On the basis of the matched case-control study, infection with *S*. Typhi in Dushanbe was associated with drinking water that had not been boiled during the 30 days before onset of symptoms. The odds ratio increased with the amount of water consumed each day (Figure 4). Drinking at least 1 glass of water that had not been boiled had a matched odds ratio of 3; drinking 2 glasses had a matched odds ratio of 12; and drinking > 2 glasses had a matched odds ratio of 40.

Obtaining water from a tap outside the home and eating food obtained from street vendors were also associated with illness. Using boiled water in the home and eating butter, apples, or onions were determined to be protective factors.

Factors not associated with illness (data not shown) included type of toilet facilities; drinking beverages with ice; eating or drinking at restaurants or a friend’s or relative’s home; traveling outside Dushanbe or receiving visitors who usually reside outside Dushanbe; and consuming raw fruits and vegetables (other than apples and onions), dairy products (other than butter), and medicines.

Figure 4. Odds ratios by amount of water consumed per day that had not been boiled, case-control study, Dushanbe,Tajikistan, 1997.



Investigators undertook a multivariate logistic regression analysis that included all exposures identified as significantly associated with infection in the univariate analysis (Table 3).

Table 3. Multivariate analysis of reported exposures to risk factors for infection with Salmonella Typhi, case-control study, Dushanbe, Tajikistan, 1997.

|  |  |  |  |
| --- | --- | --- | --- |
| Exposure\* | Matchedodds ratio | 95% confidence interval | P value |
| Using water obtained from an outside tap | 16.7 | 2.0−138 | 0.009 |
| Drinking water that had not been boiled | 9.6 | 2.7−34 | 0.0005 |
| Eating food obtained from a street vendor | 1.5 | 0.9−5.6 | 0.3 |
| Eating onions  | 0.6 | 0.5−2.1 | 0.2 |
| Eating apples | 0.2 | 0.04−0.9 | 0.03 |
| Eating butter | 0.1 | 0.04−0.4 | 0.001 |
| Boiling water in home | † | † | † |

\*Exposure during the 30 days before becoming ill (case-patients) and during the 30 days before the interview (control subjects)

†Although significantly associated with typhoid fever in the univariate analysis, this variable was not included in multivariate logistic regression analyses because of its inverse correlation with drinking water that had not been boiled.

**Question 10:** Can you postulate why eating apples and butter were protective against typhoid fever? (Does an apple a day really keep the doctor [typhoid fever] away?)

By Nalini Singh

There is no printed or valid evidence that exits for apples and butter being protective against typhoid fever. Maybe these people who ate apples and butter drank less water, so they were not at risk of being affected by contaminated water.

**PART IV. ENVIRONMENTAL STUDIES AND WATER SUPPLY INVESTIGATION**

Concurrent with the case-control study, SES investigators evaluated the Dushanbe public water supply to identify factors that might have allowed introduction of pathogenic organisms into the drinking water or the survival of such organisms.

**Question 11:** What activities would you include in the evaluation of the public water supply? With whom would you talk? What records or data sources would you review?

By Eliana Alonzo

***Note:*** *The quality of treated water is affected by multiple variables that interact in a complex manner. Therefore, the investigation team should include persons who have extensive knowledge of water treatment methods and plant engineering (e.g., environmental health specialists and utility engineers).*

1. ***Activities***

Some of the activities I would include to evaluate the public water supply will be:

\*Collection of information on the source of the water, both groundwater and surface water (by using maps); the likely of the water to get contaminate (with waste products); and how to protect this water from contamination.

\*Inspect water plants, the equipment implemented and the water treatment process, (for example, what chemicals are used and the techniques that are used to treat the water).

\*Collect specimen from raw water and treated water and compare factors such as pH, turbidity, residual disinfectant, etc. between this two specimens to evaluate the effective of the water plants and the techniques they are using.

\*Inspect water distribution systems such as water pipes, pumps and tanks.

1. **Consultants**

I will contact a panel of professionals such as engineers, laboratorians, microbiologists, water plant maintenance technicians and others who are knowledgeable about the water distribution system and sources in the town.

1. **Records and data sources**

\*Water-quality analyzes from both raw water and treated water (pH, temperature, turbidity)

\*Water treatment procedures (list of chemicals used to treat the water and the techniques implemented)

\*Records from the inspection of water distribution systems (condition of tanks, pipes, etc)

\*List of risk factors for contamination of the water.

 To evaluate the Dushanbe public water supply, SES investigators first talked with the superintendent of public water and viewed maps of the watersheds for the water treatment plants. They then toured all of the water treatment plants (and associated wells) and spoke with water treatment plant operators and maintenance technicians. Investigators observed procedures used to treat the water at each plant and inspected equipment used in water treatment.

SES investigators learned that the city of Dushanbe had four water treatment plants that used surface and groundwater. The two treatment plants in the northern part of the city (i.e., the Napornaya and Samotechnaya Stations) used surface water from the Varzob River. The two treatment plants in the southern part of the city (i.e., the Kafernigan and South-West Stations) used groundwater.

**Question 12:** What is meant by the terms surface water and groundwater? How do the health hazards differ for the two?

By Mykhayla Tseplikh

Groundwater and surface water should never be thought of as separate entities. What those trying to develop either water sources in many countries originally mistook is now more understood as a close relationship, which must be properly balanced for both to function properly. Change in any of these sources will affect the quality and quantity of the other.

Groundwater is found below the earth’s surface in natural reservoirs. Groundwater is the product of surface water and is usually clear of many contaminants and bacteria that could be found in surface water due to the prolonged precipitation process that cleanse those contaminants out. Groundwater however does tend to contain minerals from rocks and thus chemicals such as pesticides or nitrates can be found in many of the ground water supplies.

Almost all-surface water is from sources that interact closely with the atmosphere and are found in sources such as streams, lakes, reservoirs, wetlands and estuaries. Because surface water is in such interactive relationship with the ground, it is more prone to contamination. Contamination of surface water is caused by sources such as industrial waste, animal and human waste, pesticides, fertilizers, and erosion. In countries with few resources of proper water purifying system, surface water is more likely to cause greater impact of diseases than groundwater.

Resources:

**Winter, T. (1998). USGS Ground Water and Surface Water. In Ground Water and Surface Water a Single Resource.. Retrieved July 1, 2013, from** <http://pubs.usgs.gov/circ/circ1139/pdf/circ1139.pdf>**.**

The Varzob River’s source is in the Hissar Mountain range, 72 km north of Dushanbe, and is fed by the Siyoma, Ojuk, Kondara, Maikhura and Tagob Rivers. Heavy rains in the winter and spring and snowmelt result in periodic flash floods along the watershed. Lack of wastewater purification facilities or storage in villages and factories along the river resulted in the discharge of communal wastes directly into the river. Within the Dushanbe city limits, water was drawn from the Varzob River through a system of canals into the surface water treatment plants (i.e., Napornaya and Samotechnaya Stations).

Typically, the water was strained and held in open sedimentation basins where particulates were allowed to settle out naturally. Chlorine was added directly to the sedimentation basins before the water was passed through sand filters to allow for adequate contact time. From the filters, water was pumped into the distribution system without further storage.

The water for the two groundwater treatment plants (i.e., Kafernigan and South-West Stations) was pumped directly from the wells into holding tanks and from the holding tanks into the public water distribution system without treatment.

**Question 13A:** What are the usual steps in treating a public water supply to make it safe to drink?

BY Marlene Marquino

**Coagulation and Flocculation**

Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc.

**Sedimentation**

During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation.

**Filtration**

Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals.

**Disinfection**

After the water has been filtered, a disinfectant (for example, chlorine, chloramine) may be added in order to kill any remaining parasites, bacteria, and viruses, and to protect the water from germs when it is piped to homes and businesses.

arquino

Source: Center for Disease Control http://www.cdc.gov/healthywater/drinking/public/water\_treatment.html

 **Question 13B:** Would you make any changes to the routine water treatment processes at the surface water treatment stations in Dushanbe? At the groundwater treatment station?

Absolutely, the mere fact that there is an outbreak and investigation revealed depopulated system I would make the process of Coagulation and Flocculation, filtration, disinfection and sedimentation as standard process throughout the country.

Source: Center for Disease Control http://www.cdc.gov/healthywater/drinking/public/water\_treatment.html

On inspection of the surface water treatment stations, investigators noted that the sedimentation basins were filled with silt and algae. Dredging machines used to remove the silt were broken. Sand filters had formed mud balls (i.e., conglomerations of filter material that form if a filter is not cleaned adequately) and displayed substantial fouling with iron-oxide that can compromise the filtration process.

Water at the surface water treatment stations had not been chlorinated regularly since December. The chlorine-producing facility in Yavan, Tajikistan, which once supplied chlorine to the entire country, had closed in 1996.

Inspections of the groundwater treatment stations were unrevealing. The wells were in good condition and wellhead seals were functioning correctly. However, approximately half of the pumps at these stations were not operational, limiting the ability to provide the city with adequate water pressure. Plant workers had scavenged spare parts to maintain the functionality of the remaining pumps.

SES investigators tested treated water samples from each of the water treatment plants for turbidity and fecal coliforms.

**Question 14:** What is turbidity? What do fecal coliforms indicate?

By Tracy Smith

Turbidity is having sediments or foreign particles stirred up or suspended. These particles can also create a muddy consistency. Fecal coliforms are present in the digestive tract of warm- blooded animals and are excreted in the feces. The presence of fecal coliforms indicate a possible presence of organisms that can cause illnesses when present in places such as a body of water depending on whether there are large or small numbers of fecal coliform bacteria.

Source

USGS

 http://ga.water.usgs.gov/edu/turbidity.html

 had a turbidity of 70 NTUs; fecal coliforms were 118 CFU/100 mL. Both Water leaving all four water treatment plants entered an interconnected distribution system where surface and groundwater blended. To distinguish the source of water supplied to different parts of the city, SES investigators measured water hardness at the treatment plants and at a sample of consumer taps. They determined that the northern part of the city received water primarily from the surface water treatment plants. The southern part of the city received water primarily from the groundwater treatment plants. The central part of the city received water from both the surface and the ground water treatment plants (Figure 5).

**Question 15:** Reexamine the incidence of typhoid fever by polyclinic as illustrated in Figure 3 in light of the water-quality data and water distribution maps from the four Dushanbe water treatment plants (Figure 5). Does this information provide further clues about problems within the public water supply?

By Anthony Browne

The incidence of the outbreak was not closely related either source of water, ground or surface. Outbreak occurred in all areas regardless of source. This suggests that there is a opportunity for cross contamination occurring as stated the system is plead by broken and corrosive pipe and is a probable case of the cross contamination.

Source

World Health Organization. Guidelines for drinking water quality. 2nd ed. Geneva, Switzerland: World Health Organization, 1993.

Figure 5. Water source by polyclinic, Dushanbe, Tajikistan, 1997.



The water distribution system in Dushanbe was approximately 690 km in total length and consisted mainly of steel and cast-iron pipelines. Approximately 5% of pipes were asbestos or plastic. Distribution pipes had corroded over the years, and breaks occurred intermittently throughout the city.

SES investigators undertook a community survey to assess domestic water quality and use in Dushanbe. Households were selected from each polyclinic catchment area by using a stratified random-sampling scheme. At each house or apartment, investigators recorded the number of residents, frequency of water outages and other problems, and attitudes toward water use. They also collected water from the tap for fecal coliform testing and quantified water usage.

**Question 16:** How would you collect a water sample from a water tap for fecal coliform testing?

By Janeta Ramdat

1. Make sure you are collecting from correct source
2. Collect in sterile container
3. Allow the water to run to waste for 5−10 seconds. Adjust the flow so that the thiosulfate is not washed out of the container.
4. The sample should be stored in the dark at temperatures between 2−4°C (35.6–39.2ºF). Ideally, bacteriologic samples should be examined within 6−24 hours of collection

Source: The International Association of Milk, Food, and Environmental Sanitarians, Inc. (IAMFES)

SES investigators learned that low and intermittent water pressure was common across the city, resulting in water outages on a daily basis. Apartment buildings often had supplemental water pumps that were activated at times of low water pressure. Residents in households and apartment buildings without supplemental water pumps were forced to obtain water from outside taps. In addition, nonstandard connections to waterlines were commonly used to supply homes. Investigators also observed that water pipes ran inside storm drains along roadsides.

Water usage at the surveyed households was substantial. On average, 1,000 L of water were used/person/day, the majority of which was wasted. A total of 300 L/person/day were lost because of open taps within the households, and another 300 L/person/day were lost because of broken pipes or faucets within the house. An additional 400 L/person/day were wasted because of open or broken taps or pipes in public areas. (**Note:** For comparison, according to a 2006 United Nations Development Programme report,4 water usage was approximately 575 L/person/day in the United States and 200−300 L/person/day in Europe.)

Surveyed residents considered the water supply a free commodity. Approximately 2% of domestic users paid the tariff charged by the public water utility, which by the majority of standards was quite low (i.e., US$0.004/1,000 L equivalent for domestic consumers). Residents did not consider running taps to be wasteful or as a contributing factor to the typhoid fever epidemic.

Based on the water samples collected during the survey, 97% of household and community taps throughout the city had water contaminated with fecal coliforms. The average fecal coliform concentration in water samples was 175 CFU/100 mL.

**Question 17:** Summarize the actions necessary to ensure safe drinking water in the city of Dushanbe. Which actions can be undertaken more quickly? Which will be longer-term efforts?

By Chuchana Paul

To ensure safe drinking water in the city of Dushanbe, there are a series of actions that need to be executed in order to control the spread of waterborne diseases such as typhoid fever. There are changes that need to be made involving the handling and treatment of the water supply. Some actions can be achieved more easily than others for instance; the staff at the treatment plants needs thorough training on how to execute the water purification process, the plant needs to secure and include more chlorine and coagulant in the water treatment and lastly the watershed of the Varzob River needs to be protected. These actions will all procure safer water supply.

Source

Department of Health

[www.health.qld.gov.au/disaster](http://www.health.qld.gov.au/disaster)

Emergency Management Queensland

ww.emergency.qld.gov.au/emq/css/beprepared.asp**PART V. PREVENTION AND CONTROL MEASURES**

Prevention and control of typhoid fever and other waterborne diseases in Dushanbe required many actions, including improved protection of the watershed of the Varzob River, repair or replacement of equipment at the water treatment plants (e.g., dredging machinery, sand filters, and pumps), thorough training of water treatment plant staff, changes to the water treatment processes, procurement of adequate amounts of chlorine and coagulant, and repair and replacement of the aging water distribution system. In addition, public education on water conservation was needed to decrease water wastage across the city.

Officials estimated that these efforts might cost at least US$150 million and require years to complete. Public health officials considered implementing point-of-use water treatment to protect the public’s health while more costly improvements were being made to the water system.

**Question 18:** What is point-of-use water treatment? What are examples of point-of-use water treatment methods?

By Tamika Mills

Portable water purification devices – also known as point-of-use (POU) water treatment systems and field water disinfection techniques– are self-contained units that can be used by recreational enthusiasts, military personnel, survivalists, and others who must obtain drinking water from untreated sources (e.g., rivers, lakes, etc.). The objective of these personal devices is to render chlorinated water potable (that is, safe and palatable for drinking purposes). Examples would be filtration, boiling, activated charcoal UV.

Source

Wright J, Gundry S, Conroy (2003). Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. & Int’l Health 9(1):106-17*. - Policies that aim to improve water quality through source improvements may be compromised by post-collection contamination. Safer household water storage and treatment is recommended to prevent this, together with point-of-use water quality monitoring

SES investigators worked with the Tajikistan Ministry of Health in developing a citywide public education campaign about point-of-use water treatment. A health educator from the Ministry of Health was designated to lead and coordinate campaign efforts.

**Question 19:** What are the likely goals of the public education campaign? What steps would you include in planning the campaign? Who might you recruit to help educate and motivate residents to use point-of-use such water treatments?

**KATE IDOWU RN**

The goals of the public education campaign is about Point-of- use water treatment in order ;

-        To prevent and control Typhoid fever and other water borne diseases

-        To promote community awareness of water safety problem and its link to water borne diseases.

-        To educate the public about the different water treatment options available and conservation, so as to decrease water wastage across the city

-        To promote and encourage the consistent and correct health behavior and way of water treatment that will enhance health benefits.

-        To promote thorough training of water treatment in other to protect the public’s health.

Training regarding different  water treatment options available, the process of implementing point-of-use water treatment, the target population, their priority and concerns about water quality, the form and language of communication, etc. will be given to those recruited for the public education campaign. To help educate and motivate residents to use point-of-use water treatment, the following will be considered for recruitment

-        Health educators, teachers and school administrators

-        Public and community health nurses, members of staff of the polyclinics

-        The water treatment plant operators and maintenance technicians

-        Some community leaders/ activist, religious leaders/members and political leaders.

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**HANDOUT ON TYPHOID IN TAJIKISTAN**

[**WWW.CDC.GOV**](http://www.cdc.gov/)

**EPILOGUE**

Use of multiple barriers to keep water contaminants from entering the water supply and surviving is the best approach to achieving a healthy public water supply. Development of multiple barriers to protect the water means that the system will continue to perform adequately despite the failure of part of the system.

The Dushanbe typhoid fever outbreak resulted from failures at multiple points in the water treatment and distribution process. The factors contributing to the state of water services in Dushanbe included

* chronically contaminated surface waters caused by discharge of untreated sewage into the river and heavy flooding each spring;
* inadequate treatment processes (e.g., lack of chlorination because of inadequate supplies, improperly maintained sand filters, and lack of residual chlorine levels in water leaving the water treatment stations);
* disrepair of the water treatment plants resulting from inadequate initial design, unavailable or low-quality of materials and equipment, limited financial resources, and departure of trained staff;
* frequent low and intermittent water pressure because of nonoperational water pumps at treatment facilities, breakages in the water distribution lines, and water wastage in the community; and
* inadequate monitoring of the water system to identify and correct problems.

In 2002, the World Bank began funding the Dushanbe Water Supply Project. Loans were approved to address the most critical deficiencies of the water supply, including replacement of pumps and other equipment at the treatment plants and repair of major sections of the distribution system. Despite improvements, many Dushanbe residents still had inadequate water service and outbreaks of typhoid fever reoccurred on an annual basis. In 2006, the World Bank approved additional funds to continue work on the water system. Renovations and repairs are ongoing.5

Although the investigation of the typhoid fever outbreak in Dushanbe presents a dramatic third world image, similar problems occur elsewhere. In 2007, the U.S. Environmental Protection Agency estimated that 240,000 water mains in the United States break each year, resulting in a loss of 1.7 trillion gallons of water.6 These problems are attributed to factors that are reminiscent of the Dushanbe situation and include reductions in resources devoted to water treatment system maintenance, a growing backlog of needed repairs, aging treatment equipment and distribution pipes, and loss of trained personnel to maintain the systems.

In the majority of U.S. cities, water supplies have not yet been adversely affected. However, a growing number of localities have had serious problems resulting in at least a temporary loss of potable water and substantial commitment of resources to correct the problem. If steps are not taken to understand and address these growing problems, a widespread decline in drinking water quality and reliability, even in the United States, is possible.

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**APPENDIX A: Typhoid and Paratyphoid Fever** (by Eric Mintz)

Also available at <http://wwwnc.cdc.gov/travel/yellowbook/2010/chapter-2/typhoid-paratyphoid-fever.aspx>.

**Infectious Agent**

Typhoid fever is an acute, life-threatening febrile illness caused by the bacterium *Salmonella enterica* serotype Typhi. Paratyphoid fever is a similar illness caused by *S*. Paratyphi A, B, or C.

**Mode of Transmission**

* Humans are the only source. No animal or environmental reservoirs have been identified.
* Typhoid and paratyphoid fever are most often acquired through consumption of water or food that have been contaminated by feces of an acutely infected or convalescent individual or a chronic asymptomatic carrier.
* Transmission through sexual contact, especially among men who have sex with men, has rarely been documented.

**Occurrence**

* An estimated 22 million cases of typhoid fever and 200,000 related deaths occur worldwide each year; an additional 6 million cases of paratyphoid fever are estimated to occur annually.
* Approximately 400 cases of typhoid fever and 150 cases of paratyphoid fever are reported to CDC each year among persons with onset of illness in the United States, most of whom are recent travelers.

**Risk for Travelers**

* Risk is greatest for travelers to South Asia (6 to 30 times higher than all other destinations). Other areas of risk include East and Southeast Asia, Africa, the Caribbean, and Central and South America.
* Travelers to South Asia are at highest risk for infections that are nalidixic acid-resistant or multidrug-resistant (i.e., resistant to ampicillin, chloramphenicol, and trimethoprim–sulfamethoxazole).
* Travelers who are visiting friends or relatives are at increased risk.
* Although the risk of acquiring typhoid or paratyphoid fever increases with the duration of stay, travelers have acquired typhoid fever even during visits of less than 1 week to countries where the disease is endemic.

**Clinical Presentation**

* The incubation period of typhoid and paratyphoid infections is 6–30 days. The onset of illness is insidious, with gradually increasing fatigue and a fever that increases daily from low-grade to as high as 102° F–104° F (38.5° C–40° C) by the third to fourth day of illness. Headache, malaise, and anorexia are nearly universal. Hepatosplenomegaly can often be detected. A transient, macular rash of rose-colored spots can occasionally be seen on the trunk.
* Fever is commonly lowest in the morning, reaching a peak in late afternoon or evening. Untreated, the disease can last for a month. The serious complications of typhoid fever generally occur only after 2–3 weeks of illness, mainly intestinal hemorrhage or perforation, which can be life threatening.

**Diagnosis**

* Infection with typhoid or paratyphoid fever results in a very low-grade septicemia. Blood culture is usually positive in only half the cases. Stool culture is not usually positive during the acute phase of the disease. Bone-marrow culture increases the diagnostic yield to about 80% of cases.
* The Widal test is an old serologic assay for detecting IgM and IgG antibodies to the O and H antigens of *Salmonella*. The test is unreliable, but is widely used in developing countries because of its low cost. Newer serologic assays are somewhat more sensitive and specific than the Widal test, but are infrequently available.
* Because there is no definitive test for typhoid or paratyphoid fever, the diagnosis often has to be made clinically. The combination of a history of being at risk for infection and a gradual onset of fever that increases in severity over several days should raise suspicion of typhoid or paratyphoid fever.

**Treatment**

* Specific antimicrobial therapy shortens the clinical course of typhoid fever and reduces the risk for death.
* Empiric treatment of typhoid or paratyphoid fever in most parts of the world would utilize a fluoroquinolone, most often ciprofloxacin. However, resistance to fluoroquinolones is highest in the Indian subcontinent and increasing in other areas. Injectable third-generation cephalosporins are often the empiric drug of choice when the possibility of fluoroquinolone resistance is high.
* Patients treated with an appropriate antibiotic still require 3–5 days to defervesce completely, although the height of the fever decreases each day. Patients may actually feel worse during the time that the fever is starting to go away. If fever does not subside within 5 days, alternative antimicrobial agents or other foci of infection should be considered.

**Preventive Measures for Travelers**

**Vaccine**

* CDC recommends typhoid vaccine for travelers to areas where there is a recognized increased risk of exposure to *S*. Typhi.
* The typhoid vaccines currently available do not offer protection against *S*. Paratyphi infection.
* Travelers should be reminded that typhoid immunization is not 100% effective, and typhoid fever could still occur.
* Two typhoid vaccines are currently available in the United States.
* Oral live, attenuated vaccine (Vivotif vaccine, manufactured from the Ty21a strain of *S*. Typhi by Crucell/Berna)
* Vi capsular polysaccharide vaccine (ViCPS) (Typhim Vi, manufactured by sanofi pasteur) for intramuscular use
* Both vaccines protect 50%–80% of recipients.
* Table 2-10 provides information on vaccine dosage, administration, and revaccination. The time required for primary vaccination differs for the two vaccines, as do the lower age limits.
* Primary vaccination with oral Ty21a vaccine consists of four capsules, one taken every other day. The capsules should be kept refrigerated (not frozen), and all four doses must be taken to achieve maximum efficacy. Each capsule should be taken with cool liquid no warmer than 37° C (98.6° F), approximately 1 hour before a meal. This regimen should be completed 1 week before potential exposure. The vaccine manufacturer recommends that Ty21a not be administered to infants or children<6 years of age.
* Primary vaccination with ViCPS consists of one 0.5-mL (25-μg) dose administered intramuscularly. One dose of this vaccine should be given at least 2 weeks before expected exposure. The manufacturer does not recommend the vaccine for infants and children <2 years of age.

Vaccine Safety and Adverse Reactions

Information on adverse reactions is presented in Table 2-11. Information is not available on the safety of these vaccines in pregnancy; it is prudent on theoretical grounds to avoid vaccinating pregnant women. Live, attenuated Ty21a vaccine should not be given to immunocompromised travelers, including those infected with HIV. The intramuscular vaccine presents a theoretically safer alternative for this group. The only contraindication to vaccination with ViCPS vaccine is a history of severe local or systemic reactions after a previous dose. Neither of the available vaccines should be given to persons with an acute febrile illness.

Precautions and Contraindications

Theoretical concerns have been raised about the immunogenicity of live, attenuated Ty21a vaccine in persons concurrently receiving antimicrobials (including antimalarial chemoprophylaxis), IG, or viral vaccines. The growth of the live Ty21a strain is inhibited in vitro by various antibacterial agents. Vaccination with Ty21a should be delayed for >72 hours after the administration of any antibacterial agent. Available data do not suggest that simultaneous administration of oral polio or yellow fever vaccine decreases the immunogenicity of Ty21a. If typhoid vaccination is warranted, it should not be delayed because of administration of viral vaccines. Simultaneous administration of Ty21a and IG does not appear to pose a problem.

Table(s) 2-10a. Dosage and schedule for typhoid fever vaccination

**Oral, live, attenuated Ty21a vaccine (Vivotif)**

| Vaccination | Age (Years) | Dose/Mode ofAdministration | No. of Doses | Dosing Interval | Boosting Interval |
| --- | --- | --- | --- | --- | --- |
| Primary series | ≥6 | 1 capsule1, oral | 4 | 48 hrs | Not applicable |
| Booster | ≥6 | 1 capsule1, oral | 4 | 48 hrs | Every 5 years |

1Administer with cool liquid no warmer than 98.6°F (37°C).

Table(s) 2-10b. Dosage and schedule for typhoid fever vaccination

**Vi Capsular polysaccharide vaccine (Typhim Vi)**

| Vaccination | Age (Years) | Dose/Mode ofAdministration | No. of Doses | Dosing Interval | Boosting Interval |
| --- | --- | --- | --- | --- | --- |
| Primary series | ≥2 | 0.50 mL,intramuscular | 1 | Not applicable | Not applicable |
| Booster | ≥2 | 0.50 mL,intramuscular | 1 | Not applicable | Every 2 years |

1Administer with cool liquid no warmer than 98.6°F (37°C).

**Table 2-11. Common adverse reactions to typhoid fever vaccines**

| Vaccine | FeverReactions | HeadacheReactions | Local Reactions |
| --- | --- | --- | --- |
| Ty21a1 | 0%–5% | 0%–5% | Not applicable |
| Vi Capsular polysaccharide | 0%–1% | 16%–20% | 7% erythema or induration 1 cm |

1The side effects of Ty21a are rare and mainly consist of abdominal discomfort, nausea, vomiting, and rash or urticaria.

*Page last reviewed: July 27, 2009 Page last updated: July 27, 2009*

*Content source: Division of Global Migration and Quarantine, National Center for Preparedness, Detection, and Control of Infectious Diseases*