Ethical Considerations for Wastewater Surveillance in the United States Department of Defense

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Abstract

The U.S. Department of Defense (DoD) is beginning to establish its wastewater surveillance capacities to support public health, force health protection, and national security. Wastewater surveillance is an emerging technology that has traditionally been utilized for detecting infectious diseases. However, its potential future uses may bring a staggering and unpredictable amount of information that could be used for a wide variety of purposes both health and non-health related. The U.S. military serves an inimitable role for the country and its citizens, and it exercises significant levels of control over its service members compared to civilian organizations. Further, its presence and potential wastewater surveillance activities may reach far beyond just military installations. As such, there arise unique ethical considerations that
must be accounted for to ensure the DoD implements a wastewater surveillance network in a manner that is both impactful in supporting public health and appropriate to the scope and population under surveillance. Therefore, this paper explores important ethical features in conducting wastewater surveillance that are both specific to the DoD experience and applicable for wider public health interests.

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Abstract:
The U.S. Department of Defense (DoD) is establishing its wastewater surveillance capacities to support public health, force health protection, and national security. Wastewater surveillance is an emerging technology that has traditionally been utilized for detecting infectious diseases. However, its potential future uses may bring a staggering and unpredictable amount of information that could be used for a wide variety of purposes both health and non-health related. The U.S. military also serves an inimitable role for the country and its citizens, and it exercises significant levels of control over its service members compared to civilian organizations. Further, its presence and potential wastewater surveillance activities may reach far beyond just military installations. As such, there arise unique ethical considerations that must be accounted for by leaders and policymakers to ensure the DoD implements a wastewater surveillance network in a manner that is both impactful in supporting public health and appropriate to the scope and population under surveillance. Therefore, this paper explores important ethical features in conducting wastewater surveillance that are both specific to the DoD experience and applicable for wider public health and environmental science interests.

Keywords:

Military; Bioethics; Infectious Disease; Health Security; Ethics; Wastewater Testing

Synopsis:

Wastewater surveillance is a rapidly developing field for public health and the military. There are both unique and generalizable ethical considerations that must be accounted for as this technology advances.

Ethical Considerations for Wastewater Surveillance in the United States Department of Defense

I. Introduction

Wastewater represents a promising source for obtaining valuable public health data to inform decision-making and response efforts.[1] Wastewater testing includes the tools and technologies which are used for various activities (e.g. research, law enforcement, public health), and wastewater surveillance (WWS) is the activity of assessing biological, chemical, and analyte signatures to determine population-level health trends to inform public health decision-making.[2-5] Wastewater surveillance has traditionally been leveraged to monitor for select infectious disease pathogens such as poliovirus and, more recently, SARS-CoV-2 during the COVID-19 pandemic.[2-4,6] However, wastewater testing has been utilized in recent years to detect myriad other targets ranging from dietary patterns to the genetic makeup of communities.[2,3,6-10] Wastewater surveillance is an appealing public health instrument due to its scalability, cost effectiveness against clinical monitoring, and ability to detect surges in infectious disease cases days before they become clinically relevant.[11,12] Recognizing the potential utility and value of WWS, the Centers for Disease Control and Prevention (CDC) led the development of the National Wastewater Surveillance System (NWSS), whereby environmental scientists and public health departments across the country track specific pathogens including SARS-CoV-2, influenza A, respiratory syncytial virus, and mpox, and report into the NWSS to inform public health decision-making.[13] This system currently collects data from over 1,000 sites across the U.S. representing 35% of the U.S. population, and it continues to add other pathogens of public health concern to its surveillance list.[13] There are also plans by researchers and private corporations to further expand the detection capabilities of wastewater testing technologies to include illicit drug use, non-communicable diseases, genetic information, and more. There are meaningful differences in the ethical considerations between wastewater testing versus WWS, partly because wastewater testing also carries a broader application of uses, such as research, law enforcement, and espionage.[14,15] However, this paper focuses on WWS and only addresses wastewater testing as it applies to WWS as a public health activity.

Recently, the DoD has begun prioritizing wastewater testing and surveillance, as highlighted in the emerging capabilities and technologies section of the 2023 Biodefense Posture Review.[16] It

currently oversees myriad individual WWS projects both in the U.S. and overseas, is partnering with other government agencies and private industry to explore and expand its wastewater testing technologies, and is building out its capacity to develop and manage a DoD WWS network. It has already invested tens of millions of dollars towards advancing its WWS efforts. The DoD plays an inimitable security role in society and maintains a unique relationship with its Service members. A DoD WWS network has a potentially massive global scope with coverage of myriad populations both civilian and military.[17] Given that 1) the DoD has unique population and security considerations, 2) wastewater testing technologies are promising in their applications and are rapidly evolving, and 3) there remain significant unknowns regarding the potential future uses of wastewater technologies, there is therefore an urgent need to discuss and address the ethical considerations inherent to implementing a WWS network for the DoD to ensure it is executed appropriately and has suitable policies in place to manage it.

It is critical that environmental scientists, policymakers, and those engaged in WWS are aware of current and future ethical issues related to wastewater testing and surveillance. Policy, especially that which is crafted for emerging technologies, must be focused on its ethical implications and should strive to provide appropriate guidance and boundaries. As such, this paper explores these ethical features of WWS and offers recommendations to address these concerns, which are important considerations for any group planning to implement a WWS system. However, though many of the ethical considerations discussed in this paper are universal to any WWS system, the ways in which they apply to the DoD (whether in identity, scope, or importance) compared to other contexts are unique and deserve particular attention.

II. Targets of Wastewater Surveillance

First, the scientific evidence and methodology for wastewater sampling and testing must be established for each pathogen or target under consideration for surveillance. It would be ineffective and an unethical use of resources to blindly pursue at-scale sampling of targets without first determining a sufficient level of understanding of them. For infectious diseases, this might include pathogen-specific knowledge of 1) sampling and detection methods, 2) laboratory testing and genomic sequencing and analysis, 3) relationship of detection levels in wastewater compared to clinical detection in humans, and 4) methods to mitigate the spread of the disease. A key component of conducting ethical public health activities includes ensuring the surveillance and responses to that surveillance are done so in effective, scientifically sound, and evidence-based ways. If not, the negative opportunity costs of inefficiently utilizing public health funds could cause harms in other

health areas where the funds could have otherwise been distributed. Addressing this concern might include pilot testing of new pathogen targets or wastewater testing technology as well as cost-effective analyses prior to full integration into WWS system.[18] For example, if a pilot project discovered that a new potential feature to the WWS system only marginally limited infectious disease and did so at significant cost, those funds might be better directed to more effective public health activities.

Kass describes an ethical framework for the assessment of public health programs and rightly concludes that one of the key aspects of an ethically conducted program includes its effectiveness in achieving its stated goals.[19] Relatedly, monitoring and program evaluation should be baked into the running of a public health program to ensure it is supporting its goals.[20] For WWS, this might involve monitoring to see whether WWS programs do an effective job of limiting infectious disease transmission among communities where it is being conducted compared to those it is not. Additionally, as WWS technologies and methodologies are developed and refined, there should be efforts to assess for concordance between what is detected by WWS and what is found in clinical and on-ground surveillance. Thus, an ethical WWS program is one that is scientifically sound in its sampling and analysis methods as well as one that is effective in achieving its goals as supported by clinical and epidemiologic evidence.

Currently, most WWS programs are focused on infectious diseases. However, there are other potential targets that have been explored beyond infectious pathogens (e.g., non-communicable diseases such as cardiovascular disease and cancer), and it is difficult to predict what technologies will become available in the future to assess WWS.[21,22] Yet many of the core ethical issues at present will remain salient regardless of the future technological capability. DoD leadership should be cognizant of preventing excessive mission creep (i.e., broadening of the original objective).[23,24] Utilizing WWS for purposes beyond the focus of promoting and preserving health can be dangerous and cause ethically fraught scenarios. For example, opioids and other substances of abuse (e.g., methamphetamines, cocaine, nicotine) could be monitored via WWS, but this raises equity concerns and risks of over-policing.[25] Not only does the DoD already implement randomized drug screening for its Service members (SMs), but it carries additional equity concerns. Many higher-ranking personnel and officers live off-base, so on-base areas where the DoD would more accessibly conduct WWS might result in military leadership focusing punitive efforts on lower ranking enlisted personnel in an inequitable, unjustified way when other levels of the command structure might use illicit substances in equal measures but simply live off-base undetected. This would be particularly problematic in considering that WWS captures all individuals using the sanitation system, including

SMs, families, civilian and contractor employees, and visitors. It could also be the case in the future where WWS could be used to detect many other medication-related metabolites (e.g., reproductive health medications), human genetic content (e.g., racial/ethnic composition of communities), and other potentially damaging or politically contentious targets. It is important to thoughtfully consider what could become possible for WWS and what DoD leaders and policymakers must be aware of moving forward so they can keep the focus of WWS trained on appropriate health targets and health-promoting outcomes.

III. Populations and Areas of Wastewater Surveillance

Second, where should the DoD focus its wastewater surveillance efforts? This question is important practically, legally, and ethically because there are relatively few areas where one could conduct WWS with *only* DoD SMs present. Understanding the size and vulnerability of the populations targeted by WWS can influence the interpretation of and reactions to data produced by it.[26] Thus, exploring where the DoD should conduct WWS naturally leads to the question: on whom should the DoD focus its WWS efforts?

On-base DoD locations and DoD transport vessels are obvious areas to focus WWS efforts. There are four primary location types that can be considered for on-base WWS: 1) facilities, 2) clinics and hospitals, 3) recruit and trainee sites, and 4) housing. On-base DoD locations refer to areas both within the U.S. and abroad, including permanent international installations and temporary bases established during conflicts. On-base facilities (both medical and non-medical) and recruit/trainee sites seem to be the least ethically problematic locations, as these typically constitute the areas with the most force health protection (FHP)-relevant activities and the highest concentration of SMs. While there are also DoD civilian and contractor personnel who also work in these areas, executing WWS in these locations is both fully within the DoD's responsibility and legal jurisdiction to support and promote the health of DoD Service members as well as civilian and contractor personnel. Military transport vessels (e.g., large aircraft and naval ships) may prove to be particularly important catchment points for sentinel surveillance, especially for the transmission of infectious diseases.[27-29]

On-base housing is another area that is highly FHP-relevant, as these are the locations SMs and those closest to them spend most of their off-duty time. An SM's family often lives on-base with them, and the family's health can impact the health of SMs and their units. Further, infectious diseases present among SM families are likely also present among SMs, so conducting surveillance of beneficiaries would better inform the epidemiologic picture of infectious disease prevalence and

transmission for military units. Thus, there is a high probability of detecting pathogens of DoD significance in these areas. There is a precedent of the DoD assuming some fiduciary responsibility for promoting the health and well-being of SM families, as evinced by their support of them through a variety of clinical and social support systems (e.g., Tricare healthcare coverage, paternity/maternity leave policy, education options, free counseling services for families, housing support, wellness centers, etc.). It is also nearly impossible to extricate on-base housing WWS sampling of SMs from family members who live with them. Therefore, it is within the DoD's purview to promote SM families' health, and if the WWS is conducted in a minimally invasive, deidentified, and ethically sound way, WWS may be a valuable way to further support these health objectives.

The DoD also has a vested interest in WWS abroad; these international locations can be grouped into three categories: 1) joint military exercises, 2) ally military installations, and 3) foreign areas of mutual interest with the host nation. There should be two key underlying requirements for all international locations (outside DoD installations located abroad): 1) the DoD must obtain the permission of the host nation in which they are guests to conduct WWS, and 2) there should be some benefit of the WWS to that host nation. Ensuring these criteria are fulfilled will promote an equitable relationship between nations and help avoid exploitative or colonialist interpretations of mutually beneficial public health activities. Another critical consideration for the DoD conducting international WWS is that the host nation should be empowered to exercise as much sovereign control over the public health activities occurring in its own territory as it sees fit. The DoD and the host nation may both have interests in conducting WWS in certain locations in that country, but it should be the host nation's decision regarding if and how that happens. The DoD's role should be that of support, but this support can manifest in a variety of ways depending on the context and needs of the host nation, including leading the WWS project, funding host nation researchers, providing methodologic input and subject matter expertise, developing technical and analytical capabilities, etc. Having the DoD approach the host nation from a perspective of support, providing the host nation opportunities to lead decision-making, and emphasizing the mutually beneficial aspects of the collaboration all support an equitable partnership.

Joint military exercises serve as collaborative training opportunities for two or more militaries to build cohesiveness, promote mission readiness, and grow camaraderie among allies. As such, it is acceptable for either the DoD or any of the other militaries to take the lead in conducting the WWS, but it should also be the case that all the participating militaries whose wastewater is sampled endorse their permission for WWS to be conducted during the exercise and for the data to be shared with the sampled parties that participated, if requested. This supports the participating

military's autonomy by providing an opportunity for group informed consent whereby a nation's military can provide permission or denial of participation for its SMs. For WWS in ally military healthcare facilities and installations, it is most appropriate for the ally military to lead the WWS effort and for the DoD to support these efforts as defined by what is agreed upon between the two militaries. Again, the flow of data should be bidirectional and beneficial for both parties in order for the endeavor to be equitable. For international civilian contexts such as healthcare facilities, the ally nation's relevant health organization (e.g., ministry of health, health research institute) should be a key partner, and the DoD should support and coordinate with them in the conduct of the surveillance and sharing of data. The host nation's organization should make efforts to ensure the areas in which they are conducting WWS are aware of the WWS program, and for the case of specific buildings such as healthcare facilities, the facility's leadership should be aware and approve of the WWS.

IV. Management of Wastewater Surveillance Data

Third, once WWS has been conducted, what should happen with the data? There are important ethical considerations regarding how the DoD should manage WWS data and what type of data they ought to collect. There is a challenging balance that must be struck between allowing useful and beneficial access to data and the protection of that data. A plethora of data is obtainable within and surrounding WWS from molecular and biological signatures, markers of health and disease, monitoring of illicit activities through biochemical reporters, and tiebacks to demographic and associated identifiable metadata.[17] While the possession of large amounts of data is typically beneficial to determine correct response, course of action, and preventive planning, there are also crucial considerations required for protecting these data, and the DoD arguably experiences more frequent and powerful attacks to its information security infrastructure compared to other organizations. Managing the focus on which data to protect (e.g., personally identifiable information vs aggregate) and how (e.g., cloud/server vs hardline firewalls) will be crucial to ensuring data weaponization or leakage is improbable or limited in outcome. Wastewater surveillance can produce highly granular data that can be used by public health researchers and officials for the good of the communities they serve but are not essential when communicating to end users. Establishment of defined data sharing agreements which implement ethical concern guidelines and treat WWS data with the same scrutiny as Controlled Unclassified Information and Classified determinations, wherein raw information sharing is done as needed, will aid in reducing improper use of WWS information. Data security can be handled in a similar fashion, whereby escalating access and storage restrictions are imposed as data aggregation and type become more specific. For instance, aggregated community-level detection data for public health targets could be stored on shared drives with

minimal restriction; however, individual molecular and genetic data could be stored behind hardline firewalls on dedicated information technology machines. Anonymization and beacons are additional potential methods to help ensure individual human subjects cannot be identified in WWS, but these both have their own sets of weaknesses.[30] Nonetheless, it is likely that approaches to data security will not lend to "one size fits all" solutions and will be dictated by the surveillance effort, parties involved, and required outcome of the surveillance effort. This DoD must take strong measures to ensure only authorized personnel are able to access levels of WWS data appropriate to them.

As WWS data becomes more granular and specific, the greater the ethical responsibility becomes to ensure data security and appropriate utilization and access of that data. This escalation of responsibility in proportion to level of granularity of the data is derived from the increasing probability of that information being personalized and potentially damaging to individuals and small groups. For example, depending on where the wastewater is sampled, it could be possible to pinpoint illicit drug use or the location of an individual to a specific household. In fact, analyzing local sewage for genetic markers was one of the methods potentially used by the U.S. to confirm Osama bin Laden's location prior to his killing in 2011.[15] It may also become possible in the future to obtain personal genetic information via WWS and to associate this with personally identifiable information; the DoD must be prepared to either dispose of or strongly protect this data. Not only are there risks should foreign adversaries gain access to this level of data, there are also real hazards as to how this information could be misused domestically in politically motivated ways. One way to combat these concerns is to establish clear sampling strategies with requirements to destroy unused sample portions once the appropriate predetermined targets are tested for and/or detected.

There are also important considerations regarding the sharing of WWS data when it has broader implications beyond the DoD and is relevant to other public health entities, such as U.S. Government groups (e.g., local health departments, the CDC), ally nations, and non-governmental organizations (e.g., Bill and Melinda Gates Foundation). There are certain ethical responsibilities in the sharing of appropriate levels of data when that information can also be of benefit to others, and the DoD should take steps to collaborate with these other groups to promote health security. Thus, taking all these considerations into account, one overarching goal for a DoD WWS network is to ensure the data is maintained at an aggregate level as much as possible to monitor for community and population-level trends rather than information on individuals or small groups.

V. Use of and Responses to Wastewater Surveillance Information

Fourth, public health surveillance data should not be collected unless there is the potential for

a meaningful and actionable response to that information. If surveillance findings are not translated to public health action or policy changes, then minimal benefits accrue from the surveillance work.[31] To collect data for the sake of having the data is not an appropriate use of resources, and there should be focused and organized plans in place regarding how to use WWS systems and the information derived from them ahead of their implementation. There should also be rigorous discussions about how military leaders and public health officials respond to such information as it arrives to them. There are innumerable ways in which leadership *could* respond to WWS data when received near real-time, and with that new stream of information comes the opportunity to ethically utilize that data and the risk of responding inappropriately to it.[32] It is important to note that oftentimes it is a military commander who makes the final decision for a public health action or intervention, particularly those of consequence. It will likely not be a medical or public health professional making the decision, and the military commander may have no background in science, medicine, or public health. The military commander and their leadership team making the intervention decisions in response to WWS data should lean heavily upon the expert advice of their medical and public health professionals to best inform their decisions to help ensure they take the most appropriate action. The key consideration here is that the responses – whether they be determined by military command or leadership from preventive medicine, public health, and/or clinical groups – should be appropriate, proportional, and context- and community-specific to the information received through the WWS system.

VI. Other General Ethical Considerations

Finally, there are unique ethical considerations the DoD must account for that civilian organizations do not necessarily need to address to the same degree. The military has deep authority, control, and access to its SMs' lives. It can dictate anything ranging from what to wear, where to live, how to behave, and more across nearly every aspect of SMs' lives. Because of the extent of control the DoD exerts over its SMs and the durability and depth of the effects of this control, the DoD holds an elevated ethical responsibility to the health and well-being of its SMs.[33] Further, there is a public health ethics principle which argues that a public health program must utilize the least invasive or minimally burdensome (to the population being targeted by the program) means to accomplish its goals.[16,34] Service members already yield much of the autonomy otherwise afforded to them as civilians, so any public health program that might additionally strip away at their comparably limited abilities to exercise their autonomy must be seriously deliberated before implementation. Although the act of conducting WWS may not directly interfere with the lives of SMs as it is collected, the actions related to WWS (e.g., how leadership responds to the information, what data is collected, and

how the data is managed) could infringe upon their privacy and autonomy. Yet, if conducted appropriately, the potential health benefits for the SMs would likely greatly outweigh minor privacy or autonomy concerns. Additionally, there are more than just military populations at stake when considering the health of SMs. The mission of the DoD and SMs is to protect U.S. citizens, interests, and national security. Thus, if SMs are unwell, experience disease outbreaks, or are targeted with bioweapons, this places the country at risk, as they will be less able to support their security objectives by failing to achieve optimal operational capabilities and mission readiness. It is also the case that SMs and military installations do not exist in a vacuum. If an infectious disease causes problems among a military population in a certain area, it is likely there is a similar problem in the surrounding civilian community, or at least the risk is present for them as well. These considerations therefore add to the elevated responsibility of the DoD to support and promote the health of its SMs.

There are also several broad ethical considerations the DoD should account for in the ways it conducts WWS. There is a tension underlying many public health actions: the question of preserving personal freedom and autonomy of individuals versus maximizing the public health good of the group. This tension is manifested in several ways through the discussion surrounding WWS when considering: the amount and types of data to be ascertained, the proportionality and appropriateness of the response to the data, the level of invasiveness of the surveillance, the populations and areas selected for surveillance, etc.[35,36] DoD leadership should seek to strike the balance of protecting the freedom and autonomy of its SMs while also prioritizing the health of the force from a population perspective.[33] Additional resources providing ethical guidance for the operation of public health surveillance systems that are applicable for WWS include the American Public Health Association's Public Health Code of Ethics and the World Health Organization's Guidelines on Ethical Issues in Public Health Surveillance.[34,37]

Justice is also a key ethical concept, and when appraising a DoD WWS program, two key perspectives of justice must be considered: distributive justice and procedural justice. Distributive justice is an ethical principle concerned with the fair distribution of benefits and burdens. In the DoD WWS context, this can involve ensuring that the distribution of resources, outcomes, and interventions based on the surveillance findings is done so in an equitable way (e.g., distributing vaccines based on findings of acute elevations in vaccine preventable diseases in WWS). It can also involve the fair distribution of resources for conducting WWS throughout U.S. and international installations. Procedural justice is an ethical principle concerned with fair processes and methods. It includes such features as inclusion, transparency, neutrality, respect, and trust.[38] For DoD WWS, this might include transparent communications and decision-making, community considerations,

stakeholder participation, access to relevant data for the surveilled communities, etc.

There are a variety of other general ethical considerations that are applicable to WWS, which are briefly mentioned here and should be explored further. One issue includes the differences between conducting public health surveillance versus research and what the regulatory, oversight, and ethical requirements might be. Second, there may be differences in what becomes permissible when considering baseline surveillance versus what may be needed during public health emergencies. Finally, there are inevitably future possibilities beyond our current capabilities or knowledge regarding what might become possible through conducting WWS. What might WWS be capable of in the future, and how do we anticipate and plan for that? Though there are myriad ethical considerations for the appropriate conduct of WWS by the DoD both currently and in the future, it is undoubtedly a burgeoning area of public health that the DoD should pursue and be engaged in a substantial, effective, and meaningful way, as there are innumerable potential benefits to a DoD WWS network.

VII. Conclusions

Wastewater surveillance offers tremendous promise and opportunities to advance public health by expanding what is possible in terms of conducting disease surveillance, informing public health and clinical decision-making, and improving public health response times to mitigate negative health impacts to populations.[39,40] The DoD should pursue WWS and position itself to take advantage of the current and potential future benefits that come with it. It should also understand the practical and ethical differences between using wastewater testing for public health surveillance versus research versus other potential military purposes. With around 1.3 million active-duty Service members, 1.1 million National Guard and Reserve members, and 700,000 civilian personnel, the DoD is the largest organization in the U.S., and it has responsibilities to their health and readiness.[41] Further, the Military Health System serves approximately 9.5 million total beneficiaries which includes not just Service members, but their families and others.[42] WWS has the potential to benefit not only these populations, but others in the U.S. and abroad. Yet with these opportunities also come the potential for misuse to the detriment of those being surveilled, which raises important ethical questions for how and why WWS should be conducted. The DoD also has elevated ethical obligations to the well-being of its Service members due to the breadth and depth of control it exercises over them. Although ethical issues may arise related to WWS, these issues can and should be addressed through proper deliberation and policy implementation because the potential public health benefits could be substantial. The DoD has interests in and responsibilities to protecting the

national security of its citizens broadly, which implies a needed role in infectious disease surveillance for outbreaks as well as bioengineered and emerging pathogen threats. Thus, the DoD should pursue wastewater surveillance in an ethically appropriate, scientifically robust, and thoughtfully planned and executed way that will inform its public health decision-making to protect the well-being of its SMs and support U.S. Government health security objectives.

Abbreviations:

CDC = Centers for Disease Control and Prevention

DoD = Department of Defense

SM = Service member

WWS = wastewater surveillance

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