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Paediatric diarrhoea — rehydration therapy revisited

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Acute infective diarrhoea remains one of the most common causes of morbidity and mortality in children under 5 years of age. This paper reports on a 7-year experience of management of paediatric diarrhoea at King Edward VIII Hospital, Durban, in which an inpatient case-fatality rate of nearly 25% was reduced to less than 7%, and the admission rate was reduced by 60% by a cumulative effect of the following measures: one of four paediatric wards was converted into a diarrhoea ward; improved attention to protocol resulted in a rapid reduction in the inpatient case-fatality rate, but further improvement resulted from a strong commitment to an efficient outpatient oral rehydration protocol to reduce the pressure on inpatient beds, as well as a simplified approach to fluid therapy; and a formula was developed based on units of 5 ml/kg/h, and applicable to both oral and intravenous routes.

The most important assessment of dehydrated patients is determination of a need for resuscitation. In less severely ill patients it is not necessary to calculate rehydration fluid requirements by a 'percent dehydration' formula.

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Acute infective diarrhoea remains one of the most common conditions affecting infants and young children in the developing world, with many deaths due to dehydration and electrolyte imbalance. The exact prevalence of diarrhoeal disease is unknown in black South African children, but general experience indicates that it remains one of the most common causes of morbidity and mortality in children under 5 years of age. In 1970, gastro-enteritis was responsible for more than twice as many deaths as were due to the second most common cause of mortality in black and 'coloured' children,[1] while a review of South African mortality data for 1968 - 1985 showed that 43,5% of deaths of blacks in the post-neonatal period were attributed to diarrhoea.[2]

Oral rehydration therapy is now widely accepted and has prevented many deaths, but in some institutions has paradoxically resulted in an increase in the inpatient case-fatality rate owing to admission of smaller numbers of patients with more severe diarrhoea. Thus the International Center for Diarrhoeal Diseases Research (ICDDR-B) reported that while the admission rate for acute diarrhoea had been reduced from 22,4% to 4,4% subsequent to the introduction of oral rehydration therapy, the inpatient case-fatality rate had increased from 2,3% to 11,9%.[3]

Inevitably, parenteral rehydration therapy continues to be required for a certain number of patients. Many published recommendations for parenteral fluid therapy base the calculation of the required volume of rehydration fluid on the estimated degree of dehydration, expressed as a percentage of body weight.[4] A patient with estimated 5% dehydration therefore requires 50 ml/kg body weight for rehydration. This volume and any additional fluid required is then administered at a rate calculated to achieve rehydration within approximately 24 hours.

This mathematical model has served well, but it is flawed in several respects: the estimation of the degree or 'percent dehydration' is no more than an educated guess,[5] as each of the clinical signs of dehydration may be influenced by other factors, such as the amount of subcutaneous fat or the serum sodium level. Furthermore, a mathematical model introduces the idea of mathematical accuracy into volume calculations, when in practice neither hydrated weight nor exact stool losses are known at the time of presentation. Additionally, further calculations are required to accommodate ongoing stool losses, maintenance requirements and the contribution of any oral fluids to the fluid balance. Repeated reassessments and recalculations are generally required to ensure progressive rehydration.

Accordingly, mistakes readily occur. In busy hospitals with severe staff shortages, frequent review and recalculation of fluid requirements may not be possible, leading to many preventable deaths due to inadequate rehydration.

King Edward VIII Hospital serves the rapidly expanding urban and semi-urban black population of Durban. The total annual outpatient population of 85 000 - 100 000 children includes an estimated (minimum) 20 000 cases of diarrhoea, representing 20 - 30% of all paediatric outpatients,[6] although records are only kept of total numbers. Before 1985, approximately 2 500 patients with all types of diarrhoea, including cases with severe malnutrition or parenteral diarrhoea, had to be admitted annually and had an inpatient case-fatality rate of about 24%.[7] Large-scale malnutrition, with more than 50% of patients having a weight for age less than the 3rd National Center for Health Statistics (NCHS) centile, gross overcrowding and a serious lack of medical and nursing staff contributed to this picture.

Under such circumstances, it becomes imperative to design simplified and safe oral and parenteral rehydration schedules for adequate outpatient rehydration to reduce the pressure on hospital beds, and to be able to maintain the hydration of patients suffering from dehydrating diarrhoea in inadequately staffed hospital wards.

This paper reports on a 7-year experience of management of paediatric diarrhoea at King Edward VIII Hospital, using an approach to rehydration therapy in which fluid therapy is based on a simplification of the 'percent dehydration' calculation.

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Patients and methods

At the end of 1985, one of four paediatric inpatient wards with 52 beds was allocated to accept only patients with dehydrating diarrhoea, irrespective of any associated conditions such as kwashiorkor, respiratory infection or the post-measles state. There was no increase in medical or nursing staff, and outpatient rehydration therapy continued to be given in the same overcrowded conditions. In view of the extreme pressure on the outpatient rehydration facility, the decision to admit a patient from the outpatient department had to be taken within 24 hours.

During 1986, emphasis was placed on adherence to the standard fluid therapy protocols as published in relevant handbooks, but thereafter a protocol was evolved in which emphasis was placed more on a careful clinical assessment of the state of the circulation, noting the presence or absence of signs of dehydration, hypovolaemic shock and peripheral vasoconstriction, rather than on expressing the degree of dehydration in percentage terms.

A protocol of fluid therapy was instituted for dehydrated patients. Intravenous fluids were indicated for the treatment of shock (as defined by impalpable radial pulses or a capillary filling time longer than 4 seconds), significant abdominal distension, severe acidosis with vasoconstriction, encephalopathy, and deterioration or lack of improvement after adequate oral fluids for 2 - 4 hours.

Shocked patients were resuscitated with plasma volume expanders (Ringer lactate or Plasmalyte L, 20 ml/kg fast). They were additionally given a slow bolus injection of sodium bicarbonate, 2 mmol/kg. After successful resuscitation, they received half-strength Darrow's solution with 5% dextrose at a rate of 10 ml/kg/h until oral fluids could be re-introduced.

In patients who were not shocked but required intravenous fluids according to other criteria including large stool losses, the drip rate was sometimes increased to 15 ml/kg/h for 4 - 6 hours. In patients with hypernatraemia, however, the rate was restricted to 10 ml/kg/h.

Those patients not requiring intravenous fluids as defined above were given oral rehydration fluid (SAPA formulation — Sorol, containing sodium 64 mmol/l, potassium 20 mmol/l, chloride 54 mmol/l, bicarbonate 30 mmol/l and glucose 2%), either by mouth or by nasogastric drip at an initial rate of 15 ml/kg/h, offered in frequent small quantities and increased to 25 ml/kg/h when the child wanted more, until hydration had improved. At that stage, feeds were re-introduced and hydration maintained by administering Sorol 5 - 15 ml/kg, depending on the child's thirst, offered after feeds.

Patients were admitted to the ward within 24 hours in accordance with set guidelines relating to age, nutritional state, duration of diarrhoea and the presence of additional or complicating factors.

Inpatients with severe ongoing diarrhoea were subsequently maintained by means of oral rehydration solution administered by nasogastric tube at rates of 5 ml/kg/h, given in addition to the refeeding programme and increasing to 10 ml/kg/h if necessary to avoid recurring dehydration, except where very watery stools and a positive bedside Clinitest suggested osmotic diarrhoea with sugar malabsorption.

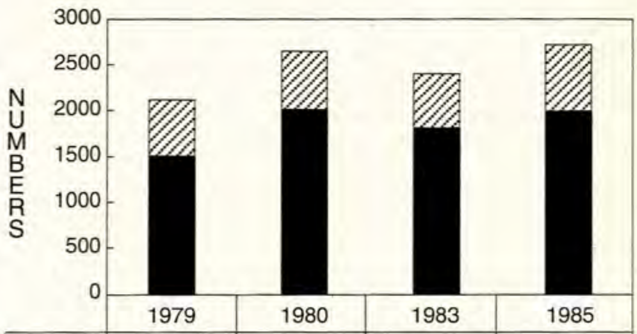
Other aspects of diarrhoea management, including the use of antibiotics where indicated in severely malnourished children or those with evident parenteral infection, the 'bowel cocktail'[8] and a graded approach to refeeding, were carried out in accordance with established guidelines.

For this review, the departmental database served as the source for the annual totals of paediatric admissions. The ward admission and mortality statistics were kept by the consultant in charge. This included regular review of deaths occurring in the ward in an attempt to identify the important precipitating causes.

The ward data were compared with the departmental figures for the period 1979 - 1985. Statistical comparisons were carried out by means of the chi-square analysis for linear trend in proportions.

Results

In the 7 years prior to 1986, the hospital inpatient case-fatality rate for patients with diarrhoea had ranged from 27,3% in 1979, through 22,9% in 1983 to 25,3% in 1985 (Fig. 1).

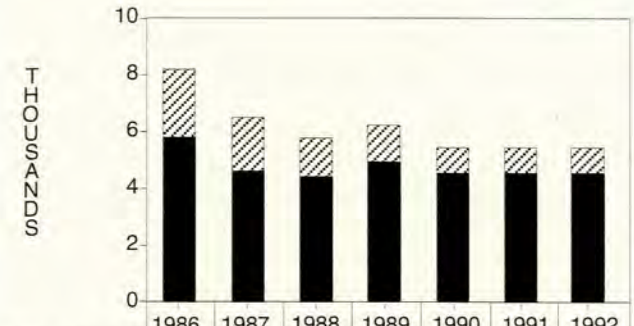


	1979	1980	1983	1985
Dead	577	618	552	682
Alive	1539	2035	1855	2016

Alive ▨ Dead

Fig. 1. Paediatric diarrhoea at King Edward VIII Hospital — inpatient case fatality rate pre-oral rehydration therapy.

The data on the inpatient admissions to the paediatric wards over the 7-year period are shown in Fig. 2. The abrupt reduction in admissions between 1986 and 1987 was mostly due to a policy decision not to admit more than one child per cot at the beginning of 1987, but thereafter there occurred a significant continued reduction in diarrhoea admissions, while the non-diarrhoea admissions have remained at a similar level since 1987. The proportion of admissions due to diarrhoea has significantly decreased from nearly one-third of the total in 1986 to the present one-fifth. For a short while, 'overflow' patients had to be accommodated in other wards, but subsequently the diarrhoea ward has only rarely been full, even in the summer months. The mean ward occupancy for the busy months of December to May decreased from 88% in 1988 to 73% in 1992. The patients admitted more recently have been more seriously ill with a more protracted course, with a mean hospital stay in surviving patients of 12 days. This indicates that most patients with milder disease have been managed successfully in the outpatient department.

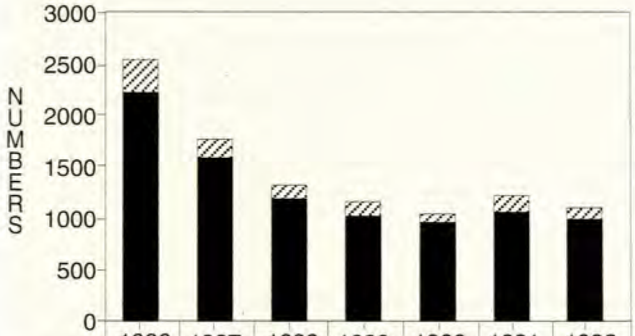


	1986	1987	1988	1989	1990	1991	1992
Diarrhoea ward	2,609	1,791	1,357	1,135	1,015	1,114	1,067
General wards	5,59	4,644	4,494	5,059	4,541	4,477	4,514

■ General wards ▨ Diarrhoea ward

Fig. 2. Paediatric ward admissions at King Edward VIII Hospital.

The inpatient case-fatality rate for the diarrhoea ward decreased by half from 14% in 1986 to 6,3% in 1991 (Fig. 3). This is a highly significant reduction (χ^2 for linear trend 83,549, $P < 0,000001$). Initially, the deaths were commonly attributable to errors of fluid rate calculation, or errors of omission of important components of the total fluid requirement such as the volumes required for estimated daily maintenance and ongoing losses. More recently, the vast majority of deaths in the diarrhoea ward are classified as unpreventable, with HIV infection being associated with a rapidly increasing percentage of the deaths. In addition, we have not identified systematic trends in the development of complications perhaps attributable to the method of fluid therapy such as fluid overload or electrolyte or blood gas disturbances.



	1986	1987	1988	1989	1990	1991	1992
Dead	364	192	135	96	74	70	68
Alive	2245	1599	1222	1039	941	1044	999

■ Alive ▨ Dead

Fig. 3. Paediatric diarrhoea ward, King Edward VIII Hospital.

Discussion

Our data show a remarkable improvement in the outcome of children hospitalised with diarrhoea at King Edward VIII Hospital. The first step was the establishment of a dedicated ward for the management of diarrhoea, in which a standardised protocol of therapy could be introduced and adhered to. In the absence of an adequate short-stay facility, this ward had to cope with severe acute dehydrating diarrhoea as well as all other forms of diarrhoeal disease, including severe malnutrition. This centralisation of therapy was most likely the reason for the initial rapid improvement in the case-fatality rate from the appalling 23 - 27% prior to the establishment of the diarrhoea ward to the 14% seen in 1986. Improved attention to careful clinical assessment and attention to detail of fluid administration and treatment protocol undoubtedly saves lives.

The second step involved the evolution of a simplified approach to fluid therapy, preferably applicable to both oral and intravenous routes. In the management of dehydrating diarrhoea, the main emphasis should be on oral rehydration. This is simple and effective and can prevent many admissions and deaths. The remarkable reduction in admissions for diarrhoea achieved at King Edward VIII Hospital is to a large extent due to efficient outpatient rehydration by the oral route. We have shown, as have numerous others,[9] that good improvement is possible without any increase in staff or facilities in an overcrowded, understaffed Third-World hospital.

For those patients needing intravenous fluids, a simple scheme is likewise required in circumstances where errors of calculation or of administration might go undetected. The 'percent dehydration' method of calculating fluid deficits, as published in most paediatric textbooks, has the additional risk of a mistaken under-assessment of the patient's degree of dehydration and erroneous reliance on the correctness of fluid volume calculation according to a mathematical formula. Practical experience in a very busy, understaffed hospital has shown that this method, while time-honoured and widely and very successfully used, has been associated in Durban with large numbers of dehydration-related preventable deaths. The clinical signs of dehydration are acknowledged to be unreliable in predicting the degree of dehydration, and therefore the 'percent dehydration' assessment has generally been accepted to be no more than a guide to the severity of dehydration.

A fluid volume of 5 ml/kg/h (120 ml/kg/24 h) is equivalent to the maintenance fluid requirement of an infant. It is also equivalent to the rehydration volume needed for approximately '10% dehydration', or to the 24-hour fluid replacement requirement of a '5%' dehydrated child with persisting losses. Based on these considerations, it was possible to establish a simplified fluid therapy protocol in multiples of 5 ml/kg/h, applicable to both oral and intravenous administration. This has the advantage of simplicity in avoiding the confusion between the various calculations for rehydration, maintenance and ongoing losses, and also sets desirable volumes to be administered for adequate oral rehydration. However, in oral rehydration, somewhat larger volumes need to be given than by the intravenous route in view of possible osmotic losses or incomplete absorption.

Comparison of this simplified fluid volume calculation with the standard recommended method shows the close agreement as regards total volumes administered per 24 hours and also complies with the World Health Organisation policy on oral rehydration.

We do not claim that clinical assessment is not required in dehydrating diarrhoea. We do, however, suggest that a careful assessment of the state of the circulation and of the need for resuscitation are the important issues in diarrhoeal dehydration. Once these have been taken care of, there is no real further urgent need to achieve rehydration within a set time frame, provided the patient receives more fluids than he is actually losing. Oral fluid therapy has been shown to achieve rehydration at least as rapidly as the intravenous route,[10] even though the prescription of how much fluid is to be given or how fast is generally much less specific than in the case of intravenous therapy. Expressing the degree of dehydration in terms of a percentage of body weight for the purpose of calculating fluid volumes has little further management relevance in a Third-World context and can safely be relegated to the files of medical history.

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