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Sodium dichloroisocyanurate (NaDCC) tablets as an alternative to sodium hypochlorite for the routine treatment of drinking water at the household level

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Abstract

Household water treatment using sodium hypochlorite (NaOCl) has been recognized as a cost-effective means of reducing the heavy burden of diarrhea and other waterborne diseases, especially among populations without access to improved water supplies. Sodium dichloroisocyanurate (NaDCC), which is widely used in emergencies, is an alternative source of chlorine that may present certain advantages over NaOCl for household-based interventions in development settings. We summarize the basic chemistry and possible benefits of NaDCC, and review the available literature concerning its safety and regulatory treatment and microbiological effectiveness. We review the evidence concerning NaDCC in field studies, including microbiological performance and health outcomes. Finally, we examine studies and data to compare NaDCC with NaOCl in terms of compliance, acceptability, affordability and sustainability, and suggest areas for further research.
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Keywords: Chlorine; Household; NaDCC; Sodium hypochlorite; Sodium dichloroisocyanurate; Water treatment

Background

Contaminated drinking water, along with inadequate supplies of water for personal hygiene and poor sanitation, are the main contributors to an estimated 4 billion cases of diarrhoea each year causing 2.2 million deaths, mostly among children under the age of five in developing countries (Kosek et al., 2003). Unsafe water is also an important contributor to other potentially waterborne diseases, including typhoid, hepatitis A and E, polio and cholera.

An estimated 1.1 billion people lack access to improved water supplies; many more are forced to rely on supplies that are microbiologically unsafe (World Health Organization (WHO), 2004). While universal access to safe, piped-in water is an important long-term goal, this is likely to be elusive for many years to come due to the costs of building and maintaining such systems. Improving the microbiological quality of drinking water, particularly at the household level, is effective in preventing diarrhoea in settings where it is endemic (Clasen et al., 2006). The WHO is promoting the treatment of water at the household level to provide

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a means of accelerating the health gains associated with safe drinking water (http://www.who.int/household_water/en/).

A review of the available methods of treating water at the household level found chlorination to be among the most promising in terms of effectiveness, affordability and potential sustainability (Sobsey, 2002). Research has also shown that chlorinating water in the home is one of the most cost-effective means of preventing diarrhoeal disease (WHO, 2002; Hutton and Haller, 2004). Produced and sold widely as household bleach, sodium hypochlorite (NaOCl) is perhaps the most accessible, and thus potentially sustainable, of drinking water disinfectants. Interventions using NaOCl to treat water at the household level have demonstrated its health impact in preventing diarrhoea (Quick et al., 2002; Reller et al., 2003; Luby et al., 2004). At the same time, uptake outside an epidemic has proved challenging even when supported by social marketing and other campaigns (Makutsa et al., 2001). Educational and motivational approaches increase adoption but add to program cost (Quick, 2003). Program implementers are thus seeking alternatives that may be more readily embraced by the target population.
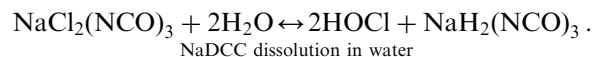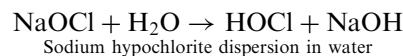
One possible alternative is dichloroisocyanurate (NaDCC), also known as sodium dichloro-s-triazine-trione. Widely used for the emergency treatment of water, NaDCC has recently been approved by the United States Environmental Protection Agency and the WHO for the routine treatment of drinking water. Like other forms of chlorine, NaDCC produces hypochlorous acid, a well-known oxidizing agent. Bound with cyanuric acid, however, the compound presents certain advantages over NaOCl as a water disinfectant (Macedo and Barra, 2002). It may also offer other advantages in terms of stability, safety, up-front cost and convenience. This review compares NaDCC with NaOCl and examines the available evidence concerning its use as a possible alternative for the routine treatment of drinking water by householders in low-income settings.

Basic chemistry and potential advantages of NaDCC over NaOCl

Chlorine has been used as a disinfectant for the treatment of drinking water for more than 100 years. It is by far the most commonly used means of disinfecting water, and its effectiveness as a microbicide has been widely assessed (AWWA, 2000). While most conventional systems in developed countries treat water with chlorine gas (delivered as a liquid in pressurized systems), other common alternatives include calcium hypochlorite, sodium hypochlorite, lithium hypochlorite and chloroisocyanurates (sodium dichloroisocyanurate

or trichloroisocyanuric acid). Until recently, the isocyanurates were used chiefly in the disinfection of water for swimming pools and industrial cooling towers. They are also a common microbial agent in cleaning and sanitizing applications, including baby bottles and contact lens (Dychdala, 2001).

All of these compounds disinfect water by releasing free available chlorine (FAC) in the form of hypochlorous acid (HOCl). For example,

$$NaOCl + H_2O \rightarrow HOCl + NaOH$$
Sodium hypochlorite dispersion in water

$$NaCl_2(NCO)_3 + 2H_2O \leftrightarrow 2HOCl + NaH_2(NCO)_3 .$$
NaDCC dissolution in water

FAC (chlorine in the +1 oxidation state) is an effective biocide against a wide range of bacteria, fungi, algae, and viruses (White, 1998). Regardless of the original source of the available chlorine, the active microbicidal agent is hypochlorous acid. This also means that the most common method used in the field to assess the safety of drinking water—measuring FAC using the DPD reagent—is equally applicable with respect to water treated with NaDCC.

While both NaOCl and NaDCC rely on HOCl as the active agent, there are important differences in the performance of the two compounds. Unlike NaOCl which releases all of its chlorine as FAC, NaDCC releases only approximately 50% of the chlorine as FAC, the balance remaining as "reservoir chlorine" (bound) in the form of chlorinated isocyanurates (Bloomfield and Miles, 1979). When the FAC is used up, the equilibrium is disturbed, immediately releasing further FAC from the "reservoir" until the total available is used up. Thus, as shown in Figs. 1 and 2, the stabilized chlorine in NaDCC acts as a reservoir of HOCl which is rapidly released when the free available chlorine is depleted (Kuechler, 1997, 1999).
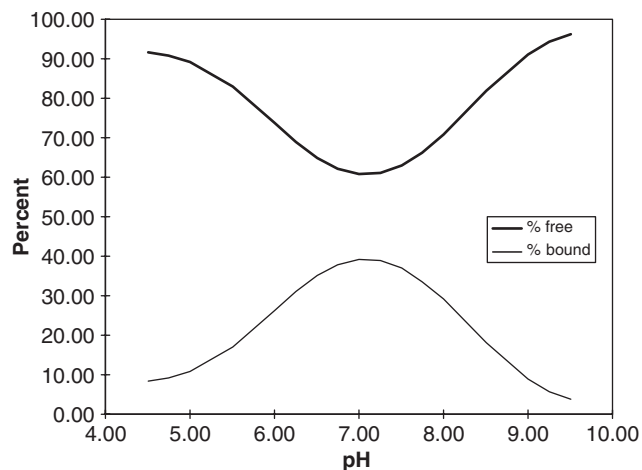

Fig. 1. Free and bound available chlorine in a solution of 1 mg/l NaDCC.
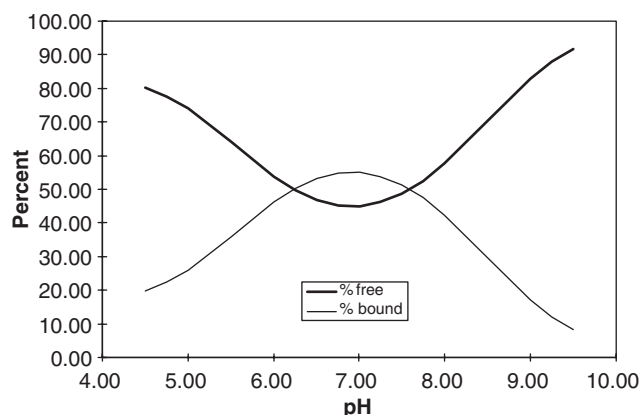
Fig. 2. Free and bound available chlorine in a solution of 3 mg/l NaDCC.

This "reservoir" of FAC also enhances the biocidal protection over NaOCl when water is subject to high or variable organic loads (Bloomfield and Uso, 1985). Such conditions are common in some remote settings, forcing the use of more costly point-of-use water treatments (Crump et al., 2004).

NaDCC also presents certain advantages over NaOCl in those settings where the pH is high or variable. Hypochlorous acid is a weak acid, which tends to dissociate in water at increasing pH:
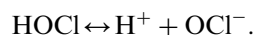
$$HOCl \leftrightarrow H^+ + OCl^-.$$

It is well known that chlorine loses its effectiveness to disinfect water at higher levels of pH, due to the dissociation of HOCl (Hurst, 2001). While 78% of chlorine exists in the active HOCl at neutral pH 7, at pH 8 the level drops to 26%. The capacity of NaDCC to continue to release significant amounts of HOCl allows it to operate over a wider pH range (Dychdala, 2001). Moreover, insofar as NaDCC tablets are acidic in solution, (the effervescent base contributes to their acidity), they tend to reduce the pH of water favouring the formation of undissociated HOCl; hypochlorites, being alkaline, tend to disadvantageously increase the pH and, therefore, the dissociation of HOCl (Macedo and Barra, 2002). This is another parameter that is difficult to control or adjust for in household treatment in the field.

Even in a tightly closed opaque bottle, NaOCl has a recommended life of only 6 months after opening. Decomposition produces undesirable by-products (chlorite or chlorate ions). Internal testing under industry standards has shown that tabulated and strip-packaged NaDCC, on the other hand, has a shelf life of 5 years in temperate and tropical climates. The stability and retention of chlorine activity has been cited as an advantage of NaDCC not only over NaOCl but also over other donors of free chlorine (Macedo and Barra, 2002).

Finally, the different presentation of the chlorine sources makes effervescent (self-dissolving) NaDCC tablets considerably more convenient to use than NaOCl. Bleach, though less hazardous than elemental chlorine, is a corrosive liquid subject to spillage. For water treatment, users typically measure out the recommended dose using the bottle cap. NaDCC, on the other hand, is delivered as a solid tablet specifically sized to treat a given volume of water, typically 10 or 20 l in household applications. While liquid NaOCl (bleach) contains approximately 5% available chlorine, anhydrous NaDCC contains about 62%, roughly the equivalent of calcium hypochlorite. A single 67 mg NaDCC tablet, for example, can treat 20 l of clear water at a FAC dosage of 2 mg/l. (Two 67 mg NaDCC tablets are recommended for turbid waters, at a dosage of 4 mg/l FAC.) The potential for mis-dosing is minimized with the use of tablets, whereas the use of a bottle cap can lead to over or underdosing. Excess dosing would lead to an unpalatable level of residual chlorine and higher concentrations of potentially toxic chlorinated aromatic compounds (Crump et al., 2004). Investigators have found NaDCC to be advantageous to NaOCl in the production of trihalomethanes (Macedo, 1997).

Toxicity and regulatory review

All chlorine products have some level of toxicity; this is what renders them such effective microbicides. When chlorinated water is ingested, however, the available chlorine is rapidly reduced by saliva and stomach fluid to harmless chloride ions salts (Kotiaho et al., 1992). This is true for all sources of chlorine, including both NaOCl and NaDCC. The unique characteristic of the isocyanurates is cyanuric acid, the carrier that allows the chlorine to be contained in a solid, stable and dry form. It is the potential toxicity of such cyanuric acid, therefore, that required review by regulatory agencies prior to the approval of NaDCC for the routine treatment of drinking water.

Cyanuric acid ($H_3C_3N_3O_3$), while confusingly similar in name, is not chemically related to cyanide. The toxicity of NaDCC and cyanuric acid have been extensively studied and documented in support of the registration of isocyanurates with the US EPA. These have been summarized (Hammond et al., 1986; US Environmental Protection Agency (US EPA), 1992). Studies performed on acute toxicity and irritancy were intended to assess the safety of handling the dry product. These studies found chlorinated isocyanurates no more than slightly toxic and not corrosive. Chronic and sub-chronic toxicity studies also found no toxicity. Developmental toxicity studies have also established

that the compound is not fetotoxic, teratogenic (causing birth defects), mutagenic or carcinogenic. Chlorinated isocyanurates are not metabolized in the body and do not bioaccumulate.

Under the US Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the manufacturer or distributor of disinfectants sold in the United States must be registered with the US EPA in a process required to demonstrate their safety and effectiveness. In July, 2001, OxyChem Corporation, the largest producer, secured such a registration for certain of its brands of isocyanurates for the routine treatment of drinking water. The US EPA approved label claims for NaDCC can be found at http://oaspub.epa.gov/pestlabl/ppls.home (registration number 935-41). NaDCC (up to 30 mg/l) is also certified by NSF International under NSF/ANSI Standard 60 (Drinking Water Treatment Chemicals—Health Effects), which extends to the health impact of water treatment additives (http://www.nsf.org).

In 2002, the WHO requested a review of the use of NaDCC as a disinfectant for drinking water as part of the rolling revisions of its Guidelines for Drinking Water Quality. The review was conducted by the Joint Food and Agriculture Organization/WHO Expert Committee on Food Additives (JECFA) and, like the EPA review, required the submission of detailed toxicological data. In June, 2003, JECFA recommended that the tolerable daily intake (TDI) for anhydrous NaDCC from treated drinking water be set at 0–2.0 mg per kg of body weight per day (WHO, 2004). Using standard methods (WHO, 1993) guideline values (GVs) for NaDCC can be derived from the TDI. This translates into a GV for adults (60 kg, with a daily drinking water consumption of 2 l) of 60 mg/l NaDCC; a GV for children (10 kg, with a daily consumption of 1 l) of 20 mg/l NaDCC; and a GV for infants (5 kg, with a daily consumption of 0.75 l) of 13 mg/l. The dosage rate for Aquatabs, for example, is between 3.5 and 7 mg/l NaDCC (2–4 mg/l FAC), well within the JECFA value for daily intake (TDI).

Microbial effectiveness

As noted above, NaDCC is an alternative source of FAC (HOCl). Accordingly, the significant body of evidence on the antimicrobial action of chlorine is as relevant to NaDCC as it is to NaOCl and other sources of chlorine (White, 1998; Dychdala, 2001; CDC, 2005). While certain bacterial spores have shown greater resistance to NaDCC (Bloomfield and Arthur, 1992), thus at least suggesting the potential for differences in activity based on the chlorine donor, no differences have been reported in respect to waterborne pathogens. Susceptibility to hypochlorous acid has been established

with respect to a wide variety of bacteria, including *Escherichia coli*, *Salmonella dysenteriae*, *Shigella sonnei*, *Campylobacter jejuni*, *Yersinia enterocolitica*; viruses, including hepatitis A, poliovirus (type 1), rotavirus, adenovirus and calicivirus; helminthes; and protozoa, including cysts of *Entamoeba histolytica* and *Giardia lamblia* (Dychdala, 2001).

Microbicidal activity is a function of chlorine concentration and contact time (White, 1998; Bloomfield, 1996). At doses of a few mg/l and contact time of about 30 min, free chlorine inactivates more than 4 logs of most waterborne pathogens. *Cryptosporidium* has demonstrated considerable resistance to chlorination (Korich et al., 1990; Venczel et al., 1997) and *Mycobacterium* has also been reported as resistant (Taylor et al., 2000; Le Dantec et al., 2002). It should also be noted that in some cases, certain viruses have also exhibited greater resistance to chlorine and chlorine compounds than common bacterial indicators of faecal contamination (Hurst, 2001). This may have implications for determining the required concentration and contact time required to kill or deactivate potential pathogens in the untreated water collected for use in emergency and development settings.

A number of studies have compared the biocidal effectiveness of NaDCC with NaOCl and other disinfectants against a variety of microbes. D'Auria et al. (1989) assessed the antimicrobial activity of NaDCC among 29 Gram-positive and 29 Gram-negative bacteria, as well as 66 fungi. They reported good activity and, significantly, no adverse influence by temperature and pH. Nascimento et al. (2003) found that at concentrations of 200 ppm, NaDCC yielded superior results compared to NaOCl and certain other agents used to sanitize fresh vegetables against aerobic mesophiles, molds and yeasts, total coliforms, *E. coli* and *Salmonella* sp. In another study at concentrations of 100 ppm, NaDCC was more effective than NaOCl against *Vibrio cholerae* (Eiroa and Porto, 1995). NaDCC has also been reported effective against encysted forms of *Acanthamoeba castellanii* (Khunkitti et al., 1996). Mazzola et al. (2003) compared the efficacy of NaDCC/sodium salt tablets with various chemical disinfectants, including a 10% solution of NaOCl on a variety of bacteria relevant to hospital settings. They recommended NaDCC over NaOCl for certain hospital applications due to its biocidal effectiveness, its slow decomposition and liberation of HOCl, its capacity to maintain an appropriate level of available chlorine without affecting the pH of the water, its low level of toxicity and its lower corrosivity against metal, plastic and rubber.

While NaDCC was shown to be comparable or superior to NaOCl in these studies of non-water treatment applications, we found few studies that compared the microbiological performance of NaDCC with other agents in respect of the treatment of drinking

water. In one study, Aquatabs[TM] tablets containing 3.5 mg of NaDCC in an effervescent base were compared to Drinkwell[TM] (25 mg/ml NaOCl), and Hydroclonazone[®] (12.2 mg chloramine) and a generic solution of 2% iodine in ethanol. Except for the Hydroclonazone, the agents performed comparably in removing all coliforms and *E. coli* from low turbidity water (NTU < 1) and 1.8–2.8 logs of viable bacteria from raw river water (NTU > 10) (Schlosser et al., 2001). The unimpressive results on more turbid water demonstrate a general weakness of chemical disinfectants. Notably, however, the required contact time for the NaDCC and iodine was 30 min compared to 60 min for the hypochlorite and chloramine based agents. In a further study, NaDCC tablets were recommended over chloramine tablets for use by the military owing to superior microbiological performance under a variety of polluted water conditions and lack of toxicity (Baylac et al., 1996).

Owing to its widespread use by defense forces, water and sanitation departments and ministries of health in developing countries, the microbiological effectiveness of NaDCC tablets has been assessed by governmental investigators in Brazil, El Salvador, France, Honduras, Portugal, South Africa, Tanzania, Vietnam and Zimbabwe. However, only one study has assessed the microbiological performance of the disinfectant in the field in the context of a household-based water treatment intervention (Afroz Molla, 2005). In that study, which involved a pilot program in Dhaka, 84% of samples from households using NaDCC tablets to treat their water were free of faecal coliform (FC) and the maximum level was 23 FC/100 ml, compared to 1000–2400 FC/100 ml in pre-intervention source water.

Health impact

There is a growing body of evidence of the effectiveness of household-based interventions, including chlorination, against endemic diarrhoea (Clasen et al., 2006; Fewtrell et al., 2005). In most intervention trials, the disinfectant was a solution of NaOCl (liquid bleach) (Austin, 1993; Kirchhoff et al., 1985; Quick et al., 2002; Reller et al., 2003; Sobsey et al., 2003; Luby et al., 2004; Crump et al., 2005; Lule et al., 2005). In other trials, the disinfectant was calcium hypochlorite (Mahfouz et al., 1995), a mixed oxidant (Quick et al., 1999) or sachets containing calcium hypochlorite (Reller et al., 2003; Crump et al., 2005). In one study, the source of chlorine was not clear (Semenza et al., 1998).

We did not identify any published studies of the health impact of treating water with NaDCC. In one unpublished study from 1996, a 12-month controlled intervention trial was conducted in Brazil by the Ministèrio de Saûde, Fundação Oswald Cruz among other things to evaluate the efficiency of NaDCC (Aquatabs) tablets in treating water at the household level (Prazeres Rodrigues et al., 1996). Following a baseline study to compare demographics and household characteristics, 197 households were allocated (though not clearly randomly) to an intervention group who were provided NaDCC tablets to treat their drinking water and a control group who continued to follow their customary practices. Thereafter, fresh stool samples were collected periodically from householders and examined for certain enteric bacteria, protozoa and helminthes. The results suggest that the intervention was protective, with lower proportions of the NaDCC householders testing positive for the specified organisms. However, the study lacks sufficient methodological rigor to provide useful evidence of the potential health impact of NaDCC.

The aforementioned assessment of the Dhaka pilot program also provides some evidence of reduced levels of diarrhea from the NaDCC intervention (Afroz Molla, 2005). Unfortunately, that study also has shortcomings in epidemiological design that limit its probative value with respect to health impact.

Compliance and acceptability

Like other health interventions, compliance with and the acceptability and affordability of household water treatment solutions are believed to be important factors in the uptake of the intervention, their wide-spread diffusion, and thus their long-term health impact. The consistent use of point-of-use water treatment has been shown to be an important factor in the prevention of endemic diarrhoea (Clasen et al., 2006). Acceptability and affordability are essential to their uptake and the scalability of the intervention (Rogers, 2003). Compared to their microbiological performance and health impact, however, these aspects have not been widely investigated. Even the tools for assessing such criteria among low-income populations using household-based water treatment are not well developed.

With respect to compliance, studies of interventions using chlorine have endeavoured to assess compliance by measuring residual chlorine levels in intervention households. Studies of interventions involving household water treatment using NaOCl have generally reported compliance of around 70% (Quick et al., 2002, 1999; Semenza et al., 1998) but also as low as 36% (Reller et al., 2003). We identified only one study that measured compliance with an NaDCC tablet intervention (Afroz Molla, 2005). That study reviewed the effect of 50 households in Dhaka self-treating their collected water using NaDCC tablets over the period of 1 month.

Householders were given NaDCC at a target dosage of 2 mg/l FAC. It reported that residual FAC levels ranged from 0.2 to 2.8 mg/l for all households for all three sampling periods. No household had over-chlorinated (>5.0 mg/l of FAC) and none had less than 0.2 mg/l; about 10% of households had residual levels less than the desired 0.5 mg/l FAC. While these results must be confirmed in other larger studies, the study suggests that NaDCC tablets may have a compliance advantage over NaOCl by the target population.

The high levels of compliance observed in the Dhaka study may be a result of greater acceptability of NaDCC by householders. In that study, 78% of mothers expressed satisfaction with the tablets because they found them easy and safe to use, they dissolved quickly, and they left no objectionable smell or taste. In 1997, an independent consumer research study sponsored by Bayer surveyed 100 households in a suburb of São Paulo, Brazil who were then treating their water with NaOCl (Data Kirsten Research, 1997). After using Aquatabs[TM] for 3 weeks, 69.6% of householders expressed a preference for the NaDCC tablets, citing convenience of use, safety in handling, and better odor and taste. In Tanzania, PSI, a leader in social marketing, has been marketing a 0.75% solution of NaOCl since 2002. Recently, it conducted focus groups to compare household preferences between the NaOCl and NaDCC tablets (PSI Tanzania, 2005). Once again, 70% of participants preferred the tablets (scoring 42 of 60 first place votes) to liquid bleach.

Affordability, scalability and sustainability

Part of the preference for NaDCC tablets expressed by the Tanzania focus groups was based on participants' perceptions about affordability. This suggests an important aspect about household economics in low-income settings that is well known by consumer companies that sell to the so-called "bottom of the pyramid": unit price minimization (Prahalad, 2005). Table 1 compares the retail price charged to consumers for 500 ml bottles of NaOCl currently paid by PSI for its WaterGuard campaign in Tanzania (PSI, personal communications). The table also shows the prices quoted to PSI Tanzania for two alternative products currently being introduced: 150 ml bottles of 1.25% NaOCl and NaDCC tablets. On a purely economic basis, looking at the volume of water that each option could treat, the 500 ml would be the most economical. In its focus groups, PSI Tanzania found that participants would prefer smaller bottles of WaterGuard or NaDCC tablets at lower unit prices even though the cost per unit treated would be higher (PSI Tanzania, 2005). At a unit retail price of US $0.09 for a 10 tablet strip pack,

Table 1. Cost and retail price of sodium hypochlorite and NaDCC tablets paid by PSI in social marketing programs in Tanzania

Product information				Cost (US$)		Retail price (US$)	
Name	Agent	Size	Treats	Unit	To treat 1000 l	Unit	To treat 1000 l
WaterGuard (Tanzania)	0.75% sodium hypochlorite	500 ml	2400 l	0.34	0.136	0.45[a]	0.19[a]
WaterGuard (Tanzania)	1.25% sodium hypochlorite	150 ml	1000 l	0.17	0.170	0.45	0.45
Aquatabs (Tanzania)	NaDCC	10×67 mg tablets in strip pack	200 l	0.046	0.229	0.09	0.45

[a]Subsidized.

NaDCC tablets will be about twice the cost of the 0.75% NaOCl marketed by PSI per litre treated. At about one-fifth the unit price, however, the NaDCC tablets may be more affordable to low-income populations, as experience has shown in marketing aspirin and dozens of other over-the-counter pharmaceutical products.

Any actual economic advantage of NaOCl at the consumer level, however, may be artificial to the extent that the retail prices are subsidized. While NaOCl can be procured locally at less cost than imported NaDCC, marketing, distribution and programmatic costs add considerably to the actual delivered cost to the consumer. For the 500 ml bottle, PSI has found it impossible to pass all these costs, much less a reasonable profit, to the consumer. Even at the subsidized prices, some vendors will not stock it due to the inventory carrying costs. Moreover, the 500 ml bottles present a problem to some distributors who reach remote locations by bicycle or on foot. Because of the lower unit prices to the consumer, PSI has no plans to subsidize the 150 ml bottle or the NaDCC tablets. If the program is successful, this will have important implications with respect to its sustainability.

In public and donor-funded interventions, however, true economic costs are more relevant. The actual cost of a water disinfection intervention must include not only the cost of the chemical agents, but also the amortized up-front and recurrent programmatic costs. This, in turn, must be compared to the effectiveness of the intervention in averting morbidity and mortality (cost-effectiveness analysis) or the health and other benefits resulting therefrom (cost–benefit analysis). To the extent that NaDCC tablets enjoy higher acceptability than NaOCl by the target population (a premise that has not be a satisfactorily answered), and this preference translates into higher uptake (an assumption that has yet to be investigated), then NaDCC tablets may require less "software" (programmatic) cost to optimize utilization and thus be more cost-effective and cost-beneficial than NaOCl even if the "hardware" (tablet) cost is greater.

Taking the intervention to scale on a sustainable basis is, of course, the long-term goal of a household-based water treatment intervention. Even if progress continues toward the Millennium Development Goal of halving the portion of the population without sustainable access to safe drinking water by 2015, hundreds of millions will still be vulnerable to waterborne diseases. Among point-of-use chemical disinfectants, NaOCl is widely available as household bleach. It can also be produced in even remote locations with relatively low-cost generators (Quick et al., 1999). NaDCC, on the other hand, must be manufactured in dedicated facilities, and strict quality standards must be observed to ensure product integrity and to avoid potentially harmful contaminants. While millions of NaDCC tablets can be produced and distributed rapidly, such as the 30 million shipped for the Indian Ocean tsunami response, scaling up the use of NaDCC on a sustainable basis would require commercial or quasi-commercial (social marketing) deployment. This would imply the establishment of widespread distribution channels and, at some point, regional manufacturing, both of which would require significant investment. While manufacturers may find such investment warranted, especially with local partners to minimize the risk and share the burden, the potential advantages of NaDCC tablets in household water treatment interventions must be weighed against these considerations about its scalability and sustainability.

Conclusion and need for further research

Like other sources of hypochlorous acid, NaDCC has been shown to be an effective antimicrobial agent. The chemical composition and physical characteristics of NaDCC tablets, however, may offer certain advantages over NaOCl as a possible donor of free chlorine in the disinfection of water at the household level. The safety of the compound for the routine treatment of drinking water has now been satisfactorily addressed. There is also evidence that suggests that use of NaDCC tablets increases compliance and is more acceptable and affordable than NaOCl thus potentially increasing overall uptake in a household-based water treatment intervention. These advantages would have to be balanced against its relative lack of availability compared to NaOCl and the issues that this raises about its sustainability.

While there is reason to believe that NaDCC may present a promising alternative to NaOCl in household-based water treatment interventions, it has yet to be subjected to the same kinds of rigorous trials to which NaOCl and certain other point-of-use interventions have been subject. Longer-term randomized, controlled trials in different settings in which NaDCC is compared not only against a control group without access to water treatment but also directly against an intervention group using NaOCl would help clarify its potential benefits, including microbiological effectiveness, compliance, acceptability and affordability. Some of these questions can also be explored in the assessment of pilot programs. Investigators should also determine the programmatic support necessary to achieve a given level of coverage in order to assess its cost-effectiveness. This research would not only address remaining issues about the possible role of NaDCC tablets as a public health intervention, but also provide useful information to determine if investment that would be necessary to bring the intervention to scale on a sustainable basis would be warranted.

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