggestions were made for analysis which require some follow-up with individuals to pin down and then with the SWG prioritise in the immediate or longer term.

- Given the sex differences found in WaSt - can we add an analysis of sex difference in mortality risk i.e. Is the mortality associated with WAZ<-3 in boys the same as the mortality associated with WAZ in girls?
- Loss to follow up is challenging (as there is a mortality bias) but it might be good to model risk of loss to follow-up in some groups.
- It may be useful to examine the differences in caseload/workload etc. in epidemic and endemic settings - i.e. for NGO style versus government run programmes. It was recognised that data might be less available for endemic situations, but it was noted that it could be important to look at, particularly as the suspicion is that the majority of child wasting is indeed happening in endemic contexts. A suggestion was made to take the analysis as it currently stands and then model it using data from endemic versus epidemic contexts.
- The analysis presented on the 1 and 3 months follow up by André may be appropriate to put in the mortality paper or may comprise an additional paper - potentially including attributable risk as well. A decision on this will be made as the write-up progresses.
- A question was raised as to whether we could we explore the issue of seasonality in the original data? Mark noted that he will look into this to see if it is possible.

Interpretation and presentation of findings

Agreed key messages to convey in the write-up/ interpretation:

- To highlight the nuances around height and WHZ: that we are not excluding WHZ but that we are capturing deaths associated with it through measuring WAZ

- To add consideration of cognitive effects into our discussion i.e. though we are looking at the outcome of mortality there are other added benefits for those identified who are not likely to die.
- We will continue the shift away from SAM and MAM terminology. Referring to severe anthropometric deficits or multiple forms of malnutrition.

Write-up and publication

- SWG members were asked to give some thought to whether they would like to be a co-author on the paper and let Carmel/Tanya know. Tanya noted that with the past papers, a smaller working group subset was formed to work more intensively on the paper for publication - with later review by the full group. This model could work again for this analysis. Tanya and Carmel will follow-up with the group on this in 2020.
- In terms of timing for publication, it was noted that the sooner the better would be best to inform the planning of the Nigeria study, therefore additional analysis will need to be minimised. However, it was noted that additional material and analysis - such as the work on endemic v. epidemic contexts, or modelling of caseload and workload implications in a number of scenarios, could form a second paper (TBD)
- It was agreed that they would aim to publish in the Public Health Nutrition journal (as this is a follow-up to our previous paper).
- The group agreed to reflect further on additional data sets that could be useful to collect/collate with respect to the discussions during the day.
- Initial discussions noted that it might be valuable to consider what recommendations can be made in light of the findings for future funders, agencies and researchers. One suggestion was to develop a plain language brief for policymakers and programmers to communicate key findings from the analysis.
- It was also noted that the SMART working group analyses has generated a lot of interest and it could be useful to develop a note on the process of developing the analysis. The note could include the pro's and con's of different kinds of data and how to map such data for broader, future reflections (TBD)

Acknowledgements

Our great thanks to all who attended in person or remotely on this rich day of discussion and again to all the cohort PIs for making their data available and entering into this journey with us. Also to OFDA/USAID for funding the analysis and to both OFDA/USAID and Irish Aid for funding this meeting. Special thanks also to our presenters and to Natalie our rapporteur and Charlotte for helping with all things on the day.