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SURVEY EXPLORING CUSTOMER COMPLAINT MANAGEMENT AND SMART WATER TECHNOLOGY ADOPTION ACROSS U.S. WATER SYSTEMS

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Abstract

High profile water quality events, including the Flint Lead in Water Crisis, have contributed to a decline in customer trust in their water utilities. For example, a recent study indicates as many as 60 million Americans do not drink tap water because they perceive risks in the cleanliness of water and do not trust water providers [1]. One way that utilities can build trust with customers is through improved management of customer complaints. Utilities can store, track, visualize, and share customer complaints to improve service and improve the way that customers interact with information about water quality. Smart water technologies, including Advanced Metering Infrastructure (AMI), data portals, and personal device applications (apps) can be utilized to better communicate with customers. Advanced data analytics can improve the insight that is gained about the source of water quality problems.

We surveyed utilities about their perspectives on trust and customer complaint management. This research explores the development, implementation, and results of a survey instrument distributed to water service providers across the United States. Survey questions explore the existing tools that utilities use to collect customer complaints, the adoption of smart technology by utilities, and characteristics of customer complaints. This research will assess capabilities to detect issues from customer complaints trends and the level of smart technology integration in United States water systems. We employ cross sectional analytical techniques to assess differences in complaint reporting and management system by utility size, urbanization, and socioeconomics of their service area. This research will develop new insight about the types of tools that utilities need and are willing to adopt to receive, analyse, and report customer complaints.

Keywords
Water Utilities, Smart Technology, Survey, Complaint Management, Smart water systems.

1 INTRODUCTION

Water utilities across the United States encounter many challenges in treating and delivering water [2]. Ageing infrastructure leads to pipe breaks and bursts, large volumes of lost water and revenue, and contamination of water supply [2]. Underfunded utilities are limited in their ability to expand water networks to meet growing demands, renew and restore aging pipes, update computational systems with advanced technology, and improve levels of service [2]. A recent study estimated that as many as 60 million Americans do not drink public water because they do not trust its safety [1]. Confidence in the quality of tap water declined at a particularly alarming rate from 2017-2018, after the Flint Water Crisis, in which toxic levels of Lead were discovered at multiple households connected to a water distribution system in Michigan [1]. The attention and timely response of utilities to address customer complaints can build public trust and track system wide quality trends [3]. Fostering communication with customers is one approach to improve customer confidence in water utilities [4]. Customers typically communicate with utilities to by reporting water quality issues, such as complaints about water discoloration, odor, or taste. In addition, analysis of trends in customer complaints can identify episodic water quality problems or water contamination events [5].

Communication between water utilities and customers can be enhanced through smart technologies such as social media, text alerts and data visualization platforms [4]. Water utilities are adopting smart technologies to track consumption, infrastructure performance, and operations[6]..Utilities can take advantage of real-time sensors, customer web portals, and social media to create transparency around water utility responses to complaints: social media expands the reach of utility communications [7]; Advanced Meter Infrastructure (AMI) provides subhourly insights about water consumption [8]; short message service (SMS) alert systems can quickly contact customers about a water quality incident [9]; data visualization platforms show household consumption trends to encourage conservation [10]; real time pressure sensors and machine learning models characterize water-end uses [11]; and Digital Twin, a computational replica of a real world pipe system that mimics its behavior can create new real-time insight around hydraulic performance of pipe systems [12]. There are different ways in which these smart technologies are useful, such as new avenues of data collection and enhancing information transfer between water service providers and consumers. However, it is not well understood how utilities are using smart technologies to build trust and improve customer satisfaction.

We conducted a survey to explore the processes and tools, including smart technologies, that utilities use to receive and store customer complaints. More than 500 respondents, representing community water systems (CWS) across the United States, participated. Data were analysed to evaluate how utilities communicate with customers, how they use smart technology, and how they use customer complaint data for operational insights. This research develops new information about the types of digital tools that utilities need and their approaches to receive, analyse, and report customer complaints, sharing an important perspective on some of the trust-building actions of water providers.

2 METHODS

2.1 Survey Instrument

The survey was developed and distributed to contact emails acquired using an internet scraper searching publicly available, online records of organizations that manage community water systems in the United States. All participants consented to sharing information about their water service operations, and the instrument was approved by an NC State University Internal Review Board. The survey was 46 questions in length and took approximately 15 minutes to complete. Respondents who indicated their consent and self-identified as a part of an organization that

provides water services were subsequently shown the full survey. No incentives were offered. Responses were collected across the entire United States over a period of three weeks in September 2021. In total, there were 504 quality-controlled responses to the online survey distributed via Qualtrics surveying software. Qualtrics conducted a soft-launch survey pilot to evaluate the survey instrument and employed quality measures including flagging responses submitted in less than a third of the average response time, incoherent responses, and inconsistent responses. The topics of questions that were included in the survey are:

- Respondent job title
- Water system locale, size, and primary source water
- Types of smart technologies in use
- Budget for smart technology
- Barriers to smart technology adoption
- Number of staff in complaint management
- Frequency of and challenges in communicating with customers
- Method receiving and storing of customer complaints
- Frequency of complaints by complaint type (i.e., taste, odor, color etc.) and season
- Applications of complaint data in trend tracking and concerns about data storage

2.2 Sample Characteristics

Survey respondents varied widely in location, size, urbanization, and other operational details. More than a fourth of responses came from very small community water systems, defined as servicing fewer than 500 connections (26.5%). Most of the respondents (32.3%) were from small, community water systems, which serve populations from 501 to 3,300 households (Table 1). Another 17% of responses were from medium providers servicing 3,301 to 10,000 households, and 17.6% were large utilities with up to 100,000 service accounts. The remaining 4% of responses come from very large utilities with more than 100,000 water connections, including three respondents who reported serving more than 1 million people (Table 1). Table 1 shows data from the U.S. Environmental Protection Agency (EPA) about how many utilities are in the US overall, by size. This survey collected responses from water systems which service about 5.1% of the US population [13]. Small and very small utilities, serving less than 3,300 or 500 connections, are particularly well captured in this survey, compared to large utility surveys that were conducted recently [14]. The total number of responses (N=504) is a statistically representative sample size for total number community water systems (CWS) in the United States [15].

Respondents self-described their service areas as 51% rural, 13% suburban, 32% small city or city outskirts and 3% large cities. Most of the water providers (62%) reported groundwater as their region's primary water source, with 31% reporting surface water sources, and another 7% indicating other water sources such as bought from another supplier, spring water or cisterns. Eighty percent of the water providers surveyed are publicly owned, 12% were private companies, and the remaining responses indicated other ownership cases such as quasi-public, quasi-governmental, or a homeowner's association. There were at least 30 responses received from each US Census Bureau region, with most responses (196) from the Southern United States.

Table 1 Sample Summary- Size Breakdown [a] 2020 U.S. population is 329 million [15]. Some estimates of utility populations are taken from previous census. [b] Data from U.S. EPA, 2021 [13]

Utility Size	Amount Served	Number of Responses	% of Responses	Total Population Served	% US population served	Number of CWS in the US [b]
Very Small	< 500	134	26.5	35,391	0.01%	26,963
Small	501-3,300	178	32.3	258,376	0.08%	13,334
Medium	3,301-10,000	86	17.0	514,099	0.16%	5,022
Large	10,001-100,000	89	17.6	2,788,882	0.85%	3,975
Very Large	>100,000	18	3.6	13,047,691	3.97%	446
	Total	504	100	16,644,439	5.06%[a]	49,740

3 SURVEY RESULTS AND DISCUSSION

3.1 Approaches to Customer Complaint Management

Responses to survey questions about approaches to manage customer complaints are explored by the size of the utility's service area. The ability of a utility to efficiently handle customer complaints is likely influenced by a broad range of factors, including size, number of staff, and importantly, the sheer volume of complaints received. Survey results indicate a wide variation in number of complaints received per week by utility size (Figure 3). Most respondents from very small (90.9%), small (91.1%) medium (80.2%), and even large (62.5%) utilities receive less than five complaints per week (Figure 1). The volume of complaints generally increases by size, and 42.1% of the very large utilities that responded receive 6 to 25 complaints per week, and 10.5% receiving more than 50. These findings demonstrate that given adequate maintenance and customer service staff, most utilities receive a small and manageable volume of complaints weekly. As utilities increase in size, growing numbers of complaints begets additional tools or smart technologies that can support response and resolution.

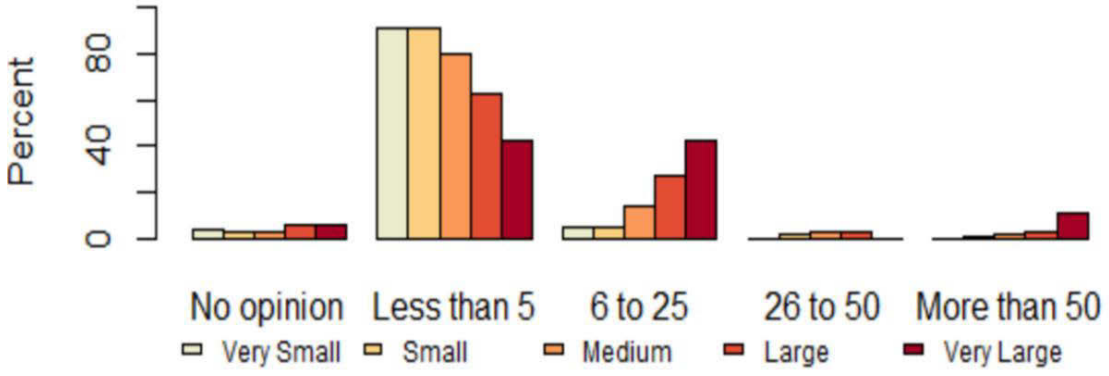

Figure 1. Percent of responses by size to "How many customer complaints are there per week?"

Analog records are less common as utility size increases (Table 2). Most large (59.1%) and very large (84.2%) utilities store records of customer complaints digitally, and all of the very large utilities are storing records in some capacity. Small (49.4%) and very small (33.3%) providers report mainly storing records on paper. Among very small providers serving less than 500 connections, 21.2% do not store records of customer complaints at all. Methods of complaint storage are important to gauge whether a utility can respond both to individual complaints that may reoccur, and clusters of complaints that can be indicative of system wide issues. For example, Gallagher and Dietrich implemented statistical analyses on the content of customer complaints from six utilities and found that incidences where there was both a high frequency of complaints and consistent descriptors in the data coincided with real episodic water quality problems [5]. With inaccessible or non-existent records, additional analyses of complaints that can yield operational insights are not possible.

The survey also explored whether complaint data is used to track system wide trends. Roughly half of very large utilities track system wide trends from complaint data (52.6%). All other utility size more often indicated that they do not use customer complaint data to track system wide trends. Table 3 presents a contingency table of how utilities store complaint data and their propensity to track system wide trends. Forty-two percent of utilities that mostly use digital storage methods of complaint data also reporting using that data to track system wide trends, while only 34.4% of those with paper storage and 6.7% of those not storing complaint records reporting trend tracking (Table 3). This supports the concept that digitalization and the integration of smart technologies is useful for utility efforts to make system wide improvements.

Table 2 Contingency table of the percentage of utilities that store complaint data on paper/digital by size

	Not stored	More on paper	Half and half	More digitally	No opinion
Very small	21.21	33.33	15.91	23.48	5.30
Small	12.78	49.44	11.67	23.89	2.22
Medium	12.79	29.07	13.95	39.54	4.65
Large	5.68	12.50	19.32	59.09	3.41
Very large	0.00	5.26	5.26	84.21	5.26

Table 3 Contingency table of utilities that store complaint data on paper/digital and their tracking of system wide trends

	Not stored	More on paper	Half and half	More digitally	No opinion
Yes, tracks trends	6.7%	34.4%	14.9%	42.1%	2.1%
No	18.7%	33.7%	11.9%	32.9%	2.8%
No opinion	12.3%	31.6%	22.8%	19.3%	14.0%

A set of open-ended questions further explored uses of customer complaint data. First, utilities were asked to indicate whether they felt their customer complaint data was utilized to its full potential. If yes, utilities were prompted to write about the ways they use their data at present; if no, utilities were asked about information they want to access from their data. A selection of free-form responses is reported in Table 4. Water providers that indicated they are using the data to

its full potential frequently cited that there very few complaints, such that they can effectively solve customer issues from complaints on a case-by-case issue as soon as they arise. Additionally, responses described that complaint information is used to guide decisions about capital improvements and to identify areas where infrastructure repairs are needed. Utilities explained that they desire for methods or algorithms to improve understanding of system wide water quality, flag customers with payment issues, showcase the utility's efforts to help the public better understand water operations, and identify root causes of customer issues. These are fertile areas for future research and product development.

Table 4 Selection of free responses to questions about data utilization

You indicated more potential uses of customer complaint data. Please elaborate on potential applications of this information.	**You indicated that you are fully utilizing your customer complaint data. Please elaborate on your applications of this information.**
"To see trends or re-occurring issues"	"Track problems and make repairs"
"Could be used to identify constant problem customers and those who have payment issues"	"When problems come in, we investigate and address. If multiple complaints occur, we look for the cause"
"Flushing programs, line replacement priority"	"Customer complaints are used in the maintenance or replacement of infrastructure."
"We store the info in … monthly report. Really have no method to retrieve the data without reviewing e-mails or reading each report."	"Look for trends of pressure complaints"
"Should be able to group customer concerns & determine if there is an identifiable cause/solution over time."	"Complaints are rare and handled as they arise."
"Target certain neighborhoods to better help them… fix leaks at homes, address aging homes and repeated leaks, replace lead lines, help with affordability "	"We store and review complaints and responses and work to minimize issues in the future through capital projects and education and outreach."
"Seasonal trending of water quality; trending of complaints with ongoing upkeep (flushing and pipe pressure testing); identifying problem areas"	"We are a small rural system, so we rarely have any complaints, and when we do have complaints, we go straight to the complaint area and work directly with the customer"
"Identify recurring issues, show customers that these issues do occur, but can be - and are - fixed when we know about them."	"Not really relevant - we resolve issues as they infrequently arise"
"We could compile the data and release it regularly, rather than periodically. "	"We use the data to develop capital improvements and operation planning (flushing, sampling, disinfection)"

3.2 Smart Technology Adoption

Smart technologies integrate digital and internet-enabled tools to automate, streamline, and improve the operations of a system [6]. Figure 2 reports the percent of utilities by size that are already implementing various types of smart technologies. Social media can open a two-way dialogue between utility and customers and allow for more rapid communication transfer [7]. A

large portion of utilities, regardless of size, indicated they already have a social media presence (Very small- 41.6%, Small- 57.8%, Medium- 69.7%, Large- 77.3% and Very large- 94.7%). Another commonly cited adoption was smart water meters. Smart meters were less common among very small providers (28.8%), but with increasing frequency by size, and 46.1% of small, 67.4% of medium, 77.3% of large and 78.9% of very large utilities have smart meters currently deployed.

Several technologies are well integrated at large utilities and more sparingly adopted among smaller providers. For example, hydraulic models are implemented by 89.5% of very large providers and 62.5% of large providers, but under 50% in other groupings; short message service (SMS) or text alert systems are in use by 63.2% of very large utilities but under 40% among smaller sizes; pressure sensors are adopted by 78.9% of very large utilities (Figure 2). Less than 40% of any utility grouping employs data dashboards that can visualize household consumption trends or allows consumers to regularly view their usage online. Implementation of data dashboards does steadily increase by utility size (Figure 2).

Only 15.8% of very large utilities and less than 5% of all smaller sizes reported using artificial intelligence or machine learning analytics, indicating these approaches are still cutting-edge and lack widespread uptake at present (Figure 2). Similarly, less than 2% of utilities of any size indicated using Digital Twins [12]. Results show differences in the current adoption of smart technologies by utility size, and, specifically, smaller utilities may have unequal access to tools that can improve infrastructure monitoring, operation, and management such as hydraulic models and real-time pressure sensors.

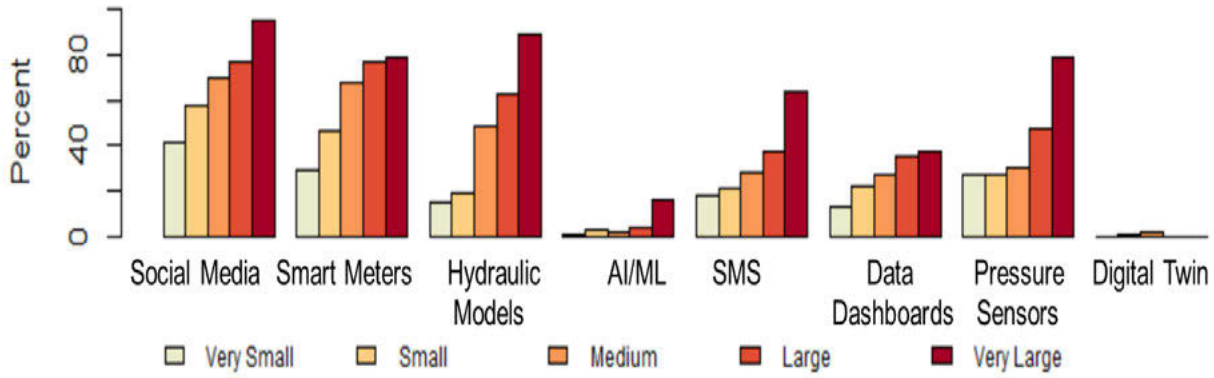

Figure 2. Percent of responses by size to "What smart technologies are currently in use?"

Most utilities, regardless of size, reported that it would be at least somewhat challenging to incorporate new smart technologies in their service area (Figure 3). Another question offered a list of possible barriers to the addition of smart technologies, and respondents indicated all which applied. Primary barriers to adoption of additional smart technologies across all respondents were finances (38%). Other barriers to the adoption of smart technologies included not enough personnel (23%), lack of staff training (22%), and that smart technologies should not be adopted because they add no value for the utility (11%). The survey also asked about smart technologies budgets, which is important because finances was the most frequently reported barrier to the adoption of smart technologies. As anticipated, budgets increased on average with utility size, and more than a quarter of very large utilities indicated at least $500,000 USD for smart technologies.

Six percent of respondents provided text responses to the question about barriers to the adoption of smart technologies and provide new insight into range of challenges utilities may face. Several cited lack of customer participation to implement new services, including a description of a "large senior population [with] low adoption of paperless billing and electronic form submission". Another theme of the text responses was trepidation about new techniques, such as responses stating "concerns about security", "personnel resistant to change", and "poorly established

innovation goals". Finally, several respondents discussed difficulties managing rural and remote water systems that impede smart technology integration: "our service area is spread out", "terrain and geographic issues" and "limited internet and phone". These insights give important context for the bounds of digital transition in water systems, which relies on adequate funding, privacy and security measures, staff training, and the performance of interconnected public services such as internet and phone.

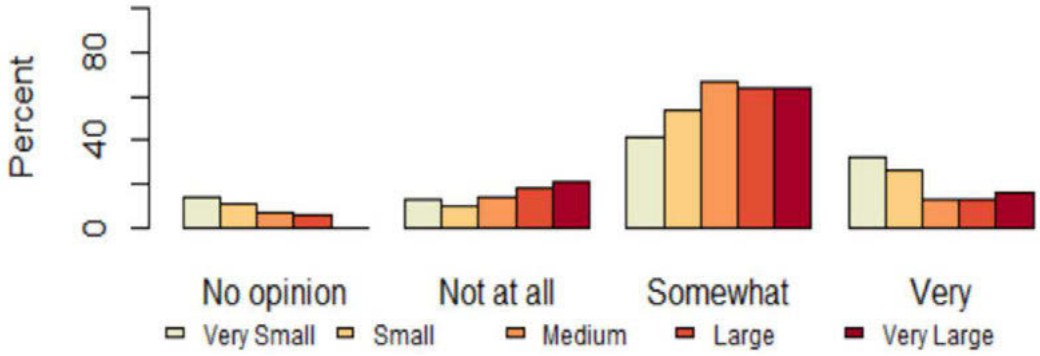

Figure 3. Percent of responses by size to "How challenging is it to adopt additional smart technology?"

4 CONCLUSION

In this research, a survey is developed and distributed to water providers across the United States to better characterize customer complaint management techniques and smart technology implementation. More than 500 water utilities responded, representing a statistically significant portion of the total number of community water systems in the United States. Respondents ranged from very small systems with less than 500 connections to urban centres with more than 100,000 households served. Responses demonstrated a range in attributes that affect system operations such as urbanization, geographic region, ownership, and primary drinking water sources.

Results reveal a dichotomy in funding, smart technology implementation, and customer complaint management approaches by utility size. Larger utilities tend to have digital storage of complaint records. Nearly a quarter of very small water providers do not store records customer complaint records at all. Some may view these records as unnecessary, given that results indicated most small providers see under five complaints per week. As a comparison, 10% of the largest utilities surveyed manage more than fifty complaints weekly. Utilities need information from data to make managerial decisions about infrastructure investment, in applications for additional funding, and to monitor system performance. Paper records or lack of records altogether are an area of improvement in which U.S. water utilities could use support. New complaint management systems can document this data automatically and securely over time. Further, less than half of all providers surveyed report applying complaint data to track system wide trends. Without collecting data and transforming it into actionable information, water systems may fail to detect systematic issues, such as the Flint lead crisis, while handling customer complaints in siloes.

Smart technologies including internet-enabled water meters, social media, hydraulic models, real-time pressure sensors and data visualization platforms help streamline utility operations, improve communication with customers, and offer structure for storing and processing customer complaint data. More than a quarter of respondents, regardless of size, already use social media and smart meters. Smart technology funding varies widely, with larger utilities being better funded, yet with many smaller utilities indicating having at least $50,000 USD to spend. Larger utilities indicated advanced capabilities more often than other groupings, including high instances of hydraulic models, text alert systems, and real time pressure sensors.

The survey collects free responses in addition to the measurable results, adding rich information about utility perceptions that can lead to new research directions. The water providers surveyed desire to learn more information for decision making from the data they collect. Particularly, utilities described want to use data to identify areas for repair and infrastructure improvements, to cluster problems for trend identification, and for education and outreach purposes. Finances and personnel issues are the main barriers to the digital transition of U.S. water systems, but other free responses about navigating rural terrain and lacking internet coverage are worthwhile areas of further investigation. Overall, this research identifies areas of improvement in customer complaint management and contribute to a more complete picture of current smart technology capabilities and barriers to further adoption in the United States.

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