# Experience, training and confidence among small, non-community drinking water system operators in Ontario, Canada

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## ABSTRACT

The water operator plays an important role in water safety; however, little published research exists that has examined this role. The purpose of this study was to develop a greater understanding of the experience, existing knowledge, confidence and future training needs of the small, non-community drinking water operator in Ontario in order to help guide future outreach and training opportunities. A cross-sectional telephone survey of 332 small, non-community drinking water operators in Ontario was conducted in July and August 2011. Survey questions pertained to respondents' experience as operators, formal training, perceived importance of water safety issues, confidence in handling water safety issues, and future training needs. Approximately 16% (54/330) of respondents had one year or less experience as a water operator, and 60% (199/332) reported that being a water operator was not a chosen profession. Only 37% (124/332) of operators reported completing operator training. Respondents reported a preference for online training courses or on-site training (compared with a classroom setting). Low training rates, inexperience, and in certain situations, low confidence, among many small water system operators highlight a need to provide continued support to the development of ongoing training opportunities in this population.

**Key words** | confidence, drinking water, experience, operator training, small, non-community drinking water systems, water operator

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## INTRODUCTION

The provision of safe drinking water is a significant challenge around the world in both large and small drinking water systems. Small drinking water systems are particularly vulnerable to contamination, as they often have fewer protective measures in place than large systems (Butterfield & Camper 2004), and even in developed countries, pose a public health concern (World Health Organization 2008). In Canada, approximately 15% of the population is serviced by small water systems (Moffatt & Struck 2011). Ontario is Canada's most populous province, with a population of 13.5 million (Government of Canada 2013).

In Ontario, approximately 80% of the population gets their drinking water from a municipal drinking water source, while for the remaining 20%, their drinking water is supplied by a privately owned system (such as a private well), a designated facility (systems that provide water to people who may be more vulnerable to drinking water contamination, such as those using schools or children's camps), or a small, non-community drinking water system (a business that has drinking water available to the public and does not get their drinking water from a municipal drinking water system, such as those serving recreational camps, restaurants and trailer parks) (Drinking Water Ontario 2014). Small, non-community drinking water systems are regulated by 'Ontario Regulation 319/08 Small Drinking Water Systems' (Government of Ontario 2013),

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which are overseen by the Ontario Ministry of Health and Long-Term Care (MOHLTC) and local Boards of Health. It is estimated that there are 9,000 small, non-community drinking water systems in Ontario (personal communication with T. Amalfa from the MOHLTC, November 2013). These systems serve both residential and transient populations; however, the exact number of people served by these systems is unknown.

Many small water systems are found in remote and isolated locations and consequently face numerous challenges in reducing the risk of contamination. These challenges include the cost of operating a treatment system for a small number of consumers, poor access to operator training and low retention of knowledgeable operators (Rupp 2001; Jalba & Hrudey 2006; Moffatt & Struck 2011). In 2000, an expert assessment of Ontario's water operators revealed that they were dedicated to their jobs but tended to lack training, faced funding limitations and had limited understanding of water treatment chemistry and regulatory requirements (Geldreich & Singley 2005). These findings were especially pronounced in communities serving less than 1,000 people. In Ontario, operators of large municipal water systems are required to complete training and must hold a Drinking Water Systems Operator certificate (Government of Ontario 2012). However, training is not mandatory for operators of a small, non-community drinking water system (Walkerton Clean Water Centre 2011).

The water operator plays an important role in water safety, and operator training has been shown to be an effective tool to improve water quality and reduce illness. For example, Bowman *et al.* (2009) found that performance-based training of small drinking water operators (serving communities <10,000 people) in the United States resulted in a statistically significant turbidity reduction in the supplied water. Hunter *et al.* (2010) examined the effectiveness of a training intervention on water quality and diarrheal illness in a small rural community in Puerto Rico, and found that providing hands-on training to small water system operators resulted in statistically significant reductions in illness rates in the intervention community compared with a control community.

Operator ability is a key aspect in protecting the water supply (Bowman *et al.* 2009; Wu *et al.* 2009; Hunter *et al.* 2010); however, little published research regarding the experience, existing knowledge, and future training needs of the operator exists. To date, most of what we know about small water operators' current knowledge and abilities in Canada arises from second-hand accounts from public health professionals (Jalba & Hrudey 2006; Boag *et al.* 2010). The objective of this study was to develop a greater understanding of the experience, knowledge and confidence among small drinking water system operators in Ontario.

## METHODS

### Study design

A cross-sectional telephone survey of small drinking water operators in Ontario, approved by the University of Guelph Research Ethics Board (REB#11MR009), was conducted in July and August 2011.

The sampling frame included operators of small drinking water systems, as defined by 'O. Reg 319/08 Small Drinking Water Systems', which had been inspected by a public health inspector as of March 2011. Business telephone numbers of the operators were obtained from the MOHLTC. This initial sampling frame included 2,454 small drinking water system operators geographically dispersed across the province of Ontario. After removing duplicate entries ($n = 454$) and those with missing contact information ($n = 165$), the total number of operators was 1,835. A sample size of 330 was determined *a priori* (calculated to provide 95% confidence, with a population size of 1,835 and the frequency of outcome factor in the population set at 50%); numbers were selected using a random number generator and calls were conducted until the 330 respondents was attained.

Eligible survey respondents spoke English, were either the person listed as the contact for the record, or an alternate person who was primarily responsible for operating a small drinking water system at the business.

### Questionnaire development and administration

Initially, ten small drinking water system operators, randomly selected from the sampling frame, participated in semi-structured interviews to identify and refine meaningful

topics, issues and common language that were used to develop the questionnaire. The data gathered during these interviews was not included in the final analysis. Five public health colleagues reviewed the questionnaire for further input; questions that were vague or difficult to understand were revised.

A total of 22 questions were included in the final questionnaire (see Appendix, available online at http://www.iwaponline.com/wh/012/063.pdf). It included closed-ended questions including yes-no responses, multiple choice questions and five point scales. Two different five-point scales were used, specifically to rate agreement with opinion statements (1 = strongly disagree; 5 = strongly agree) and the perceived importance of water protection measures (1 = not important; 5 = extremely important). A three-point scale was used to rate respondents' confidence in managing water safety issues (1 = not confident; 2 = somewhat confident; 3 = very confident). For this variable, responses for seven questions about managing water safety issues were added and divided by the number of questions the respondent answered (some respondents had not answered all seven questions), for an average confidence score for each respondent.

Telephone interviews were conducted by five interviewers. Interviewers were trained during a 3-hour session, which included an instrument review and practice session. All calls were conducted using the computer-assisted calling system WinCATI v4.2 (Survey Research Centre, University of Waterloo, Ontario, Canada). Calls were attempted during the day from 9:00 a.m. to 3:00 p.m., Monday to Friday. A telephone number was called at least three times and removed from the list if the call resulted in no answer or voicemail pick-up. Evening and Sunday calls were made if respondents requested a call back during these times. Each interview took an average of 15 min to complete.

### Data analyses

The Pearson chi-square test was used to assess the association between how respondents became water operators and whether they had taken formal operator training, and to assess an association between how respondents rated the importance of weather conditions and what type of water system they oversaw (ground water vs. surface water). A Spearman correlation was used to assess the association between years of experience and operator confidence. All statistical analyses were conducted with SPSS version 19.0 (SPSS Inc. 2011).

## RESULTS

### Response percentage

A total of 1,835 numbers were attempted at least once. Of these, 805 operators were reached; 317 were ineligible for the study, this included respondents that did not have a small drinking water system (227), wrong number (78), the business was no longer in operation (7), or a language barrier (5); 152 people refused to participate; four people did not complete the survey; and 332 completed the survey, yielding an overall response rate of 22% (332/1518). Of eligible operators that were successfully contacted, 68% (332/486) agreed to participate in the survey. The 1,030 numbers that were not reached were either busy/no answer/answering machine (1,027) or the business was closed for the season (3).

Respondents were uniformly distributed across the province when assessed by telephone area codes and an assessment of the water source used by the survey respondents was found to be representative of all small, non-community water systems in Ontario (Table 1).

### Water system characteristics

Seventy-seven per cent (254/332) of the water systems utilized ground water; 13% (43/332) surface water; 8% (27/332) a

**Table 1** | Water source reported by survey respondents and all small drinking water systems in Ontario, Canada

| Water source | Survey respondents ($n = 332$) (%) | Small drinking water system in Ontario[a] ($n = 6{,}567$) (%) |
|---|---|---|
| Ground water | 254 (77) | 5,433 (82) |
| Surface water | 43 (13) | 847 (13) |
| Both surface and ground water | 27 (8) | 0 |
| Other[b] | 8 (2.4) | 287 (4.3) |

[a]Unpublished data provided by the MOHLTC.
[b]Other includes cisterns and bulk water tanks.

combination of both, and 2.4% (8/332) utilized cisterns (Table 1). Almost 84% (278/332) of operators employed at least one form of water treatment. Specific types of treatment are presented in Table 2.

Operators' years of experience ranged from less than 1 year to 60 years, with a mean of 11.1 years and a median of 7 years. The majority of operators, 70.7% (234/331), were responsible for overseeing only one water system, while 29.3% (97/331) reported that they were responsible for two water systems. When asked how they became a water operator, nearly 60% (199/330) reported that they were the operator because they were the owner of premises with a small drinking water system and they did not employ a professional for the task; 24% (80/330) reported that they were not owners of the system and their role as a water operator was one of many responsibilities of their job; 7.5% reported it was their specifically chosen profession (25/330), and another 8% stated it was a volunteer position (26/330).

**Table 2** | Types of drinking water treatment methods used in 332 small drinking water systems in Ontario, Canada (July–August 2011)

| | Water treatment types | | | |
|---|---|---|---|---|
| **Type of source water** | **Filtration # (%)** | **Disinfection # (%)** | **Filtration & disinfection # (%)** | **None # (%)** |
| Ground water ($n = 254$) | 25 (10) | 36 (14) | 141 (56) | 52 (20) |
| Surface water ($n = 43$) | 1 (2.3) | 1 (2.3) | 40 (93) | 1 (2.3) |
| Mix of ground and surface water ($n = 27$) | 1 (3.7) | 0 | 25 (92.5) | 1 (3.7) |
| Cistern ($n = 8$) | 3 (37.5) | 2 (25) | 3 (37.5) | 0 |
| Totals | 30 | 39 | 209 | 54 |

*Disinfection methods included: UV disinfection, chlorination, water softener, reverse osmosis, sodium hypochlorite, chlorine dioxide, aluminum sulfate and hydrogen peroxide.

## Water safety perceptions

Respondents were asked to rate the importance of water safety issues (Table 3). Regular maintenance by the operator and routine microbial water sampling were rated as extremely important to water safety by 81% (267/330) and 77% (257/332) of respondents, respectively. Weather conditions such as heavy rainfall, flooding and drought, were rated the lowest in importance with only 38% (126/324) of respondents ranking them as extremely important. This response was not statistically different whether the respondent worked with ground water or surface water (Pearson Chi-square = 3.535; $p = 0.170$).

Respondents were also asked to rate their agreement with eight opinion statements related to water system maintenance (Table 4). The majority of respondents (93%; 309/331) agreed or strongly agreed that as the water operator, drinking water safety was their responsibility. Half of respondents (51%; 167/327) agreed or strongly agreed that the cost of meeting the legal requirements for water safety was a burden. Further, approximately 27% (91/331) and 26% (85/331) agreed or strongly agreed that regular water testing was a hassle and maintaining a safe water system was time consuming, respectively. Approximately one-third of respondents (31.3%; 100/319) agreed or strongly agreed

**Table 3** | Ontario small drinking water operators' rating of their perceived importance of various water safety issues (July–August 2011)

| | **5 Extremely important # (%)** | **4 Important # (%)** | **3 Neither important nor unimportant # (%)** | **2 Somewhat important # (%)** | **1 Not important # (%)** |
|---|---|---|---|---|---|
| Regular maintenance by the operator ($n = 330$) | 267 (80) | 49 (15) | 9 (3) | 3 (1) | 2 (1) |
| Routine microbial water sampling ($n = 332$) | 257 (77) | 50 (15) | 17 (5) | 5 (2) | 3 (1) |
| Water disinfection ($n = 327$) | 235 (71) | 36 (11) | 25 (8) | 7 (2) | 24 (7) |
| Surrounding land use ($n = 324$) | 197 (59) | 72 (22) | 30 (9) | 11 (3) | 14 (4) |
| Filtration ($n = 326$) | 186 (56) | 63 (19) | 39 (12) | 12 (4) | 26 (8) |
| Heavy rainfall, flooding or drought ($n = 324$) | 126 (38) | 95 (29) | 60 (18) | 19 (6) | 24 (7) |

**Table 4** | Ontario small drinking water system operators' level of agreement with statements about managing a small drinking water system in Ontario, Canada (July–August 2011)

| | 5 Strongly agree # (%) | 4 Agree # (%) | 3 Neither agree nor disagree # (%) | 2 Somewhat disagree # (%) | 1 Strongly disagree # (%) |
|---|---|---|---|---|---|
| Having poor water will negatively affect my business ($n = 330$) | 264 (80) | 35 (11) | 11 (3) | 10 (3) | 10 (3) |
| Drinking water safety is my responsibility as the operator of the system ($n = 331$) | 248 (75) | 61 (18) | 13 (4) | 6 (2) | 3 (1) |
| The legal requirements for water systems are in place to improve water safety ($n = 329$) | 179 (54) | 75 (23) | 40 (12) | 21 (6) | 14 (4) |
| The cost of meeting the legal requirements for water safety is a burden ($n = 327$) | 115 (35) | 52 (16) | 69 (21) | 42 (13) | 49 (15) |
| Public health inspectors should have a greater role in ensuring water safety ($n = 319$) | 62 (19) | 38 (11) | 116 (35) | 53 (16) | 50 (15) |
| Conducting regular water tests is a hassle ($n = 331$) | 56 (17) | 35 (11) | 50 (15) | 65 (20) | 125 (38) |
| Maintaining a safe water system is time consuming ($n = 331$) | 33 (10) | 52 (16) | 92 (28) | 73 (22) | 81 (24) |
| The safety of drinking water is out of my control ($n = 331$) | 12 (4) | 13 (4) | 30 (9) | 51 (15) | 225 (68) |

that public health inspectors should have a greater role in ensuring water safety.

## Operator training

Approximately 37% (124/332) of operators reported they had taken water operator training at some time in the past. Of these, 47% (58/124) had taken the Walkerton Clean Water Centre training, 36% (44/124) an Ontario Ministry of the Environment course and 20% (25/124) a college course. Twenty-three per cent (29/124) of operators reported having taken more than one type of training. Respondents who reported that they became a water operator as a chosen profession were significantly (Pearson Chi-square = 55.0; $p < 0.001$) more likely to have taken training than volunteers and operators who owned premises with a small drinking water system and did not employ a professional.

The most common barriers to training were reported as location and cost of training (51%; 168/332 and 43%; 144/332, respectively). Other barriers were the time/season the training was offered (35%; 117/332) and instruction being offered only in English (14%; 46/332); however, the language preferred by respondents was not assessed. A total of 18% (61/332) of respondents reported that training was not needed; of these, 56% (34/61) had not taken previous training.

Approximately 47% (155/332) of operators knew training was currently available to them. When asked what training topics were of interest (provided to them by a predefined list), trouble-shooting (defined as detecting and solving serious problems in the water system; 68%, 226/332), legal requirements (defined as the Ontario regulations applying to small drinking water systems; 67%, 223/332), and source protection (65%, 216/332) were of interest to the largest proportion of respondents.

Respondents were asked how they would prefer to receive training (multiple responses were permitted); 46% (151/332) reported through online courses; 35% (117/332) reported training delivered on their own site; 35% (115/332) reported in a classroom setting in 1 day or less; and 14% (45/332) reported by distance through the mail. Approximately 92% (305/332) of respondents reported having regular access to a computer with internet access.

## Operator confidence

Respondents were asked to rate their confidence in dealing with a list of water issues that a water operator may face. Most operators reported feeling very confident in managing

day-to-day operations (88%; 290/330), and working with the laboratory (84%; 278/332) and the public health unit (86%; 284/332). Only 52% (172/330) reported that they felt very confident in dealing with a broken septic system nearby, 58% (191/331) in repairing a broken treatment system, and 58% (191/329) taking action to improve cloudy water. Respondents' years of experience as a water operator was positively correlated with their confidence score (Spearman's correlation coefficient = 0.201; $p < 0.001$).

## DISCUSSION

This study used a cross-sectional telephone survey of small drinking water system operators and has provided an understanding of the proportion of operators with training, their relative level of confidence in their role, and an understanding of the training barriers that are most common among this group.

Previous studies (Boag *et al.* 2010; Kot *et al.* 2011) have used stakeholder consultation of small water operators and health professionals in Canada to determine the barriers faced by operators in meeting both the legal requirements and training. Kot *et al.* (2011) reported the barriers to training to be location, cost (including travel and course costs), and finding a replacement to manage the water system while away. Boag *et al.* (2010) reported the cost of operation, water sampling, accessible training and retention of trained operators were all challenges faced by small drinking water systems in Canada.

The primary findings of this study were that the majority (63%) of respondents had not taken water operator training, that confidence increases with years of experience as a water operator, and that barriers to education and training included the time of delivery, cost of training, knowledge of training opportunities, and language of delivery.

After the waterborne disease outbreak in Walkerton, Ontario in 2000 (O'Connor 2002), the Ontario provincial government made many changes to drinking water legislation, including the creation of legislation governing previously unregulated small drinking water systems (Advisory Council on Drinking Water Quality and Testing Standards 2005). The regulation of these systems was based on size and capacity, and required the owners to take legal responsibility for these systems. This created a knowledge gap as many of the small drinking water system operators in Ontario did not have extensive experience in maintaining their water system. Before inspection of these systems began in 2009, there was concern among regulators, public health professionals and water operators that requirements to meet the legal standards would be prohibitive, since the water system owners would bear the full cost of meeting these requirements (Advisory Council on Drinking Water Quality and Testing Standards 2005). The present study found 77% of operators believe the legal requirements are there to improve water safety, while 56% believed that conducting the required water sampling associated with the regulation of these systems was a hassle.

At the time of this survey, many respondents had not been a water operator for very long, with 40% of respondents having five years of experience or less; only 37% of all operators had taken training in support of their role. Those with more experience felt more confident in their knowledge and abilities than those with less experience. Furthermore, those with more experience tended to be those that had chosen small drinking water operation as a profession and felt confident in responding to adverse water conditions and events. A meta-analysis by McDaniel *et al.* (1988) found a significant correlation between work experience and job performance across a diverse sample of 83 occupation groups; however, individual ability can also be enhanced with job-specific training (Weekley & Jones 1999) and should be encouraged among water operators.

The large number of operators with relatively little experience coupled with low training rates may be cause for concern, although an association with poor water quality was not assessed here. Given the strong correlation between training and improved water quality found by others (Bowman *et al.* 2009; Hunter *et al.* 2010), training should be an important goal for all small, non-community water operators in Canada. Training helps to ensure that the person maintaining the water system is able to recognize risks to the water system and understands the steps needed to provide safe drinking water to their consumers on an ongoing basis, regardless of the past performance of the water system. Even a water supply with historically good water quality cannot be guaranteed to continue to be free of contamination (Jalba & Hrudey 2006).

Weather conditions and surrounding land uses have consistently been demonstrated to be important factors in water quality (Curriero *et al*. 2001; Auld *et al*. 2004; Thomas *et al*. 2006). However, in this survey the operators rated weather conditions and surrounding land use as the least important variables considered in water safety, with these findings being irrespective of the type of water system they oversaw. Risk perception can play an important role in how a risk is viewed (Slovic *et al*. 1979; Krewski *et al*. 2004). An operator's perception of the risks posed to the water supply is influenced by whether the operator is familiar with the risk, has had a past experience with it, whether such extreme weather events are something that rarely or frequently occurs, and their confidence in the protection measures that are in place (i.e. the treatment system). Training in drinking water system operation and adaptation to potential threats such as extreme weather events could influence the operators' perception of these risk factors.

In-person training for small water operators in Ontario is available in English through multiple providers, including the Ontario Ministry of the Environment, local community colleges, and the Walkerton Clean Water Centre (as of the date of this publication) (Ontario Ministry of the Environment 2014). Online and correspondence training are available through the Walkerton Clean Water Centre. However, barriers to training, including timing, cost, language and knowledge of opportunities, were reported by operators in this study. Online training may present a solution, and has been proven to be an effective method for adult education (Sitzmann *et al*. 2006). However, consideration must be given to the ability of operators to participate in this method of training as many small drinking water system operators are located in rural areas (Rupp 2001; Res'eau WaterNet 2014) where internet bandwidth is limited. This may improve in future, however, as small communities gain improved access to technology and internet connections. Furthermore, effective adult education methods should be used when developing online training modules.

This survey found that operators wanted training that dealt with trouble shooting, legal requirements and source protection, and that the language the training was offered in was a barrier to training; however the languages desired by respondents was not assessed. Boag *et al*. (2010) noted that access to context-specific knowledge is critical for small drinking water system operators. A needs assessment should be completed with operators of small drinking water systems that will further explore the content and languages that are needed to serve the diverse needs of rural and remote communities across Canada.

Given the low percentage of operators in this study (37%) who were aware of training opportunities, there also needs to be a concerted effort by those providing these training opportunities to ensure that operators are aware of new training opportunities each year. In this study, 63% of operators had not taken training; volunteers and those who were operators as a result of owning premises with a small water system were less likely to have completed training and to know about training opportunities available to them than those that had chosen the profession. Targeting training opportunities to those operators that are least likely to be aware of opportunities would be an effective way to increase awareness and training rates. Training should be promoted as a proactive step to improving water safety and operators should be encouraged, regularly, to take training.

## LIMITATIONS

Respondents were informed that this study was being conducted by the University of Guelph, the Walkerton Clean Water Centre and the MOHLTC; this may have increased the potential for socially desirable response bias when asked to rate water safety issues or the respondents' view of legal requirements. Since this study was limited to Ontario, these results may not be generalizable to water operators in other jurisdictions, particularly where regulation of small drinking water systems is substantially different.

Demographic variables, including education level, age, and previous professional experience was not collected and could have introduced a confounding bias. Age and previous professional experience may impact a person's confidence level; it is likely that people with previous professional experience, regardless of the industry, may report higher confidence levels, while a person's confidence may increase with age regardless of their years of experience as an operator. Education level could have an impact on the likelihood of taking training, where those with higher education levels are more likely to seek out and complete

operator training. These variables could lead to both over- and under-estimation of the frequencies reported here.

It is possible that operators overseeing certain types of premises were under-represented in this work; some of these businesses are operated seasonally or are open only during evenings or weekends and could have been unintentionally excluded from this study; it is not known if the study findings would have differed among these operators.

## CONCLUSION

This study has provided a greater understanding of the experience, knowledge and confidence of small drinking water system operators in Ontario, Canada. Low training rates coupled with the large number of operators that have relatively little experience highlights the importance of providing ongoing training support to this population. More focus on promoting training opportunities that are currently available and encouraging operators to seek out training will help to address this knowledge gap. Training providers should consider the time of delivery, cost and language of their training programs in order to increase participation and satisfaction in the target population. Online training could be an effective approach to address the access issue identified by survey respondents.

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