Evaluation of "Real-Time" Fatal Drug Overdose Surveillance by King County Medical Examiner's Office, Seattle, Washington

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Abstract: To address the challenges in monitoring the continuously accelerating drug overdose epidemic, the King County Medical Examiner's Office in Seattle, Washington, instituted a "real-time" fatal drug overdose surveillance project, depending on scene investigations, autopsy findings, and in-house testing of blood, urine, and drug evidence collected from death scenes. Validation of the project's rapid death certification methodology from 2019 through 2021 was performed at the following 3 levels: blood testing, urine testing, and death certification, and for the following 4 drugs: fentanyl, opiate, methamphetamine, and cocaine. For blood testing, sensitivity ranged from 90% to 99%, and specificity ranged from 86% to 97%. For urine testing, sensitivity ranged from 91% to 92%, and specificity ranged from 87% to 97%. The positive predictive value for cocaine was poor for both blood testing (57%) and urine testing (72%). Of 1034 deaths, 807 were certified as overdose by rapid methodology, and 803 (99.5%) were confirmed by formal toxicology results. Manners of death were changed from accident to natural in 3 of 1034 cases (0.29%). Results of this study indicate that the rapid overdose surveillance methodology described in this study offers benefits to families and provides useful, timely information for responding law enforcement and public health agencies.

Key Words: forensic pathology, drug overdose surveillance, toxicology, drug evidence testing, validation

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As the overdose epidemic continues to accelerate throughout the United States,[1–4] the goal of achieving an effective surveillance strategy by rapidly identifying the appearance and identity of specific drugs has become increasingly important.[5–12] National, regional, and local trends are all important for monitoring the impact on our communities as manifestations of the epidemic vary temporally and regionally, especially with respect to the appearance of novel synthetic drugs and seemingly limitless supplies of fentanyl and inexpensive methamphetamine.[13–20] The COVID-19 pandemic superimposed further complications that remain largely uncharted.[21,22] Monitoring the drug overdose epidemic is crucial to informing public health and criminal justice responses and guiding rational drug policies. Chief among the metrics for monitoring the crisis are mortality data derived from death certificates generated by medical examiner and coroner offices relying on analyses from toxicology laboratories. Because of the burgeoning caseload of overdose deaths relative to limited resources, crucial death investigation systems have been overwhelmed, resulting in long delays in completing death certificates.[5–7,12,16,19,21]

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As the escalating overdose epidemic overwhelmed resources in the Pacific Northwest, the King County Medical Examiner's Office (KCMEO) in Seattle, Washington, an agency of Public Health–Seattle and King County, created a rapid fatal overdose surveillance system with the goal of rapidly certifying drug overdose deaths and identifying the specific drugs involved.[11,12] This project involved dedicated personnel, specialized testing instruments, development of methodologies, and multiagency collaborations. In many instances, rapid death certification (RDC) reduced delays in death certification from weeks or months to hours or days and provided information critical for timely law enforcement and public health responses. The purposes of this report are to evaluate RDC and to validate the methods employed.

METHODS AND MATERIALS

The KCMEO serves a population of approximately 2.3 million in a mixed urban and rural population in a geographic area of 2307 square miles. Seattle is the largest city with population of approximately 0.74 million. During the 3 years of this study, the KCMEO had from 10 to 12 medicolegal death investigators who responded to death scenes, gathered information, examined decedents for evidence relative to cause and manner of death, and collected items of suspicious drugs and paraphernalia. Items of drug evidence were transported along with decedents to the KCMEO facility. In-house testing was performed on deaths due to probable overdose, identified using an algorithm described, and validated previously.[11] This study found the algorithm alone to be accurate in identifying probable overdose deaths, with a sensitivity of 83% and a positive predictive value (PPV) of 89%. The median time between death and identification as a probable overdose was 1 day, and the interquartile range was 1 to 2 days.[11]

In-house testing for RDC comprised the following 3 parts: (1) testing of urine collected at autopsy using BTNX Rapid Response fentanyl-specific dipsticks and 1-Step Detect MultiDrug Rapid Test Cups, which hold an array of 14 different drug test strips (Table 1); (2) testing of autopsy blood using Randox Evidence MultiSTAT chemiluminescence immunoanalyzer with an array of 20 different drugs (Table 1); and (3) testing of drug evidence collected at scenes such as pills, powders, crystals, pipes, straws, syringes, scorched foil, and other paraphernalia, using 2 Raman spectrometers (ThermoFisher TruNarc and Rigaku ResQ), MX908 high-pressure mass spectrometer, and BTNX Rapid Response fentanyl-specific urine dipsticks on evidence samples appropriately diluted into water. Blood samples were submitted to the Washington State Patrol (WSP) Toxicology Laboratory for comprehensive testing. The WSP Toxicology Laboratory, in turn, used NMS Labs (Horsham, Pa) to manage backlogged cases. Both toxicology laboratories used immunoassay screening for the common drug categories, gas chromatography–mass spectrometry for confirmation and quantitation of cocaine, and liquid chromatography–tandem mass spectrometry for confirmation and quantitation of fentanyl, methamphetamine, and opiate. After in-house testing

TABLE 1. Analytes in Blood and Urine Testing Used for Rapid Death Certification

Analytes in Blood and Urine Screening Methods	
Randox Evidence MultiSTAT	**1-Step Detect MultiDrug Rapid Test Cups**
ABCHMINACA	Amphetamine
ABPINACA	Benzodiazepine
ALPHAPVP	Buprenorphine
Amphetamine	Carfentanyl
Barbiturate	Cocaine
Benzodiazepine	Ethyl glucuronide
Benzoylecgonine	Fentanyl
Buprenorphine	Methadone
Ethyl glucuronide	Methamphetamine
Fentanyl	Morphine
Methadone	Oxycodone
Methamphetamine	Synthetic marijuana
6-Monoacetylmorphine	Tetrahydrocannabinol
Opiate	Tramadol
Oxycodone	
PCP	
Pregabalin	
Tetrahydrocannabinol	
Tramadol	
Tricyclic antidepressants	

of drug evidence collected at scenes, using the instruments described previously, these items were submitted to the WSP Crime Laboratory, Materials Analysis Section, for confirmatory testing by gas chromatography–mass spectrometry and infrared spectroscopy.

Rapid death certification for individual deaths was based on concurrence of scene investigations, autopsy findings, and in-house testing. A specific drug was listed on the death certificate if at least 2 independent tests of the 3 (blood testing, urine testing, and drug evidence testing) were positive for the same drug. By these combined methodologies, overdose deaths were certified within hours or few days. For those certified by RDC, the cause of death used the wording, "Acute (combination) drug intoxication including <specific drug(s) identified>"; this wording carries the implication that additional drugs may be added to the death certificate after receiving results of formal toxicology analysis. At the time of certification, to indicate specific cases in which RDC methodology was used to certify the death, whether as an overdose or to exclude overdose, the certifying pathologist would "flag" the case in a special database field. After results from the WSP Toxicology Laboratory were received, the results were used to confirm the initial death certificates based on RDC methodology or to amend them by affidavit, if necessary, adding drugs that were not identified by in-house testing or removing drugs that were not identified by WSP results.

The KCMEO developed and maintains a surveillance database structure specific for the in-house testing and other activities generating data related to fatal overdose surveillance. The surveillance database is linked by case number to KCMEO's case management system (CME Case Management Software; VertiQ Software LLC, Morgan Hill, Calif). CME is likewise linked to the Washington Department of Health Electronic Death Registration System (EDRS). After the death certificate is filed with the Washington Department of Health, the EDRS record is permanent and remains unchanged, while the CME record is updated with results from the WSP Toxicology Laboratory.

Evaluation and validation of RDC were performed for the following 4 major drugs: opiate, fentanyl, methamphetamine, and cocaine. As described earlier[23] and used in this report, "opiate" in contrast to the general drug category, "opioid," refers to heroin or probable heroin because morphine, with or without 6-monoacetylmorphine, is reported in toxicology analyses. With in-house urine and blood testing, "cocaine" refers to cocaine or benzoylecgonine. Validation was performed at the following 3 levels: blood testing, urine testing, and death certification. The WSP Toxicology Laboratory results served as the "criterion standard" for validation at all levels. Validation at the death certificate level was accomplished by comparing the initial death certificates filed in EDRS with the final death certificate in CME, identified by the RDC flag described previously. Data queries using tools of Microsoft SQL Server Management Studio, Visual Studio, Access, and Excel generated the tables for this report. Sensitivity, specificity, PPV and negative predictive value (NPV), and accuracy were computed using standard methods.[24] The Venn diagram in the Figure 1 was constructed using R/RStudio with the *VennDiagram* package. Because this study used only deidentified, aggregate data from decedents, institutional review by University of Washington, Human Subjects Division, were not required.

RESULTS

Over the 3 years of this study, 2019 through 2021, there were a total of 47,778 deaths in King County, of which KCMEO took jurisdiction in 11,080. A total of 1797 deaths (3.8% of all King County deaths and 16% of KCMEO jurisdictional cases) were certified as overdose deaths; 1710 were certified as overdose as a primary cause, and the others listed overdose as other significant condition (OSC). The RDC methods allowed rapid certification of 1005 overdose deaths (56% of all overdose deaths in the same period). In these 3 years, blood testing was performed on 1915 decedents, urine testing was performed in 1992, and drug evidence testing was done on 6047 items collected from 1213

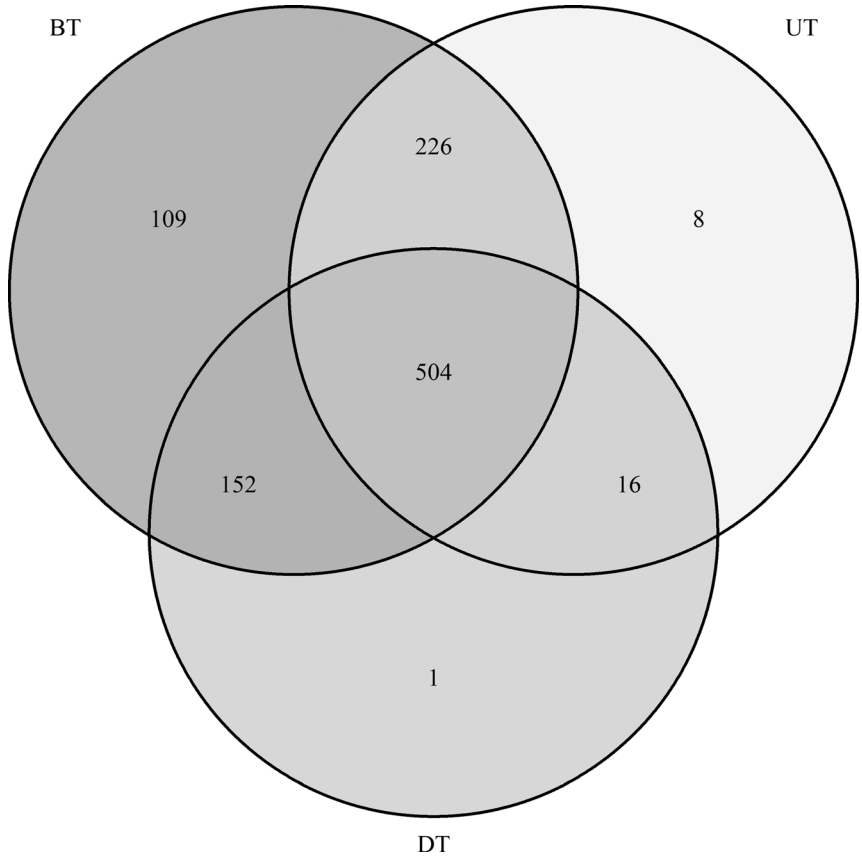

FIGURE 1. Diagram showing extent of in-house testing. BT, blood testing; UT, urine testing; DT, drug evidence testing.

death scenes. A subset of these were used to calculate performance metrics of 1507 in-house blood testing results (Table 2) and 1172 in-house urine testing results (Table 3).

There were 1034 death certificate records that were initially certified by RDC methodology, flagged as described earlier, with which to compare the final death certificates completed after receiving WSP toxicology results. Table 4A shows that of the 1034 initial deaths certificates based on RDC methodology, 807 had overdose as the primary cause of death, 19 listed overdose as a contributing condition, 10 were certified with causes other than overdose, and 198 certificates remained pending, awaiting toxicology results from WSP. After the toxicology results were received, the pending cases were updated. In the final death certificates, shown in Table 4B, overdose as a primary cause accounted for 989; of these 652 (66%) were due to a combination of drugs. Of the 807 overdose deaths initially certified as the primary cause by RDC testing, 803 (99.5%) were confirmed as overdose after obtaining formal toxicology results. Table 5 compares initial death certification, based on RDC methodology, with final certification, based on WSP toxicology results, and the agreement between the two, for each of the 4 drugs independently. In this analysis, the false-negative rates ranged from 2.9% for cocaine to 15% for methamphetamine, and the false-positive rates ranged from 0.29% for methamphetamine to 1.6% for cocaine. Death certificates were amended accordingly; that is, drugs were added to the amended death certificates for the false negatives and removed from the false positives. Tables 6 to 9 provide more extensive performance metrics of RDC relative to the extent of the individual in-house testing modalities: 991 cases of blood testing only, 730 cases of blood and urine testing, 656 cases of blood and drug evidence testing, and 504 cases having all 3 in-house testing modalities—blood, urine, and drug evidence. Overall, blood testing was most important, with 991 of the 1034 cases certified using blood testing in concurrence with urine and/or drug testing. The Venn diagram in the Figure 1 further illustrates the relative extent of testing among the 3 modalities. As expected, as the extent of testing increased, fewer cases were in each category.

TABLE 2. Sensitivity, PPV, Specificity, NPV, and Accuracy for In-House Blood Testing of 1507 Decedent Samples Compared With WSP Toxicology Results of Blood Testing

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	97	90	94	98	95
Methamphetamine	90	95	97	93	94
Opiate/morphine	92	89	95	97	95
Cocaine	99	57	86	100	88

TABLE 3. Sensitivity, PPV, Specificity, NPV, and Accuracy for In-House Urine Testing of 1172 Decedent Samples Compared With WSP Toxicology Results of Blood Testing

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	92	79	87	95	88
Methamphetamine	91	94	97	95	94
Opiate/morphine	91	75	92	97	92
Cocaine	92	72	95	99	94

In addition, specificity increased with the extent of testing while sensitivity decreased. With respect to manner of death, of the 813 deaths initially certified accident by RDC methodology (Table 4A), 5 were amended otherwise: 3 deaths initially certified accident (overdose) were amended to natural (2 heart disease and 1 alcoholic liver disease with an OSC of chronic drug use), one was amended to suicide (overdose), and one was amended to undetermined (overdose). Taking amendment from an unnatural manner to a natural manner as the most serious false positive, the overall error rate in manner certification was 0.29% (3/1034).

DISCUSSION

Guidelines for certification of overdose deaths published by the National Association of Medical Examiners[25] recommend against using screening methods to certify deaths because of the inherent false-positive rates of these tests.[26,27] While this study certainly supports this recommendation, the results also indicate that RDC can be achieved in many cases by the RDC methodology described herein, adhering to a strict protocol relying on concurrence of information gathered from scene investigation, autopsy findings, screening autopsy blood and urine, and testing drug evidence collected from scenes. Over the 3-year period KCMEO certified 56% of 1797 overdose deaths within 1 to 3 days. Using formal toxicology testing as the "criterion standard" for comparison, both the sensitivities and negative predictive values of blood and urine screenings were greater than 90% for all 4 drugs, indicating that these screening tests were fairly good in detecting the presence or absence of drugs. The specificities and PPVs for 3 of the 4 were 89% or greater, indicating that the blood and urine screening tests were also fairly good in excluding the presence or absence of drugs. The exception was for cocaine because of a high false-positive rate; only 57% of positive blood screening tests were correct, and only 72% of urine screening tests were correct. Accuracy, the overall probability that the screening test gave a correct result, positive or negative, ranged from 88% to 95% for the 4 drugs evaluated.

TABLE 5. Drugs Present in 1034 Death Certificates Based on RDC Methodology (Initial DC) Compared With Certification Following WSP Results (Final DC) and Agreement Between the Initial and Final Certification (Both) Along With Calculated FN and FP Rates

Drug	Initial DC, n	Final DC, n	Both, n	FN, %	FP, %
Fentanyl	406	493	393	8.4	1.3
Methamphetamine	363	514	360	15	0.29
Opiate/morphine	254	341	240	8.4	1.4
Cocaine	187	217	170	2.9	1.6

FN, false negative; FP, false positive.

For death certification, the most important considerations are correctly classifying overdose as the cause of death and, even more importantly, correctly classifying the manner of death. By RDC methodology, certification relied on a combination of the following 3 independent means: blood testing, urine testing, and drug evidence testing. The probability of error in certification was reduced by adhering to the "2-test" rule: a drug was listed on the death certificate only if 2 independent tests found the same drug. Comparing initial death certificates based on RDC methodology with final death certificates based on WSP toxicology results and taking the latter as the "criterion standard" for comparison found that adding an additional test to blood screening, although reducing sensitivity, substantially enhanced the specificity of certification for all drugs, even for cocaine; specificities ranged from 98% to 100% if all 3 tests were employed. Although certain death certificates were amended after receiving WSP results, either adding or removing drugs, as indicated in Table 5, this was considered a relatively minor error because the cause of death remained overdose and the manner remained accident. Because most overdose deaths (66%) in this study were due to a combination of drugs, the probability of

TABLE 4. (A) Death Certification Based on Rapid Death Certification Compared With (B) Certification Completed After Receiving WSP Toxicology Results

	Manner of Death					
A. Death Certified by RDC Methodology	**Accident**	**Suicide**	**Natural**	**Undetermined**	**Pending/Blank**	**Total**
Drug OD primary	791	10	0	6	0	807
Drug OD (OSC)*	19	0	0	0	0	19
Not drug OD	3	1	6	0	NA	10
Total	813	11	6	6	198	1034

	Manner of Death					
B. Death Certified After WSP Results	**Accident**	**Suicide**	**Natural**	**Undetermined**	**Homicide**	**Total**
Drug OD primary	965	14	0	9	1	989
Drug OD (OSC)*	21	0	0	0	0	21
Not drug OD	4	0	19	1	0	24
Total	990	14	19	10	1	1034

*Other significant conditions.

TABLE 6. Sensitivity, PPV, Specificity, NPV, and Accuracy of In-House Blood Testing of 991 Cases Compared With Final Death Certification

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	99	93	93	99	96
Methamphetamine	92	98	98	92	95
Opiate/morphine	96	90	94	98	95
Cocaine	100	70	87	100	90

correctly classifying an overdose death was very high (essentially 100%) even if some of the drugs listed on the initial death certificate were not confirmed by the toxicology laboratory results. On the other hand, changing the manner of death from accident to natural constituted a major error; this occurred in 3 of 1034 cases. Nevertheless, the overall probability of correctly classifying the manner of death was very high (99.7%).

There are definite reasons to certify overdose deaths rapidly: to benefit families who want to understand the reason for their loved ones' deaths and need death certificates for settling insurance and other business matters; to facilitate timely responses by law enforcement and public health agencies; to quickly identify emergence of novel drugs in a community; and to expedite collection of mortality data. Testing of drug evidence offers another dimension of surveillance. Although testing of drug evidence is rarely performed by medical examiner and coroner offices, this added dimension of overdose surveillance allows rapid identification of novel drugs, formulations, and routes of administrations occurring in the local community.[28,29] Furthermore, the collaboration in this project, between KCMEO and the WSP Crime Laboratory, represents a notable example of uniting resources of public health and criminal justice agencies in surveillance of illicit drugs.

There are disadvantages in RDC. It is resource intensive, requiring personnel, equipment, and funding not usually part of a medical examiner or coroner office. To deploy RDC methodology, the KCMEO made use of federal grants for purchase of instruments and supplies and to fund key positions; student interns from local colleges were found to be reliable and cost-effective. Data management was especially challenging in maintaining consistency and updating death certificates after receiving WSP toxicology results. Affidavits were often required to amend the official Certification of Death. However, another challenge was discovered when the Washington Department of Health compared data for entry into the State Unintentional Drug Overdose Reporting System; the death certificate affidavits were not making their way into the data stream for State Unintentional Drug Overdose Reporting System entry. This problem is currently being resolved and represents a growing need for data science in exploiting the valuable information collected by medical examiners and coroners.[30]

TABLE 7. Sensitivity, PPV, Specificity, NPV, and Accuracy for In-House Blood Testing Combined With Urine Testing of 730 Cases, Compared With Final Death Certification

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	93	97	97	92	95
Methamphetamine	88	99	99	90	94
Opiate/morphine	93	93	97	97	96
Cocaine	94	89	97	98	96

TABLE 8. Sensitivity, PPV, Specificity, NPV, and Accuracy for In-House Blood Testing Combined With Drug Evidence Testing of 656 Cases, Compared With Final Death Certification

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	73	99	99	78	86
Methamphetamine	75	100	100	78	86
Opiate/morphine	75	95	98	97	89
Cocaine	58	82	96	88	87

Limitations of this study and RDC methodology were largely due to the separation of KCMEO from the testing laboratories and the length of time between postmortem examination and final certification. Although excellent collaboration existed between KCMEO and WSP for the period of study, the WSP toxicology laboratory depended heavily on NMS Labs to manage their backlog. Thus, there were long delays, weeks to months, between specimen collection and receipt of final toxicology results. Furthermore, discrepancies between RDC testing and final toxicology results were difficult to resolve, requiring communications with 2 different laboratories, both external to KCMEO. This limitation was especially challenging in resolving discrepancies in results for cocaine. Part of cocaine's discrepancy seemed to be due to higher levels of reporting positive results by the toxicology laboratories compared with in-house blood testing for RDC; the higher threshold of the toxicology laboratory may have resulted in false-negative results. For example, in certain cases, scene investigation, blood testing, urine testing, and drug evidence testing all indicated cocaine's involvement in the overdose in the absence of a positive toxicology laboratory result; communicating directly with the toxicology laboratory analysts confirmed the presence of cocaine or benzoylecgonine but at levels below their reporting limit. On the other hand, relying on RDC data in the face of conflicting toxicology laboratory results jeopardized the concept of the "criterion standard." This problem deserves further study. Another limitation was due to the way death certificates were identified for analysis in this study; this depended on the certifying pathologist remembering to flag the case as described earlier. Thus, some cases initially certified by RDC may have been missed in the present analysis. On the other hand, over the course of the 3 years encompassed by this study, KCMEO pathologists became more familiar and confident with the processes, leading to a gradual maturation in using RDC methodology.

In summary, this study shows that the methods described offer a reasonable means of rapidly issuing death certificates, for the benefit of families and facilitating responses by agencies of law enforcement and public health. Because of concerted efforts in "real-time" fatal drug overdose surveillance, the KCMEO has become the center of overdose information collection and dissemination

TABLE 9. Sensitivity, PPV, Specificity, NPV, and Accuracy for In-House Blood Testing Combined With Urine and Drug Evidence Testing of 504 Cases, Compared With Final Death Certification

Drug	Sensitivity, %	PPV, %	Specificity, %	NPV, %	Accuracy, %
Fentanyl	68	100	100	69	82
Methamphetamine	71	99	100	77	85
Opiate/morphine	70	97	99	87	89
Cocaine	52	91	98	87	88

for both King County and State of Washington. Accepting a low risk of misclassifying deaths, at least for KCMEO and its partner agencies, the advantages of RDC far outweigh its disadvantages.

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REFERENCES

1. Wilson N, Kariisa M, Seth P, et al. Drug and opioid-involved overdose deaths—United States, 2017–2018. *MMWR Morb Mortal Wkly Rep*. 2020; 69(11):290–297.
2. Hedegaard H, Miniño AM, Warner M. Drug overdose deaths in the United States, 1999–2019. *NCHS Data Brief*. 2020;394:1–8.
3. Mattson CL, Tanz LJ, Quinn K, et al. Trends and geographic patterns in drug and synthetic opioid overdose deaths—United States, 2013–2019. *MMWR Morb Mortal Wkly Rpt*. 2021;70:202–207.
4. National Institutes of Health. Opioid overdose crisis. March 11, 2021. Available at: https://nida.nih.gov/drug-topics/opioids/opioid-overdose-crisis. Accessed July 8, 2022.
5. Friedman LS. Real-time surveillance of illicit drug overdoses using poison center data. *Clin Toxicol*. 2009;47:573–579.
6. Horon IL, Singal P, Fowler DR, et al. Standard death certificate versus enhanced surveillance to identify heroin overdose-related deaths. *Am J Public Health*. 2018;108:777–781.
7. Morrow JB, Ropero-Miller JD, Catlin ML, et al. The opioid epidemic: moving toward an integrated, holistic analytical response. *J Anal Toxicol*. 2019;43:1–9.
8. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. OD2A: Surveillance. March 9, 2022. Available at: https://www.cdc.gov/drugoverdose/od2a/surveillance.html. Accessed July 8, 2022.
9. Hoots BE. Opioid overdose surveillance: improving data to inform action. *Public Health Rep*. 2021;136:5S–8S.
10. O'Donnell J, Gladden RM, Kariisa M, et al. Using death scene and toxicology evidence to define involvement of heroin, pharmaceutical morphine, illicitly manufactured fentanyl and pharmaceutical fentanyl in opioid overdose deaths, 38 states and the District of Columbia. *Addiction*. 2022;117:1483–1490.
11. Vannice K, Hood J, Yarid N, et al. Accuracy of medical examiner's assessment for near–real-time surveillance of fatal drug overdoses, King County, Washington, March 2017–February 2018. *Public Health Rep*. 2022;137:463–470.
12. Shute R, Bollinger K, Tucker M, et al. Use of rapid toxicology screening tools in medical examiner/coroner offices. *U.S. Department of Justice, National Institute of Justice, Office of Investigative and Forensic Sciences*. 2021;1–9.
13. Baldwin N, Gray R, Goel A, et al. Fentanyl and heroin contained in seized illicit drugs and overdose-related deaths in British Columbia, Canada: an observational analysis. *Drug Alcohol Depend*. 2018;185:322–327.
14. Hedegaard H, Bastian BA, Trinidad JP, et al. Regional differences in the drugs most frequently involved in drug overdose deaths: United States, 2017. *Natl Vital Stat Rep*. 2019;68:1–12.
15. Lovrecic B, Lovrecic M, Gabrovec B, et al. Non-medical use of novel synthetic opioids: a new challenge to public health. *Int J Environ Res Public Health*. 2019;16:177.
16. Shover CL, Falasinnu TO, Dwyer CL, et al. Steep increases in fentanyl-related mortality west of the Mississippi River: recent evidence from county and state surveillance. *Drug Alcohol Depend*. 2020; 216:108314.
17. Thombs RP, Thombs DL, Jorgenson AK. What is driving the drug overdose epidemic in the United States? *J Health Soc Behav*. 2020;61: 275–289.
18. Baldwin GT, Seth P, Noonan RK. Continued increases in overdose deaths related to synthetic opioids: implications for clinical practice. *JAMA*. 2021; 325:1151–1152.
19. O'Donnell J, Tanz LJ, Gladden RM, et al. Trends in and characteristics of drug overdose deaths involving illicitly manufactured fentanyls—United States, 2019–2020. *MMWR Morb Mortal Wkly Rep*. 2021;70:1740–1746.
20. Ministry of Public Safety & Solicitor General. Illicit drug toxicity deaths in BC January 1, 2011–December 31, 2021. *BC Coroners Service*. 2022; 1–26.
21. DiGennaro C, Garcia GP, Stringfellow EJ, et al. Changes in characteristics of drug overdose death trends during the COVID-19 pandemic. *Int J Drug Policy*. 2021;98:103392.
22. Imtiaz S, Nafeh F, Russell C, et al. The impact of the novel coronavirus disease (COVID-19) pandemic on drug overdose related deaths in the United States and Canada: a systematic review of observational studies and analysis of public health surveillance data. *Subst Abuse Treat Prev Policy*. 2021;16:1–14.
23. Harruff RC, Couper FJ, Banta-Green CJ. Tracking the opioid drug overdose epidemic in King County, Washington using an improved methodology for certifying heroin related deaths. *Acad Forensic Pathol*. 2015;5:499–506.
24. Zhou XH, Obuchowski NA, McClish DK. *Statistical Methods in Diagnostic Medicine*. 2nd ed. Hoben, NJ: John Wiley & Sons; 2011.
25. Davis GG, Cadwallader AB, Fligner CL, et al. Position paper: recommendations for the investigation, diagnosis, and certification of deaths related to opioid and other drugs. *Am J Forensic Med Pathol*. 2020; 41:152–159.
26. McMillin GA, Johnson-Davis KL, Kelly BN, et al. Impact of the opioid epidemic on drug testing. *Ther Drug Monit*. 2021;43:14–24.
27. Kerensky T, LaRochelle M, Fan SL, et al. Non-prescription fentanyl positive toxicology: prevalence, positive predictive value of fentanyl immunoassay screening, and description of co-substance use. *J Addict Med*. 2021;15:150–154.
28. Fiorentin TR, Krotulski AJ, Martin DM, et al. Detection of cutting agents in drug-positive seized exhibits within the United States. *J Forensic Sci*. 2019; 64:888–896.
29. Fiorentin TR, Logan BK. Analytical findings in used syringes from a syringe exchange program. *Int J Drug Policy*. 2020;81:102770.
30. Berry SD, Edgar HJH. Extracting and standardizing medical examiner data to improve health. *AMIA Jt Summits Transl Sci Proc*. 2020;2020:63–70.