Figure 15.1. COMPARATIVE INVESTIGATING: Aluminum in Drinking Water

The three newspaper articles reprinted in this Figure appeared over about a one-week period in *The Globe and Mail* in 1995; they deal with the possible relationship between long-term exposure to aluminum in drinking water and development of Alzheimer's disease.

EM9502: The Globe and Mail, March 30, 1995, pages A1, A12

Canada to limit tap water aluminum

Links to memory, brain impairment

BY WALLACE IMMEN
The Globe and Mail

Health Canada plans to set limits on aluminum in drinking water in light of research linking the element to brain damage and memory loss.

An Australian research team reported this week that aluminum, which is added to drinking water in treatment plants, can accumulate in the brain, where it may kill off cells and cause memory loss. Most Canadians living in cities drink water that has been treated with aluminum, although at levels that are considered safe.

The Sydney-based Australian Institute of Biomedical Research said inorganic aluminum, the type added to water during purification, collects in the brains of rats, damaging neurons.

Although the researchers did not say that aluminum in water causes Alzheimer's disease, they said the forms of memory impairment the substance causes is characteristic of symptoms of the illness.

Institute researcher Judie Walton noted there has been a worldwide surge in Alzheimer's over the past 70 years, as many people's water has been treated with aluminum.

Some researchers continue to link high levels of aluminum in the brain with Alzheimer's, while other studies have cast doubt on the connection.

"Based on what we've seen of the research, the correlation [of aluminum to memory loss] is conclusive", Dr. Barry Thomas said yesterday.

Dr. Thomas, head of the criteria section of Health Canada's Environmental Health Directorate, said the Department will ask a committee of federal and provincial officials to set health limits for aluminum within the next year.

Although water accounts for only a small fraction of the amount of aluminum people consume in food, the type of aluminum that enters water during purification is the most likely to reach the brain, the Australian study found.

The finding, reported Tuesday in the journal *NeuroToxicology*, draws conclusions that are similar to those in a study of 2,000 Ontario men reported in January in the *Canadian Journal on Aging*. "Generally you get a risk almost 10 times as big in areas that have high aluminum levels in the drinking water," said the study's author, Dr. William Forbes, distinguished professor emeritus of the University of Waterloo.

Dr. Forbes said his research shows that a level above 300 micrograms per litre is definitely harmful. He said there is no evidence of harm from long-term use of water with aluminum levels below 100 micrograms per litre, a level common in Canadian water supplies.

Most treated water in Canada is kept below 100 micrograms per litre because any more than that affects its look and taste, said Metro Toronto water-supply director Hiroshi Taniguchi.

Dr. Thomas said that "no country currently has a health standard for aluminum in water. We're in the forefront on this". Health limits have been under discussion for at least two years, he said, and "as is often the case, there is a wide range of opinion".

At a conference in Burlington, Ont., last year, some experts argued for a health limit as low as 50 micrograms while others said 100 is necessary to avoid compromising the purifying effect of the aluminum salts in the water.

"This is not just added for no reason", Dr. Thomas pointed out. The process removes bacteria and protozoa that are serious health risks.

Water in some areas of Canada, especially the Prairies, is naturally high in aluminum, but that is not considered a health risk, Dr. Thomas noted. The organic form of aluminum in food and ground water doesn't readily enter the blood system, he said. It is the inorganic aluminum salts used to clarify water in treatment that are the concern.

Hydrated aluminum sulphate, also known as alum, is used to remove fine particles from water, said Peter Chisholm, associate professor of engineering at the University of Guelph. The compound or a related aluminum salt is used across Canada, anywhere where there is pre-treatment of water extracted from lakes and streams".

The chemical forms snowflake-like clusters known as floc. The positively charged floc attracts negatively charged mineral particles in the water as it settles to the bottom of a treatment tank. However, some aluminum remains in the purified water.

REFERENCES: Walton, J., Tuniz, C., Fink, D., Jacobsen, G. and D. Wilcox: Uptake of trace amounts of aluminum into the brain from drinking water. *NeuroToxicology* **16**(#1): 187-190 (1995). [DC Library call number: PER RC321.N437]

Forbes, W. F. and N. Agwani: Geochemical risk factors for mental functioning, based on the Ontario Longitudinal Study of Aging (LSA) III. The effects of different aluminium-containing compounds. *Canadian Journal on Aging* **13**(#4): 488-498 (1994). [DC Library call number: PER HV1475.A1C3X]

(*continued overleaf*)

EM9504: The Globe and Mail, March 31, 1995, pages A1, A11

Aluminum in drinking water poses no risk, Canadians told

Federal health officials deluged by worried callers

BY WALLACE IMMEN
The Globe and Mail

Dr. Barry Thomas spent yesterday assuring Canadians that their water is safe to drink.

After announcing that the federal Health Department will ask for limits on the amount of aluminum added to drinking water during treatment, he was deluged with calls from worried officials and inquiring media.

"As far as we can tell, there is no evidence there is a health risk anywhere in Canada," Dr. Thomas, head of the criteria section of Health Canada's environmental health directorate, said in a telephone interview.

But he added that enough questions have been raised about the effects of aluminum on the brain that "we would be remiss is we didn't establish a safe limit."

Aluminum sulphate, known as alum, is used by treatment plants across Canada to purify water.

But until now, no one has monitored how much of the substance gets into the water people drink.

Recently reported studies in Australia, Canada and Britain indicate that inorganic aluminum is particularly adept at getting into the bloodstream and collecting in brain tissue, Dr. Thomas said. This kind of aluminum, also called free aluminum, binds easily with body tissue.

The connection between aluminum and memory impairment was not seen clearly in the past because previous studies did not have the sophisticated ways of interpreting the data that are available today, said Dr. William Forbes, a gerontologist and distinguished professor emeritus of the University of Waterloo.

In a 35-year study of 2,000 men, Dr. Forbes found that the incidence of memory loss was up to 10 times higher in areas of Canada with high aluminum levels in the water.

In the past, there were wide variations in the way that water was treated, but since the 1980s more rigorous provincial standards have resulted in most cities reducing the amounts of alum used in water treatment.

Officials believe that forms of aluminum other than free aluminum pose little risk.

"Aluminum is the third-most-common element in the world; the body is designed to reject natural aluminum in food and water. Only a trace gets into the system," Dr. Thomas assured people who are concerned about the potential for long-term exposure.

Other assurances came from industry and researchers:

- "We've been getting calls from people asking whether they should throw out their aluminum pots and pans," said Steve Rudin, a spokesman for the Alzheimer Society of Canada. Alzheimer's disease affects about 250,000 Canadians. Aluminum cookware was one of the original suspects in Alzheimer's, but the aluminum from pots is not readily absorbed in the body. The amount that enters food is minute, even if you stew acidic food in an aluminum pot, a spokesman for Alcan Aluminium Ltd. said.
- Aluminum cans are coated with lacquer or plastic to prevent food or drinks from picking up any metal, the Alcan representative added.
- Antacids contain aluminum and some people take many tablets a day. "You might think this would add a lot of aluminum, but studies show it doesn't seem to make much difference," Dr. Forbes said. After a controversy five years ago, antacid makers reduced the amount of aluminum in their products.
- Deodorants contain aluminum compounds, but it is a coating on the outside of the skin and tends not to be absorbed.
- Many Canadian communities have high natural levels of aluminum in their water. Factors such as acid rain increase aluminum levels. In Newfoundland and Manitoba, for instance, naturally acidic water absorbs more aluminum from the soil. But this aluminum is the organic, or bound, form, and does not pose a risk, Dr. Thomas said.

Existing provincial recommendations on the level of alum are set for technical reasons, rather than health concerns.

A meeting on setting a health standard will be called this year, but Dr. Thomas has no idea what the final number will be. He said cities that reported to him yesterday indicated that their water had free aluminum in a range from 100 to 200 micrograms per litre of water.

Anything below 200 is considered a safe range, although Dr. Forbes said his study found a high risk of memory impairment in men who drank water with more than 215 micrograms per litre.

Meanwhile, treatment plants will continue to use alum. Alternatives are either more expensive or not as effective in eliminating contaminants from water, said Larry Williams of Alberta's environmental protection agency.

1. Describe concisely the *Question* that is the primary concern of the three articles reprinted in this Figure. If you identify more than one Question, describe them in the order you consider to be of *de*creasing importance.

2. For the (most important) Question you identified in the previous question, briefly describe the following:
   - the target population;
   - a target *unit*;
   - the main *response variate*;
   - the main *explanatory variate*;
   - an *attribute* of interest of the target population;
     - express this attribute symbolically.

3. What is the *aspect* of the Question? Justify your answer briefly.
   - Explain briefly whether the investigations of human populations described in the articles have *experimental* or *observational* Plans, and indicate what *statistical* issue is raised by this matter in the context of the Question being asked.
     - What investigation with an *experimental* Plan is mentioned in the article reprinted on the third side (page 15.3) of the Figure? Explain briefly.

(*continued*)

Figure 15.1. COMPARATIVE INVESTIGATING: Aluminum in Drinking Water (continued)

EM9506: The Globe and Mail, April 7, 1995, page A8

Variations noted in aluminum levels

Some water readings astonishingly high, can vary with seasons, geography, expert says

BY WALLACE IMMEN
The Globe and Mail

TORONTO – The amount of aluminum in municipal water supplies can vary dramatically, figures being reported to federal health officials show.

Studies of memory loss due to aluminum suggest that 70 years of drinking water with levels above 200 micrograms per litre (parts per billion) might raise the risk of memory loss in old age consistent with Alzheimer's disease.

But in 1993, one plant in Ontario turned out water with 20 times that much.

"Some readings are astonishingly high, over 1,000 micrograms per litre", said Dr. Barry Thomas, head of the federal Health Department section that is planning to set national standards for aluminum in drinking water.

Seasonal variations can affect aluminum levels. Experts say levels tend to be higher during winter and summer as well as after storms, which stir up sediment in rivers and lakes that supply water for cities. Hydrated aluminum sulphate, or alum, is added to remove silt and harmful bacteria from water during treatment. Some aluminum remains in the water piped out to consumers.

The major problem may be in hot weather, said John McGrackan, mechanical assessment officer for Ontario's Environment Ministry. "Treatment plants have to produce more water in less time during peak summer demand". Adding more alum speeds the clarification process.

Geography also plays a role. Dr. Thomas said that, in general, the Maritimes report low aluminum levels because most towns use ground water not treated with alum. Cities on the Prairies appear to have the most consistent problem. More of the aluminum salts used to clarify water must be added to overcome high natural levels of lime that makes water harder.

Saskatoon reported levels as high as 700 in its water, said Blaine Ganong, acting director of the municipal branch of Saskatchewan's Environment Department.

Aluminum added in treatment, known as inorganic or free aluminum, is considered the biggest health risk because new studies in Canada and Australia show it has an ability to reach the brain, where it collects in cells responsible for memory.

An Australian study found that free aluminum at the level of 100 micrograms per litre accumulated in significant amounts in the brains of six of eight rats after being injected with the equivalent of just one glass of water.

Drinking Aluminum

Amounts under 200 micrograms per litre of water are safe but 1993 testing showed many communities with much higher levels

Community	Maximum	Minimum	Average
Ajax	220	55	136
Bracebridge*	44	30	34
Gravenhurst	690	120	317
Hamilton	120	49	81
Kingston	250	53	144
Metro Toronto (Harris Plant)	240	81	134
Metro Toronto (Clark Plant)	110	65	83
Ohsweken	4,350	66	1,088
Ottawa	220	57	115
Port Dover	389	78	189
Rainy River	1,530	170	623
Sudbury*	19	7	11
Windsor	230	60	117

*Bracebridge and Sudbury do not treat with aluminum

Ohsweken's phenomenally high peak reading of 4,350 was the result of mechanical problems at the federally operated treatment plant, officials say

4 In the table of aluminum levels in the article reprinted above, the *average* is used as a measure of location; outline the advantage(s) and *dis*advantage(s) of this use of the average for these data.

- Suggest *another* measure of location and outline why its use would be more appropriate than that of the average.
  - To increase the effectiveness of the data presentation, what would be better than using either measure of location *by itself*? Explain briefly

5 What measure of *variation* is provided in the table of aluminum levels in the article reprinted above? Outline the advantage(s) and *dis*advantage(s) of this measure for these data.

- Suggest *two other* measures of variation and outline why they would be more useful than the measure provided.
  - From the perspective of effective data presentation, what would *you* provide in the table to quantify data varation? Justify your answer brieffly.

6 Name the components of a measuring process.

- In the articles reprinted in this Figure, two variates involving *measuring* are aluminum levels in water and the degree of brain impairment. What information is provided in the article about the measuring processes for these two variates?
  - What is a *third* major measuring difficulty? Explain briefly.

(*continued overleaf*)

6 – Rank the three measuring issues in order of *in*creasing difficulty; justify your ranking briefly.
– For each of the three measuring processes, describe briefly the main source(s) of possible measuring *inaccuracy* and measuring *imprecision*; make it clear which variate(s) are involved in your discussion in each case.

7 In the second-last paragraph of the article reprinted overleaf on page 15.3, ... *(two) new studies in Canada and Australia* ..... are referred to. What information is provided in the three articles reprinted in this Figure about the two *study populations.*
- In each case, indicate briefly how this information, or lack of it, about the study population affects the Answer about the role of aluminum in drinking water in brain impairment with regard to the *inaccuracy* and the *imprecision* of this Answer.

8 Identify the main ways in which *sampling* is involved in the human studies that are the primary concern of the three articles in this Figure.
- For each use of sampling that you identify, describe briefly the main source(s) of possible sampling *inaccuracy* and sampling *imprecision*; make it clear which variate(s) are involved in your discussion in each case.