Clinical Scales for Assessment of Dehydration in Children with Diarrhea

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SUMMARY

This systematic review assessed the diagnostic accuracy of the Clinical Dehydration Scale (CDS), the World Health Organization (WHO) Scale and the Gorelick Scale in identifying dehydration in children with acute gastroenteritis (AGE). Three databases, two registers of clinical trials and the reference lists from identified articles were searched for diagnostic accuracy studies in children with AGE. The index tests were the CDS, WHO Scale and Gorelick Scale, and reference standard was the percentage loss of body weight. In high-income countries, the CDS provided a moderate to large increase in the post-test probability of predicting moderate to severe (≥6%) dehydration, but it was of limited value for ruling it out. In low-income countries, the CDS showed limited value both for ruling in and ruling out moderate-to-severe dehydration. In both settings, the CDS showed poor diagnostic accuracy for ruling in or out no dehydration (<3%) or some dehydration (3%-6%). The WHO Scale showed no or limited value in assessing dehydration in children with diarrhea. With one exception, the included studies did not confirm the diagnostic accuracy of the Gorelick Scale. The authors concluded that limited evidence suggests that the CDS can help in ruling in moderate-to-severe dehydration (≥6%) in high-income settings only. The WHO and Gorelick Scales are not helpful for assessing dehydration in children with AGE.

COMMENTARIES

Evidence-based Medicine Viewpoint

Relevance: Acute watery diarrhea and associated dehydration are significant clinical problems in children – both at the individual level as well as from the public health perspective [1-3]. Prompt and efficient rehydration therapy has been instrumental in saving the lives of thousands of children across the globe [4,5]. Careful clinical assessment of the dehydrated child is required to guide the quantity, route and type of fluid used for rehydration. On the one hand, inaccurate estimation of the degree of dehydration can lead to under-hydration and organ damage. On the other hand, over-enthusiastic rehydration can also lead to another spectrum of clinical problems [6]. This systematic review [7] explored the diagnostic accuracy of three commonly used tools to assess and quantify the degree of dehydration in children with acute diarrhea. These were: (*i*) Clinical Dehydration Scale (CDS), (*ii*) World Health Organization (WHO) Scale, and (*iii*) Gorelick Scale. The authors concluded that none of the three scales could reliably predict the presence and degree of dehydration in children with diarrhea compared to estimation of weight loss. Similarly, the scales could not reliably rule out dehydration either.

Critical appraisal: ***Table* I** summarizes critical appraisal of the systematic review [7] using one of several tools designed for the purpose [8]. In general, the systematic review was conducted as per the expected standards for such reviews. The authors chose an appropriate participant age group, used appropriate inclusion and exclusion criteria for studies, selected appropriate interventions, and examined multiple sources for potential studies. They examined each included study for methodological biases.

One of the major challenges in reviews on this subject is the choice of the reference (*i.e.*, gold standard) test. For practical reasons, the currently accepted gold standard for assessing the degree of dehydration is the percentage of body weight lost. This poses two separate challenges.

The biggest problem with using ‘body weight lost’ as the reference standard is that it is very difficult to measure. Since the pre-dehydration weight of children is not usually known, ‘body weight lost by dehydration’ is generally calculated from ‘body weight gained by rehydration’. This apparent paradox raises two further problems. First, the body weight gained depends on the

TABLE I CRITICAL APPRAISAL OF THE SYSTEMATIC REVIEW

Parameter	*Comments*
Validity	
1. Did the review address aclearly focused question?	Yes. Although a research question was not explicitly stated, the following PICO question can be framed: In children with dehydration associated with diarrhea, what is the diagnostic accuracy (Outcome) of three designated clinical scales to assess the degree of dehydration (Intervention) compared to measurement of weight loss (Comparator)? The review was restricted to only three scales/scoring systems viz. Clinical Dehydration Scale (CDS), World Health Organization (WHO) Scale, and Gorelick Scale.
2. Did the authors look for the right type of papers?	Yes. The authors planned to include all study designs that could address the PICO question framed above.
3. Were all the important, relevant studies included?	Yes. Three of the most important electronic databases were searched, besides bibliographic lists of the identified publications. The output of these searches was presented separately. In addition, two important registers of clinical trials were also searched for ongoing and unpublished studies. The review authors attempted to contact authors of the included studies to obtain raw data. There was no language restriction. These approaches suggest a low probability of missing relevant publications. However, the basis for choosing the three included scales was not specified. Further, the detailed search strategy was not presented.
4. Did the review authors assess quality of the included studies?	Yes. The authors used the QUADAS 2 instrument for assessment of methodological quality. Most of the included studies appeared to have low risk of bias.
5. Is it reasonable to combine the results from different studies?	Although it is reasonable to combine data across studies, the authors did not do so. Instead they displayed the results of diagnostic accuracy of each study individually and provided a summary estimate by presenting the range of individual study estimates, rather than a weighted summary pooling the studies together. The authors attempted to stratify results by the setting where studies were performed, using the country income status as a surrogate marker. However, variations between studies were not explored in detail.
Results	
1. What are the overall results?	Clinical Dehydration Scale • Dehydration <3%: 4 studies, 534 participants, Sensitivity ranging from 0.00 to 0.33, Specificity ranging from 0.80 to 1.00, LR+ ranging from 1.64 to 2.20, LR- ranging from 0.79 to 0.84. • Dehydration 3-6%: 4 studies, 534 participants, Sensitivity ranging from 0.62 to 0.75, Specificity ranging from 0.30 to 0.67, LR+ ranging from 1.10 to 1.88, LR- ranging from 0.57 to 0.90. • Dehydration >6%: 5 studies, 582 participants, Sensitivity ranging from 0.31 to 0.68, Specificity ranging from 0.38 to 0.97, LR+ ranging from 1.08 to 11.79, LR- ranging from 0.60 to 0.87. World Health Organization Scale • Dehydration <5%: 2 studies, 222 participants, Sensitivity ranging from 0.03 to 0.55, Specificity ranging from 0.73 to 0.94, LR+ ranging from 0.48 to 2.00, LR- ranging from 0.60 to 1.03. • Dehydration 5-10%: 3 studies, 271 participants, Sensitivity 5 studies, 463 participants, Sensitivity ranging from 0.36 to 0.86, Specificity ranging from 0.22 to 0.69, LR+ ranging from 1.09 to 1.28, LR- ranging from 0.65 to 0.90 • Dehydration >10%: 5 studies, 463 participants, Sensitivity ranging from 0.00 to 0.79, Specificity ranging from 0.43 to 0.84, LR+ ranging from 0.00 to 2.1, LR- ranging from 0.00 to 1.22 Gorelick abridged Scale • Dehydration 5-10%: 4 studies, 457 participants, Sensitivity ranging from 0.10 to 0.79, Specificity ranging from 0.69 to 0.87, LR+ ranging from 0.40 to 6.25, LR- ranging from 0.24 to 1.20. • Dehydration >10%: 4 studies, 457 participants, Sensitivity ranging from 0.33 to 1.00, Specificity ranging from 0.23 to 0.83, LR+ ranging from 0.43 to 4.85, LR- ranging from 0.00 to 2.88. Gorelick scale • Data from different studies could not be compared on account of differences in criteria used.
2. How precise are the results?	The authors did not pool the data through formal meta-analysis, hence estimate of precision could not be made. However, given that the individual studies had widely differing precision estimates, it is likely that the overall results may not be very precise.

amount of fluid used for rehydration, which in turn depends upon the clinical estimation of dehydration severity (which is based on the very signs being investigated by the included studies). Further, the timing of the measurement of post-rehydration weight is not standardized. In this systematic review [7], three of the included studies used the discharge weight as the surrogate for pre-dehydration weight, and three studies calculated this on the basis of consecutive measurements showing nil or minimal variation, two studies did not specify how and when the final weight was measured, and one study stated 'rehydration weight' but did not clearly define this. In short, the reference standards in the various included studies were neither uniform nor even independent of the index test in some studies.

The second challenge with calculating percentage body weight lost is that although the measure is a continuous variable and intuitively appealing, in reality its interpretation can be difficult. For example, a child with 2% body weight loss is twice as dehydrated as a child with 1% body weight loss, but is not necessarily twice as sick, or having twice the risk of complications. Further, changes in the absolute percentage points can mean different things depending on the baseline status. For example, alteration in body weight lost from 2% to 3% (*i.e.*, 1% decline) does not have the same implications as change in body weight lost from 7% to 8% (also a 1% decline). Of course, the practical problems associated with weighing sick children multiple times during and after rehydration (even in hospital settings) also needs consideration.

Further the clinical scales are based on subjective observations by personnel with varying levels of training and/or experience. Some of the criteria may be difficult to distinguish across levels of dehydration severity. For example, application of the terms 'sunken' and 'very sunken' (for eyeballs) may be highly subjective. It is also important to recognize that many of the signs included in the clinical scales actually represent hypovolemic shock (which is an adverse outcome or complication of dehydration), rather than dehydration alone.

To be fair, many of the challenges highlighted above are inherent to the scales themselves and hence beyond the scope of the systematic review [7]. However, some issues pertaining to the review itself need to be addressed. For example, the authors constructed plots of the results of individual studies evaluating Clinical Dehydration Scale, but did not pool the results through meta-analysis. Instead only ranges of each outcome measure (sensitivity, specificity *etc*.) were presented. The reasons for this are unclear. Similarly, for the Clinical Dehydration Scale, the studies listed in the Table are different from those included in the Figure. Further, one of the studies in the figure shows 99 participants; although, only 98 were included.

One important issue that the authors did not consider is that their results and conclusions pertain only to diagnosing the degree of dehydration in a dichotomous fashion (*i.e.*, present or absent). They did not consider whether the scales could be useful in quantifying the exact amount of dehydration. Further, despite being an apparently continuous variable, percentage weight loss beyond the outer limit of each scale was not quantified. Thus (for example) 11% body weight loss was considered the same as 16% loss. In such a setting, the value of these scales (if any) in quantifying dehydration models was not explored through logistic regression.

Extendibility: None of the included studies was conducted in India; although, some were conducted in other developing countries. The authors also tried to stratify the data from individual studies by the income level of the country where it was performed. However, the major problem with interpretation of the data is the total lack of consideration to pre-existing or underlying malnutrition. In India, a significant proportion of children less than five years suffers from malnutrition [9]. In most such settings, malnutrition is an independent driver of mortality in children with diarrhea and dehydration [10]. Further, many of the clinical signs of dehydration are confounded by similarity with signs representing severe malnutrition. In addition, in settings where nutritional supplementation is provided along with rehydration, the final or discharge body weight may not accurately reflect the degree of dehydration.

Further, even though the systematic review did not find any of the clinical scales to have sufficient diagnostic accuracy for use in clinical practice, it should be emphasized that treatment decisions based on these very clinical observations have resulted in saving millions of lives. This apparent paradox highlights the gap between evidence of efficacy (from research studies) and evidence of effectiveness (from real-world experience); although, in this situation the latter seems superior to the former (unlike most situations).

Conclusion: This systematic review suggested that none of the three clinical dehydration scales can be considered accurate for the purpose of determining the degree of dehydration in children with diarrhea. This is in contrast to real-world experience wherein treatment decisions based on these scales (or components thereof) are believed to be highly effective.

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REFERENCES

1. World Health Organization. Diarrhoeal Disease. Available from: *http://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease.* Accessed May 12, 2018.
2. UNICEF. Diarrhoeal Disease. Available from: *https://data.unicef.org/topic/child-health/diarrhoeal-disease/.* Accessed May 12, 2018.
3. Lakshminarayanan S, Jayalakshmy R. Diarrheal diseases among children in India: Current scenario and future perspectives. J Nat Sci Biol Med. 2015;6: 24-8.
4. Fontaine O, Garner P, Bhan MK. Oral rehydration therapy: the simple solution for saving lives. BMJ. 2007;334(Suppl 1):s14.
5. Drucker G. 500,000 lives saved each year. ORT 10 years after. Int Health News. 1988;9:2
6. Houston KA, Gibb JG, Maitland K. Oral rehydration of malnourished children with diarrhoea and dehydration: A systematic review. Wellcome Open Res. 2017;2:66.
7. Falszewska A, Szajewska H, Dziechciarz P. Diagnostic accuracy of three clinical dehydration scales: a systematic review. Arch Dis Child. 2018;103:383-8.
8. Critical Appraisal Skills Programme (CASP). Available from: *https://casp-uk.net/wp-content/uploads/2018/03/CASP-Systematic-Review-Checklist-Download.pdf.* Accessed April 28, 2018.
9. Ministry of Health and Family Welfare. National Family Health Survey - 4. Available from: *http://rchiips.org/nfhs/pdf/NFHS4/India.pdf.* Accessed April 29, 2018.
10. Ravelomanana N, Razafindrakoto O, Rakotoarimanana DR, Briend A, Desjeux JF, Mary JY. Risk factors for fatal diarrhoea among dehydrated malnourished children in a Madagascar hospital. Eur J Clin Nutr. 1995;49:91-7.

Pediatric Gastroenterologist's Viewpoint

Diarrheal dehydration is so common in pediatric practice that it falls more in the domain of General Pediatrics rather than of a Pediatric Gastroenterologist. Nevertheless, a gastroenterologist could possibly view it with more critical eyes.

The systematic review by Falszewska, *et al*. [1] assessed the diagnostic accuracy of three clinical dehydration scales, and reported that all the three scales had limited sensitivity and specificity over different degrees of dehydration as reported in different studies analyzed for this review. They concluded that WHO [2] and Gorelick scales [3] are not helpful in assessment of dehydration both in developed and developing countries while CDS scale [4] has better reliability in predicting moderate to severe dehydration in developed countries. It is important to note that individual signs of dehydration have limited predictability and only a combination of signs have better predictability.

The systematic review suffers from an important lacuna, as it could not find adequate studies from developing countries, particularly those assessing the adequacy of scales in children with mild to moderate dehydration. It is important, as applicability of these scales of dehydration has never been validated in malnourished children who form a significant proportion of diarrheal children in the developing countries.

WHO system of dehydration assessment was introduced not as a scientific scale (it does not have numerical values attached to various features) but more as a tool to simplify rehydration protocol in hands of health workers and peripheral physicians in countries with limited resources. It basically helped to separate children who could be managed with oral hydration alone (some dehydration) versus those who required immediate resuscitation with intravenous fluids (severe dehydration). It also eliminated the complexities of calculating biochemical compositions of rehydration and maintenance fluids and just recommended using Ringer's lactate for all intravenous rehydration and WHO oral rehydration salt (ORS) solution for all other rehydration. Although not scientifically very accurate, it has served well in the field situations for which it was created and recommended. However, it does not take into consideration special problems of assessment of dehydration in malnourished children or those children who are unable to take adequate ORS solution because of vomiting. To overcome these possible lacunae, the WHO system can be even further simplified to divide diarrheal children into 2 categories: (*i*) those who are alert and thirsty ready to drink adequate ORS; and (*ii*) those who are lethargic, drowsy or vomiting excessively, unable to drink or retain adequate ORS. The former category can be managed safely at peripheral level with oral rehydration under supervision while the latter category needs intravenous rehydration.

Diarrheal dehydration is not only fluid imbalance but is also accompanied by a complex spectrum of dyselectrolytemias, which need to be managed at individual level. From the point of view of a gastroenterologist, any clinical system of assessment of dehydration that does not keep dyselectrolytemias in consideration, can only be a starting point of dehydration management, That further needs to be modified for individual patients.

Thus, for trained pediatricians, a system of dehydration assessment and management, which we learnt as trainee residents in Pediatrics during late sixties, at the All India Institute of Medical Sciences

(New Delhi) was probably much better. We followed a 10-point score where increased thirst, sunken eyes, lost skin turgor and dry mucus membranes were each given a score of one while acidosis (deep and fast breathing), severe oliguria or anuria and shock were given 2 points each. The total score reflected the percentage of dehydration and each percent score required administration of 10 mL/kg rehydration fluids, which were given over 8 hours together with maintenance requirements (30-50 mL/kg for 8 hours). Interestingly, the rehydration fluid recommended was 1:2:3 solution, with 1 part one-sixth molar Sodium bicarbonate, 2 parts Normal saline and 3 parts 5% Dextrose, acknowledging the universality of metabolic acidosis [5] in moderate to severe diarrheal dehydration.

Another simplified version of the same was giving 50/100/150 mL/kg over 8 hours (which included maintenance requirements for 8 hours) for mild (<5%), moderate (5-10%) and severe dehydration (10%), respectively. Here fluids containing 75 mEq/L of Sodium (N/2 saline) was used for rehydration, acknowledging the fact of higher sodium losses in severe diarrhea. [6]. If acidosis was clinically apparent or if documented by plasma bicarbonate levels, sodium bicarbonate was given in bolus as one-sixth molar solution (3-5 mL/kg). Potassium (20 mEq/L) was added to IV fluids only after passage of urine. Fluids containing 30-40 mEq/L of sodium were used for maintenance purposes.

Either of these two systems adequately served the purpose of initiating the rehydration therapy in large majority of diarrheal children not only for restoring hydration status but also taking care of frequently observed electrolyte disturbances.

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REFERENCES

1. Falszewska A, Szajewska H, Dziechciarz P. Diagnostic accuracy of three clinical dehydration scales: a systematic review. Arch Dis Child. 2018;103:383-8.
2. World Health Organization. Treatment of Diarrhea: A Manual for Physicians and Other Senior Health Workers. Available from: *http://apps.who.int/iris/bitstream/10665/43209/19241593180.pdf*. Accessed May 07, 2018.
3. Gorelick MH, Shaw KN, Murphy KD. Validity and reliability of clinical signs in the diagnosis of dehydration in children. Pediatrics. 1997:99:e6
4. Friedman JN, Goldman RD, Srivastava R, Parkin PC. Development of a clinical dehydration scale for use in children between 1 and 36 months of age. J Pediatr. 2004;145:201-7.
5. Narchi H. Serum bicarbonate and dehydration severity in gastroenteritis. Arch Dis Child. 1998;78:70-1.
6. Molla AM, Rehman AM, Sarkar SA, Sack DA, Molla A. Stool electrolyte content and purging rates in diarrhea caused by rotavirus, enetrotoxigenic E coli and V. cholerae in children. J Pediatr. 1981;98:835-6.

Pediatrician's Viewpoint

Dehydration due to diarrhea remains a major cause of morbidity and mortality in developing countries. Dehydration assessment tools with high diagnostic accuracy, good discriminative ability and interrater reliability are of utmost importance in low- and middle-income countries where children have to travel hours to reach a healthcare facility and resources are limited. Various diagnostic tools have been developed and used over the years [1].

So far in literature, the established reference standard to assess degree of dehydration and validate these diagnostic scales, is the percentage difference between pre-illness and admission weight. In case of non-availability of pre-illness weight, percentage weight change before and after resuscitation correlates best with percentage volume loss. But it is of retrospective use, has been shown to be poor predictor of dehydration among infants, and of no value in emergency settings [2].

In this systematic review, the authors have analyzed the evidence so far on diagnostic accuracy of three clinical dehydration scales namely CDS (created at hospital for sick children in Toronto), WHO (recommended by world health organization) and Gorelick Scale (created at the children's hospital of Philadelphia) in identifying dehydration among children with acute gastroenteritis, both in developing and developed countries. All the three scales are based on subjective findings which lack high sensitivity, specificity and reliability. WHO scale integrated with IMCI (Integrated Management of Childhood Illness) has been universally followed in India based on expert opinion [3-5]. In 2008, ESPGHAN and ESPID had concluded that none of the dehydration scales have been validated in individual patients, and there was insufficient evidence to support its use for management of individual child. A decade later, the authors conclude that the clinical scales evaluated provide some improved diagnostic accuracy but their ability to identify children with some dehydration and without dehydration is suboptimal. There is limited evidence in favour of CDS in ruling-in severe dehydration in high income settings while WHO and Gorelick scales are not helpful for assessing dehydration.

Clinical scales which seem to perform well in high-resource settings might not be accurate in low-income countries where there are higher number of undernourished children, severe forms of diarrhea (*e.g*., cholera) and the first contact is with community health workers who have limited training. Inappropriate categorization of children with diarrhea can cause direct harm to the child and lead to misuse of limited resources and longer hospital stays.

This review highlights the need for more research into better bedside methods and objective tools for detecting the severity of dehydration in low-income countries. Newer scales like Dhaka score need to be externally validated [5]. Other imaging tools like bedside ultrasound and capillary digital videography are also promising [6].

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REFERENCES

1. Jauregui J, Nelson D, Choo E, Stearns B, Levine AC, Liebmann O, *et al*. External validation and comparison of three pediatric clinical dehydration scales. PLoS One. 2014;9:e95739.
2. Pruvost I, Dubos F, Chazard E, Hue V, Duhamel A, Martinot A. The value of body weight measurement to assess dehydration in children. PLoS One. 2013; 8:e55063.
3. WHO. The Treatment of Diarrhoea: A Manual for Physicians and Other Senior Health Workers. Geneva: World Health Organization; 2005.
4. WHO. Handbook: IMCI Integrated Management of Childhood Illness. Geneva: World Health Organization; 2005.
5. Levine AC, Glavis-Bloom J, Modi P, Nasrin S, Atika B, Rege S, *et al*. External validation of the DHAKA score and comparison with the current IMCI algorithm for the assessment of dehydration in children with diarrhoea: a prospective cohort study. Lancet Glob Health. 2016;4:e744-51.
6. Freedman SB, Vandermeer B, Milne A, Hartling L. Pediatric Emergency Research Canada Gastroenteritis Study Group. Diagnosing clinically significant dehydration in children with acute gastroenteritis using noninvasive methods: a meta-analysis. J Pediatr. 2015;166:908-16.