1. INTRODUCTION

Dehydration, or the loss of fluid and salt from the body, can be an uncomfortable and sometimes life-threatening disorder. In the healthy individual, dehydration may occur as a result of vigorous exercise, after exposure to extreme degrees of heat, or in industrial workers working in warm to hot ambient temperatures with protective clothing. The degree of dehydration determines the occurrence of symptoms and complications. Low levels of dehydration (2% loss of body weight or more) impair cardiovascular and thermoregulatory responses and reduce the capacity for further work or exercise (1). Dehydration may also occur as a result of illness characterized by excessive loss of fluid from the body, such as in diarrhea or in diseases that lead to excessive vomiting or excessive loss of water in the urine. In these conditions, water loss may sometimes exceed 10% of body weight, and the disturbance of homeostasis may become life-threatening. Indeed, dehydration from diarrhea is a significant cause of morbidity and mortality in children in developing countries. Rehydration refers to the replacement of fluid and electrolytes to correct dehydration. In severe dehydration, particularly when there is ongoing fluid loss, as in diarrhea, rehydration must be achieved intravenously. In less severe dehydration (and in the absence of significant vomiting), the gastrointestinal (GI) tract has the capacity to absorb fluid rapidly and can be the route of rehydration. This chapter focuses exclusively on oral rehydration and briefly examines recent progress in the understanding of the mechanisms underlying intestinal absorption of fluid and electrolytes and how this understanding affects the design of beverages intended for oral rehydration. This chapter also distinguishes between oral rehydration solution (ORS), which was originally introduced for the treatment of dehydration in diarrhea, and other fluids (oral rehydration fluids, ORF) that do not meet the recommended formulation for ORS but can nevertheless be used to maintain hydration in selected situations. Such a distinction has been recommended by a Working Party of the World Congress of Gastroenterology 2002 (2).
2. PHYSIOLOGICAL BASIS FOR ABSORPTION OF ELECTROLYTES AND WATER FROM THE INTESTINE

Water absorption from the intestine and colon is entirely passive and linked to the active absorption of ions (e.g., sodium) or nutrients (e.g., glucose and amino acids). Active absorption implies the expenditure of energy for absorption and can occur against concentration or electrochemical gradients. Sodium is the major ion that is actively absorbed by the epithelial cells lining the intestine and colon, and its absorption is a significant driving force for water absorption. Chloride, another major ion in the diet, is either actively absorbed by epithelial cells coupled to sodium or absorbed passively through the paracellular pathway, depending on the segment of intestine that is under consideration.
Table 1
Pathways for Active Absorption in Different Levels of the Intestine

<table>
<thead>
<tr>
<th>Segment of intestine</th>
<th>Absorptive pathway</th>
<th>Effect of aldosterone</th>
<th>Effect of cAMP and other secretagogues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jejunum</td>
<td>Na-H exchange</td>
<td>Inhibited</td>
<td>Inhibited</td>
</tr>
<tr>
<td></td>
<td>Glucose-Na cotransport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aminoacid-Na cotransport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ileum</td>
<td>Coupled NaCl absorption</td>
<td>Inhibited</td>
<td>Inhibited</td>
</tr>
<tr>
<td></td>
<td>Na channels</td>
<td>Enhanced absorption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glucose-Na cotransport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amino acid-Na cotransport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal colon</td>
<td>Coupled NaCl absorption</td>
<td>Inhibited</td>
<td>Inhibited</td>
</tr>
<tr>
<td></td>
<td>SCFA-linked NaCl absorption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal colon</td>
<td>Na channels</td>
<td>Enhanced absorption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCFA-linked NaCl absorption</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Na-H exchange signifies sodium-hydrogen exchange; SCFA-linked NaCl absorption indicates electroneutral sodium chloride absorption linked to short-chain fatty acids; — indicates that no effect on this process is known.

Different absorptive pathways predominate in different segments of the intestine, as shown in Table 1. The upper small intestine is responsible for absorption of glucose and other nutrients, after digestion within its lumen. Water absorption in the upper small intestine follows the absorption of nutrients, particularly glucose and amino acids. Perfusion studies of human jejunum have demonstrated that net sodium absorption ceased when luminal sodium concentration fell below 133 mmol/L (3). The intercellular junctions between epithelial cells in the jejunum are permeable or “leaky” and allow the rapid movement of fluid either into or out of the intestinal lumen, depending on the balance between osmotic forces in the lumen of the intestine and the blood. Thus, if a meal or beverage with high sugar content (i.e., high osmotic load) is ingested, fluid quickly rushes into the lumen of the jejunum. On the other hand, rapid absorption of water occurs if the beverage is of lower osmolarity than plasma. In the ileum, different processes for sodium absorption predominate, and the junctions between the epithelial cells lining the intestine are less leaky, causing greater dependence of water absorption on sodium absorption. Sodium absorption is more avid and can occur even from a solution with a sodium concentration of 35 mmol/L (3).

In the colon, the epithelial cells have a great capacity to absorb sodium. In addition, the intercellular junctions between epithelial cells in the colon are tight. These two attributes confer on the colon the ability to dehydrate the luminal contents. Perfusion studies have demonstrated sodium absorption from the colon, even when the concentration of sodium in the luminal solution is as low as 25 mmol/L (4). Measurement of ileocecral flow in healthy adults, using slow marker perfusion, suggests that the normal colon absorbs approx 1500 mL water, 190 mmol sodium, and 95 mmol chloride daily (5).
The colon's ability to absorb sodium and water is physiologically significant. Subjects who have had their entire colon removed are well adapted under normal circumstances but may become dehydrated when exposed to heat or a low-sodium diet or during diarrhea. In chronic dehydration, aldosterone secretion increases and the renin-angiotensin system is activated. The colon responds to both of these hormones by increasing sodium absorption via sodium channels (6,7) and coupled NaCl absorption (8), respectively, allowing it to further conserve sodium and fluid in the adaptation of the body to dehydration.

One must recognize that the mechanisms responsible for sodium and water absorption in the healthy intestine may be altered in the presence of intestinal disease. In the healthy intestine, the normal sodium absorptive pathways remain intact and can be used for fluid absorption and for rehydration. On the other hand, sodium-hydrogen exchange and coupled NaCl absorption, which are the transport mechanisms responsible for the bulk of sodium absorption in health, are inhibited in diarrhea resulting from the cellular effects of the second messengers that mediate diarrhea (Table 1). Glucose-linked or amino acid-linked sodium absorption in the intestine is not inhibited in diarrhea, and this is the rationale for the use of oral rehydration solutions (9). By administering sodium and other salts along with glucose, it is possible to stimulate sodium and water absorption from the intestine, even though fluid secretion (which is secondary to active chloride secretion) into the lumen of the intestine continues alongside. The composition of the rehydration fluid, therefore, depends, to a large extent, on the purpose for which it is intended, the specific absorptive pathway that is targeted, and the accompanying disturbances in homeostasis that it is designed to correct.

3. CONSIDERATIONS IN DESIGN OF REHYDRATION SOLUTIONS FOR USE WITH NORMAL INTESTINE

Dehydration may occur with excessive sweating and skin losses. Intense exercise can cause the loss of 1–3 L of fluid/h (10) and may be aggravated by warm climates. The fluid deficit typically ranges from 2–4% of body weight. At this level of dehydration, body fluid replacement can be achieved efficiently by oral rehydration, and intravenous (iv) rehydration is unnecessary. Ingested liquids are generally rapidly emptied from the stomach to reach the duodenum and jejunum, where maximum absorption is intended to take place. Studies in horses indicated that more than 90% of a single dose of 8 L fluid instilled into the stomach was emptied within 15 min (11). However, in studies in exercising volunteers, ingestion of beverage of approx 23 mL/kg was accompanied by a gastric emptying rate of 13 mL/min, indicating that it would take nearly 2 h for the stomach to empty the ingested beverage (12). The volume and nutrient content of the beverage ingested, but not its osmolarity, determine the rate of gastric emptying and must be considered in the design of oral rehydration beverages (13). In the duodenum, water quickly moves into or out of the bloodstream, so that the osmolality within the lumen approaches 280–290 mOsm/kg by the time the contents enter the jejunum (12,14). Bulk flow of water is, thus, a major consideration here, whereas the active sodium absorption mechanisms shown in Table 1 contribute to fluid absorption in the longer term. Although carbohydrate inclusion in the beverage provides substrate for oxidation and energy needs, the sugar concentration that is included is critical to ensuring efficient absorption. For
instance, a 2% carbohydrate electrolyte drink was more efficient in replacing plasma volume and increasing physical performance than a 15% carbohydrate electrolyte drink (15). Monosaccharides and disaccharides impose a high osmotic load, which likely interferes with fluid absorption from the duodenum and jejunum. Complex carbohydrates (e.g., glucose polymers) can, in theory, be advantageously used in this situation, because they are rapidly hydrolyzed in the jejunum to provide glucose for sodium and water absorption, without increasing luminal osmolarity (16). The sweat and urinary losses during vigorous exercise have been calculated at approx 1800 mL water, 80 mmol sodium, and 33 mmol potassium per hour (17). Some studies indicate that ingestion of water alone expands the plasma volume to the same extent as solutions containing electrolytes or carbohydrate and electrolytes but that the effect of water ingestion is comparatively ill sustained (17). Animal studies suggest that isotonic plasma-like solution is more effective in restoring plasma volume than an equivalent amount of water (18).

Debate regarding the composition of rehydration solutions designed for use during exercise relates to the carbohydrate and electrolyte composition. The current evidence regarding these parameters is summarized as follows. Sodium content and osmolarity of rehydration beverages does not significantly affect intestinal absorption of water or plasma volume changes during exercise (12), but carbohydrate-containing solutions provided better hydration than plain water (19). Sodium concentrations ranging from 25 to 50 mmol/L are adequate to provide hydration and restoration of cardiovascular function for rehydration after exercise (20). Increasing the sodium content leads to more rapid restoration of plasma volume and removes the stimulus to drink further, whereas the complete absence of sodium rapidly removes the osmotic stimulus for absorption. Hence, sodium content at the lower end of the suggested range is optimal to strike a balance during rehydration (21). All these observations relate to the ingestion of rehydration beverages during exercise, and there is evidence to indicate that rehydration carried out after exercise may require the use of fluids with higher sodium content (22).

4. CONSIDERATIONS FOR THE DESIGN OF ORAL REHYDRATION SOLUTIONS FOR USE IN DIARRHEA

Diarrheal illness causes considerable morbidity and mortality in children in developing countries. Compiled health statistics indicate that mortality from diarrheal disease in children under the age of 5 yr has reduced to 1.8 million/yr compared to more than 3 million/yr a decade ago (23). ORS was introduced in the 1960s after the recognition of glucose-linked sodium absorption as an important pathway of sodium and fluid absorption in the intestine and one that was intact in the secreting intestine in diarrhea (9). ORS revolutionized diarrhea management, correcting dehydration and preventing unnecessary deaths, especially in children. The reduction in mortality resulting from the use of ORS made it one of the important medical advances of the 20th century, because of its simplicity and scope to save lives (24). Nonetheless, global use of ORS has been considerably lower than expected.

Several reasons underlie this disappointing rate of ORS use in the community. Intravenous rehydration may be preferred because of its ease, particularly in developed countries (25). The perception of ORS as a "nondrug" has also led to inadequate prescription and use (26). The basis of ORS use is that the enterotoxins causing diarrhea do not impair
sodium absorption linked to specific substrates (i.e., glucose and amino acids) (9). Although it enhances fluid absorption from the secreting intestine, the glucose-based ORS that has, in the past, been recommended by the World Health Organization and UNICEF does not reduce intestinal secretion or diarrhea and may paradoxically increase diarrhea (27). This was one factor responsible for poor use of ORS, especially by previous users (28).

During the last 20 yr, numerous studies were conducted to develop an improved or “super” ORS that could, in addition to being effective therapy to treat and prevent dehydration, reduce the severity and duration of diarrhea. The inclusion of amino acid substrates (glycine, alanine, and glutamine) in ORS to replace or supplement the effect of glucose on sodium absorption did not prove advantageous compared with glucose ORS (29). Glutamine, which is particularly interesting because of its role in providing energy to intestinal epithelial cells and its effects on immunity, was effective in reducing small intestinal secretion in experimental models of diarrhea. However, clinical trials in children with noncholera diarrhea did not show any advantage compared with glucose ORS (30). Maltodextrins and cereal-based ORS were introduced to change the carbohydrate substrate in ORS, by providing glucose in the lumen at a reduced osmotic penalty compared with glucose ORS. Maltodextrin ORS did not show any advantage compared with glucose ORS (29). The greatest promise came when several rice-based solutions were introduced to manage diarrhea. Meta-analysis of 15 evaluable clinical trials indicated that rice ORS was superior to glucose ORS in cholera (leading to reduced stool output) but not in noncholera diarrhea in children (31). Early refeeding of patients, commencing within 4 h after initiation of rehydration, has now become the standard of care in treating diarrhea, contrary to the earlier practice of withholding feeds. This possibly achieves some of the same effects as rice ORS. The ability of rice ORS to shorten diarrhea in cholera has been attributed to the low osmolarity of the solution, as well as a kinetic advantage resulting from the hydrolysis of starch end-products close to the sodium glucose cotransporter (32). However, other factors, including a possible antisecretory factor found in rice (33), could contribute to its effect in cholera.

The single most widely accepted change in the formulation of ORS for diarrhea has been in reduced osmolarity solutions. The glucose ORS that was recommended by the World Health Organization has an osmolarity of 311–331 mOsm/kg (see Table 2). Physiological studies established that reducing the osmolarity increases absorption of sodium and water from the proximal small intestine in both normal and secreting animals (38,39). Following several clinical trials of reduced osmolarity ORS, a multicenter evaluation of hypoosmolar ORS was conducted, and the reduced osmolarity solution decreased stool output by 39%, ORS intake by 18%, and duration of diarrhea by 22% compared with standard ORS in children with diarrhea (40). A second multicenter trial failed to demonstrate any benefit from reduced osmolarity solution in stool volume or diarrhea duration (41). However, the need for unscheduled iv fluids was reduced by a third in the reduced osmolarity group compared with glucose ORS. There is general consensus that hypoosmolar ORS is preferable to treat diarrhea in children (which is usually the result of rotavirus or bacterial causes other than cholera), and that early refeeding is equally important in diarrheal management (42). The goal of oral rehydration is to achieve reduction in mortality using a single rehydration fluid, which would be applicable in all clinical situations. In areas where cholera is prevalent, there has been worry regarding the
### Table 2
Recommendations of Health Organizations and Professional Bodies Regarding Composition of Oral Rehydration Solution for Use in Diarrhea

<table>
<thead>
<tr>
<th>Solution</th>
<th>Na (mmol/L)</th>
<th>K (mmol/L)</th>
<th>Cl (mmol/L)</th>
<th>Citrate (mmol/L)</th>
<th>Other (mmol/L)</th>
<th>Glucose (mmol/L)</th>
<th>Osmolarity (mOsm/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO <em>a</em></td>
<td>90</td>
<td>20</td>
<td>80</td>
<td>10</td>
<td>111</td>
<td>311</td>
<td></td>
</tr>
<tr>
<td>(Citrate) 1976 (34)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHO Bicarbonate 1976 (36)</td>
<td>90</td>
<td>20</td>
<td>80</td>
<td>HCO₃ 30</td>
<td>111</td>
<td>331</td>
<td></td>
</tr>
<tr>
<td>ESPGAN 1992 (35)</td>
<td>60</td>
<td>20</td>
<td>60</td>
<td>10</td>
<td>74–</td>
<td>200–</td>
<td>250</td>
</tr>
<tr>
<td>WHO Resomal <em>b</em> 2000 (37)</td>
<td>45</td>
<td>40</td>
<td>70</td>
<td>7 Mg 3</td>
<td>75</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>WHO 2002</td>
<td>75</td>
<td>20</td>
<td>65</td>
<td>10</td>
<td>75</td>
<td>245</td>
<td></td>
</tr>
</tbody>
</table>

*WHO, World Health Organization; ESPGAN, European Society for Paediatric Gastroenterology, Hepatology and Nutrition; AAP, American Academy of Pediatrics.*

*a*2002 WHO recommendations are proposed and in process.

*b*Resomal is intended for use in diarrhea in severely malnourished children.

The use of hypoosmolar ORS in the community because of the possibility of developing symptomatic hyponatremia in a minority of patients with cholera and high purging rates. A recent clinical trial of the reduced osmolarity solution in 300 adult patients with cholera concluded that the new solution was as effective as the glucose ORS regarding hydration and diarrhea (43). Although hyponatremia (serum sodium below 130 mmol/L) was twice as common in the reduced osmolarity ORS group, it did not lead to symptoms in any patients. Persistent diarrhea, or diarrhea that lasts longer than 14 d, is seen in a small proportion of children who develop acute diarrheal illness. A recent trial examined the efficacy of reduced osmolarity solution on stool volume, need for rehydration fluid, and resolution of illness in infants with persistent diarrhea. The reduced osmolarity solution reduced stool volume by 40% and ORS requirement by approx 25% and hastened resolution of illness (44). Based on these lines of evidence, the World Health Organization is now changing its recommended formulation to a new solution containing 75 mmol/L sodium and 75 mmol/L glucose, which has considerably lower osmolarity than the previous recommended solution.

All the interventions (glucose, amino acids, and hypoosmolar solutions) described were targeted at small intestinal fluid absorption. Although it is true that the small bowel has the capacity to absorb between 12 and 22 L of fluid per day when needed, this capacity to absorb is compromised in diarrheal disease. The colon absorbs approx 1.5 L of water
per day in health (5). However, when stressed, as in diarrhea, the colon can absorb up to 6 L of water per day (45). The reserve capacity of the colon to absorb fluid is tremendously important in diarrheal disease, where it acts to minimize fecal fluid losses (46). The absorptive capacity of the colon is impaired by the effect of enterotoxins such as cholera toxin and Escherichia coli heat stable toxin (47). Indeed, perfusion of the colon in patients with cholera indicate that colonic absorption of sodium and water is absent in these patients (48). Therefore, it is likely that interventions specifically targeted at enhancing colonic absorption may limit diarrhea.

Fermentation of unabsorbed dietary carbohydrate by anaerobic bacteria in the colon results in the production of short-chain fatty acids (SCFA), of which acetate, propionate, and butyrate are found most abundantly in the human colon. SCFA are the primary stool anion, with concentrations ranging from 100 to 130 mmol/L. SCFA significantly increase sodium and water absorption from the normal human colon, through a process of linked ion exchanges across the luminal membrane of colonic epithelial cells (49). This pathway of sodium absorption, i.e., that linked to SCFA, is not inhibited by cyclic AMP (50). In addition, there is evidence from animal studies that SCFA may inhibit active chloride and fluid secretion in the colon caused by cholera toxin and other bacterial enterotoxins (47, 50, 51). Restricting normal dietary intake during diarrhea reduces the availability of unabsorbed carbohydrate to the colon and leads to reduced SCFA concentration in the feces in patients with diarrhea (52, 53). SCFA are rapidly absorbed from all levels of the intestine and cannot be included in ORS because they would not be expected to reach the colon, their site of action. Amylase-resistant starch, nonstarch polysaccharides (e.g., pectin), and fructooligosaccharides are all different classes of carbohydrate that escape digestion in the small intestine to reach the colon for SCFA fermentation (54). Of these, starch has a favorable profile of fermentation because significant production of butyrate results from its fermentation (55). Incubation of stool from patients with cholera with starch resulted in SCFA production, indicating that the colonic flora in cholera retained the capacity to ferment carbohydrate (56). On the basis of these studies, amylase-resistant starch was given to patients with cholera, along with ORS, assuming that SCFA resulting from its fermentation would increase colonic fluid absorption (57). Addition of the amylase-resistant starch to ORS resulted in significant reduction in diarrhea (approx 30% reduction in stool volume after 12 h) and in diarrhea duration (reduced by approx 37%) in the test group compared with glucose ORS. Resistant starch ORS was also significantly better than rice ORS, which was included as another group for comparison.

Studies with rice ORS suggest that the response of the patient with cholera may differ from that of patients with other forms of diarrhea. It is, therefore, interesting to examine the evidence for the inclusion of indigestible carbohydrate (for fermentation to SCFA in the colon) in diarrhea other than cholera. Rotavirus is a major causative agent of diarrhea in infants and children. Pigs infected with transmissible gastroenteritis virus provide a model of rotavirus infection, and studies in these animals showed that diarrhea developed only in young animals but not in older animals (58). Investigation of their intestinal and colonic content showed that infected animals of all ages secreted fluid into the small intestine. However, in contrast to older animals, the young ones demonstrated fluid secretion into the colon in addition to the intestine, which was associated with inability to ferment carbohydrate to SCFA in the colon. Experiments in rats show that recovery
from osmotic diarrhea is accelerated by substrates, such as gum arabic or modified tapioca starch, which are potential sources for colonic fermentation (59). Some of these inclusions in ORS may have other effects. Gum arabic promotes absorption by acting on nitric oxide (60), which is another potential ingredient to include in ORS for the treatment of diarrhea. Diarrhea is also common in patients who receive enteral polymeric feeds directly through a tube into the stomach or intestine. Fluid secretion into the colon has been noted in these patients and may be responsible for diarrhea (61) and can be reversed by the presence of SCFA in the luminal fluid (62). The role of colonic carbohydrate substrate in ORS for noncholera diarrhea was addressed by a study in children with diarrhea. Partially hydrolyzed guar gum (a soluble fiber designed to increase SCFA levels in the colon) was added to ORS as a source of fermentable carbohydrate. Children who received this ORS showed an 18% reduction in diarrhea duration and a trend to reduced stool volumes compared to glucose ORS (63). The use of SCFA to manage diarrhea has also been indirectly shown in persistent diarrhea. In children with persistent diarrhea, addition of mashed green banana (high content of resistant starch) or pectin (soluble fiber) to therapy resulted in rapid recovery and reduced need for further rehydration compared with children given standard therapy (64).

Addition of other constituents to ORS may also help early recovery from illness or prevent complications, such as persistent diarrhea and malnutrition. Vitamin A and zinc are nutrients essential for intestinal epithelial function; they are lost during any diarrheal illness (65,66), and their depletion continues with prolonged illness. Deficiency of these micronutrients may, in turn, contribute to impaired intestinal mucosal function and persistence of diarrhea. It may, therefore, be appropriate to add micronutrients to ORS meant for the treatment of diarrhea in children (67). Efforts have also been made to provide high carbohydrate content in ORS without increasing osmolarity to increase the energy density of ORS and, thus, to improve the nutrition of children with diarrhea. Complex carbohydrates, such as starch, provide energy without increasing osmolarity but increase ORS viscosity. In practice, this may be overcome by using α-amylase to partially hydrolyze the starch before adding it to ORS (68), resulting in an energy-dense solution with osmolarity within the prescribed limits for ORS. This approach is experimental but may become commercially feasible if trials indicate that it is acceptable to the caregivers in the community.

5. CONCLUSION

The physiologic principles underlying the design and use of beverages intended for rehydration are now more clearly understood. The present state of our knowledge suggests that rehydration fluid composition should vary according to the specific conditions demanding their use. Rehydration in the presence of normal intestinal function can be conducted with several fluids, without leading to harmful side effects. The composition of these is, therefore, largely dictated by the additional benefits to be obtained from such fluids. On the other hand, rehydration in patients with diarrhea necessitates the use of a formulation complying with a narrower range of specific requirements. Multiple factors continue to hinder the general acceptance of rehydration fluids and beverages in the community. Physiologic, clinical, and operational research has already helped to optimize the composition of rehydration fluids to a considerable extent, but further progress in this area is expected.
6. MAIN POINTS FOR PRIMARY AND CLINICAL REVIEW

1. Normal losses of fluid from sweating can generally be easily replaced by reabsorption from the intestine using a 25–50 mmol/L sodium or 2% carbohydrate solution or a mixture of both.

2. In the late 1980s, diarrheal disease killed over 3 million children yearly, largely as a result of dehydration. Oral rehydration therapy (ORT) and its glucose-linked sodium absorption have massively reduced this.

3. ORT is inadequately prescribed to affected children, in part because it paradoxically increases diarrhea formation while improving patient fluid rehydration status.

4. WHO currently suggests that ORT solutions should contain 75 mmol/L sodium and 75 mmol/L glucose, which consists of a lower osmolarity than original formulations.

5. A rice-based ORT solution apparently helps anaerobic bacteria produce short-chain fatty acids that may improve colonic sodium and water reabsorption, in addition to inhibiting active chloride and water secretion stimulated by choleratoxin.

REFERENCES


