Hyponatraemia and hypokalaemia are commonly found in malnourished children suffering from gastro-enteritis.1,2 Among 101 Bantu infants with acute gastro-enteritis studied by us, hyperkalaemia was not encountered on admission, and in about two-thirds of the infants the potassium levels were less than 3·4 mEq/litre.3 This is a report on the follow-up electrolyte values of some of the patients whose pretreatment electrolyte concentrations and nutrition status have been reported.4 The purpose of this investigation was to ascertain whether electrolyte levels in Bantu infants with acute gastro-enteritis return to normal and remain within the normal range during the first few days after therapy has been instituted.

**MATERIAL AND METHODS**

Sixty-eight Bantu male infants admitted to hospital with acute gastro-enteritis, uncomplicated by other diseases (as previously defined),5 were studied during the first 6 days of their hospital stay. Only males were selected to facilitate separate stool and urine collections as part of another study in which the effect of different sugars and two levels of fat intake on diarrhoea was evaluated. Patients who appeared moribund on admission were excluded from this study. All patients were weighed immediately on admission and daily thereafter. Blood samples were collected immediately on admission and again on the morning of the second, fourth and sixth days. Plasma sodium, potassium, chloride, total bicarbonate and urea concentrations were determined according to methods previously described.

The 'normal' range of the plasma electrolyte values was the same as previously discussed:6 sodium, 126-144 mEq/litre; potassium, 3·4-5·1 mEq/litre; chloride, 91·0-105 mEq/litre; total bicarbonate, 18-25 mEq/litre. Levels below or above the specified range were designated 'low' or 'high' respectively. Plasma urea concentrations up to 350 mg/100 ml were considered to be normal, and higher values were designated 'high'.

**Therapeutic Regimen**

In 16 of the 68 patients dehydration was thought to be slight and they were given oral fluid and electrolytes only. Nine had half-strength Hartmann's solution and 7 half-strength Darrow's solution until the morning after admission, when it was discontinued and replaced by oral feeds. Fifty-one patients had moderate to severe dehydration and received intravenous fluid and electrolytes. In 23 patients one-third strength Darrow's solution with 5% dextrose was infused, preceded by sodium bicarbonate solution in 4 patients and Ringer's lactate solution in 1 patient. In 28 patients half-strength Darrow's solution with 5% dextrose was given, preceded by sodium bicarbonate in 5 and Ringer's lactate in 2 patients. Ringer's lactate solution (10 ml/lb body-weight) was infused first in those patients who were in a shock-like state. Sodium bicarbonate (10 ml/lb body-weight of a 1·4% solution) was given first in those who appeared clinically severely acidotic. One patient had a subcutaneous infusion of half-strength Ringer's lactate with 2½% dextrose. The quantity of fluid, replacement and maintenance, was estimated according to the degree of dehydration and body-weight of the patient. Some of this was allowed by mouth as half-strength Hartmann's solution in patients receiving parenteral fluid and electrolytes. Oral feeds commenced the morning after admission. Intravenous therapy was discontinued at this stage unless dehydration was still present. Fifty of the 68 patients received a food formula7 containing Casilan, sunflowerseed oil, electrolytes, water and either no sugar or one of 4 different sugars (details to be published). Eighteen patients received 1 of 4 different proprietary milk powders prepared in full strength.8 The quantity of feeds offered was 2½-3 oz/lb/day. Tetracycline phosphate (40 mg/kg/day for 5 days) was prescribed for all patients. It was, however, replaced if indicated after stool culture.

**RESULTS**

Two patients died during the experimental period. Details of the plasma electrolyte and urea levels and the mean body-weights of the patients, as determined on the different days, are tabulated in Table I. The percentage incidence of normal and abnormal electrolyte and urea values (as defined) on the different days after admission is shown in Table II.

There was a step-wise increase of mean sodium, potassium and total bicarbonate concentration as well as mean body-weight from the first to the sixth day. The mean plasma urea level was highest on the first and lowest on the second day. Of the electrolytes, plasma sodium levels were the first to return to normal. Even on the 6th day after admission, low levels of sodium and chloride were respectively found in 15% and 17% of the patients.

No attempt was made to compare the values on the second day (when fluid and electrolyte therapy was usually discontinued) of patients who received one-third strength or half-strength Darrow's solution intravenously. The plasma potassium levels of 2 main groups (Table III) were compared, namely those on the Casilan diet (28 mEq/litre of potassium) and those who received the powdered milk formulae (41 mEq/litre of potassium). To analyse the potassium values of these 2 groups statistically, a suitable model was sought. The present experiment seemed to fit the so-called theory of multifactor experiments having
TABLE I. PLASMA ELECTROLYTE* AND UREA† LEVELS, AND BODY-WEIGHTS OF BANTU MALE INFANTS WITH GASTRO-ENTERITIS ON THE FIRST, SECOND, FOURTH AND SIXTH HOSPITAL DAYS

<table>
<thead>
<tr>
<th>Day</th>
<th>Mean Potassium</th>
<th>Range</th>
<th>SD</th>
<th>Mean Chloride</th>
<th>Range</th>
<th>SD</th>
<th>Mean bicarbonate</th>
<th>Range</th>
<th>SD</th>
<th>Mean Urea</th>
<th>Range</th>
<th>SD</th>
<th>Mean Body-weight (kg)</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>First day</td>
<td>130±4</td>
<td>108-164</td>
<td>10±78</td>
<td>3±02</td>
<td>1±1-5-1</td>
<td>0±83</td>
<td>93±8</td>
<td>70-123</td>
<td>1±11-20</td>
<td>14±31</td>
<td>4-6-27</td>
<td>5±32</td>
<td>47</td>
<td>6-190</td>
<td>52-24</td>
</tr>
<tr>
<td>Second day</td>
<td>130±5</td>
<td>108-149</td>
<td>10±77</td>
<td>3±09</td>
<td>1±2-9-5</td>
<td>1±06</td>
<td>93±2</td>
<td>72-113</td>
<td>1±90-0</td>
<td>18±4</td>
<td>6-5-30</td>
<td>5±58</td>
<td>25±7</td>
<td>5-70</td>
<td>19-46</td>
</tr>
<tr>
<td>Fourth day</td>
<td>135±0</td>
<td>120-154</td>
<td>10±74</td>
<td>3±36</td>
<td>1±7-5-3</td>
<td>0±93</td>
<td>96±8</td>
<td>82-116</td>
<td>1±107</td>
<td>20±6</td>
<td>8-2-32</td>
<td>5±78</td>
<td>35-4</td>
<td>8-91</td>
<td>18-77</td>
</tr>
<tr>
<td>Sixth day</td>
<td>135±7</td>
<td>125-169</td>
<td>10±67</td>
<td>4±01</td>
<td>2±4-5-5</td>
<td>0±86</td>
<td>98±2</td>
<td>85-128</td>
<td>1±61</td>
<td>20±4</td>
<td>7-29-9</td>
<td>5±31</td>
<td>34±3</td>
<td>12-107</td>
<td>18-88</td>
</tr>
</tbody>
</table>

*Mean mEq/litre. †mg/100 ml.

TABLE II. PERCENTAGE INCIDENCE OF NORMAL AND ABNORMAL ELECTROLYTE AND UREA LEVELS (AS DEFINED) IN BANTU MALE INFANTS WITH GASTRO-ENTERITIS ON THE 1ST, 2ND, 4TH AND 6TH HOSPITAL DAYS

<table>
<thead>
<tr>
<th>Day</th>
<th>Sodium</th>
<th>Potassium</th>
<th>Chloride</th>
<th>Bicarbonate</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>First day</td>
<td>7±4</td>
<td>32±4</td>
<td>60±2</td>
<td>45±6</td>
<td>75±0</td>
</tr>
<tr>
<td>Second day</td>
<td>3±0</td>
<td>22±4</td>
<td>74±6</td>
<td>4±5</td>
<td>75±0</td>
</tr>
<tr>
<td>Fourth day</td>
<td>10±6</td>
<td>9±1</td>
<td>80±3</td>
<td>4±3</td>
<td>75±0</td>
</tr>
<tr>
<td>Sixth day</td>
<td>6±1</td>
<td>1±1</td>
<td>92±4</td>
<td>3±2</td>
<td>75±0</td>
</tr>
</tbody>
</table>

TABLE III. PLASMA POTASSIUM LEVELS (mEq/litre) OF PATIENTS ACCORDING TO TYPE OF DIET

<table>
<thead>
<tr>
<th>Day</th>
<th>Casilan*</th>
<th>Milk†</th>
<th>Statistical difference</th>
<th>(5% level of significance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd day</td>
<td>3±10</td>
<td>±0-62</td>
<td>3±38</td>
<td>±1-76</td>
</tr>
<tr>
<td>4th day</td>
<td>3±39</td>
<td>±0-86</td>
<td>4±32</td>
<td>±0-68</td>
</tr>
<tr>
<td>6th day</td>
<td>3±93</td>
<td>±0-92</td>
<td>4±33</td>
<td>±0-58</td>
</tr>
</tbody>
</table>

*Containing 28 mEq/litre potassium. †Containing 41 mEq/litre potassium.

The plasma potassium levels on the second day (when the highest incidence of hypokalaemia was found) were plotted against the percentage of expected body-weight corrected for dehydration as defined (Fig. 1). There was a significant positive correlation between potassium levels and percentage expected weight (r = 0·3127; 95% critical value = 0·233), indicating that patients with the largest weight deficit had the lowest plasma potassium levels.

**DISCUSSION**

Malnutrition was an important contributory cause of hypokalaemia in the patients studied, since a significant positive correlation existed between potassium levels and percentage expected weight. Body potassium depletion and the importance of supplementary potassium administration are well appreciated in kwashiorkor. In the present series potassium levels remained low in a large number of patients, most probably a reflection of inadequate potassium replacement. The plasma potassium values of the patients receiving the higher potassium diet (milk formulae) returned more rapidly to normal than the values of those receiving the Casilan formula. A Student t-test applied to the data on the different days indicated that the values differed significantly at the 95% confidence level on the 4th day, although they were comparable at the time when the diets were introduced (2nd day) and again on the 6th day. The importance of potassium deficiency is further borne out by the fact that 27% of the patients still had abnormally low potassium levels on the 6th day. Structural renal changes may appear and concentration of urine may be hampered by severe potassium deficiency. Considering the sustained hypokalaemia, as well as the high incidence of hyponatraemia initially, half-strength Darrow's solution is to be preferred to a...
one-third strength formula in Bantu infants with gastro-enteritis in our area. If severe hypokalaemia exists, additional potassium may be safely added as soon as urinary flow is established. The oral administration of half-strength Hartmann’s solution to these patients should be discouraged, since it contains only 2 mEq of potassium/litre. Instead, half-strength Darrow’s solution in 5% dextrose should also be given by mouth.

The increased plasma urea levels found on admission were most probably due to impaired kidney excretory function as a result of dehydration. The mean urea level decreased from 47 mg/100 ml on admission to 26 mg/100 ml on the 2nd day, but increased again thereafter, and remained abnormally elevated in about 31% of the patients. The decrease on the 2nd day was probably due to improvement in the hydration state of the patients. The subsequent increase was probably not the result of a generalized worsening of the hydration state, since this was not clinically evident (except in a few patients who had exacerbations of their diarrhoea), and furthermore, the mean body-weights increased step-wise during the experimental period. The increase of the urea concentrations was most probably due to the effect of high protein feeds (commenced on the 2nd day), in the presence of malnutrition. It is well known that in kwashiorkor patients, blood urea levels, although low initially, increase to abnormally high levels soon after dietary treatment is instituted.10,11

SUMMARY
Plasma electrolyte and urea levels of 68 Bantu male infants admitted to hospital with acute gastro-enteritis were determined on admission, as well as on the 2nd, 4th and 6th days following admission. The patients were weighed daily. A Casilan food formula (containing approximately 28 mEq/litre of potassium) was administered to 50 patients, and proprietary milk formulae (containing approximately 41 mEq/litre of potassium) were given to 18. There was a high incidence of hypo-electrolytaemia in general, with potassium and total bicarbonate remaining lower than normal in a large percentage of patients up to the 6th day. There was a significant positive correlation between potassium concentration and percentage expected body-weight, indicating that malnourished patients (with the greatest weight deficit) had the lowest potassium values. The plasma potassium levels of the patients receiving the higher potassium diet (milk formula) returned towards normal sooner than those on the Casilan formula with a lower potassium content. The increased blood urea levels on admission declined on the 2nd day, but subsequently rose and remained elevated in many patients. The implications of the results are discussed.

We wish to thank the Medical Superintendent of H. F. Verwoerd Hospital for permission to publish particulars of the patients, and Prof. L. S. de Villiers, Head of the Institute of Pathology, University of Pretoria, for the plasma electrolyte determinations.

REFERENCES

TETANUS PROPHYLAXIS—ANTIBIOTICS VERSUS ANTITETANUS SERUM*
B. W. HELLBERG, F.R.C.S. (Edin.), Edendale Hospital, Pietermaritzburg

Several generations of medical practitioners have been reared in the belief that equine antitetanus serum (ATS) is an effective prophylactic against tetanus, and that its use is an essential part of the treatment of patients presenting surgically indicated and antibiotics were given according to individual circumstances.

As from 1 January 1966 the following regimen was instituted:

1. The wound was treated according to the usual surgical principles.

2. In all cases active immunization was commenced with an injection of 0.5 ml adsorbed tetanus toxoid. The patient was advised to return in 6 weeks for his second injection and was issued with a card printed in English and Zulu explaining the necessity for his return.

3. A clean, fresh, incised wound with minimal tissue damage received no further prophylaxis.

4. Other wounds were treated with penicillin, usually benzathine penicillin G 1-2 million units, and the patient was advised to return in 4 days for the wound healing to be assessed.

5. The occasional case with gross tissue damage and a severely infected wound of longer standing was given, in addition, ATS 1500 units after the preliminary sensitivity test dose. The use of ATS even in category 5 was finally completely abolished during the latter part of 1966.

RESULTS
In this discussion all cases of tetanus neonatorum are excluded as the question of prophylaxis does not then arise.