Characterizing drug use incidents on transit vehicles and its impact on transit operators

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Abstract

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Drug misuse, specifically of synthetic opioids and methamphetamines, has increased in the United States, often occurring on public transit, creating potential for secondhand exposure for transit operators. These exposures could result in physical or mental health impacts. Here, we characterize drug use incidents on transit vehicles and its impacts on transit operators. Using a quantitative survey of transit operators in the Pacific Northwest, we fit ordinal logistic regression models to investigate transit operators' perceived risk of workplace exposure to drug use incidents, occupational stress, and job satisfaction, and their association with intent to leave their job. We found that higher perceived risk scores were significantly positively associated with greater intent to leave (OR: 1.08; 95% CI: 1.02, 1.14), but occupational stress and job

satisfaction, which were significantly associated with greater intent to leave, attenuated this relationship.

We subsequently conducted qualitative interviews of transit operators to explore their experiences with passenger drug use, risk perceptions, impacts, availability and effectiveness of existing supports and guidance pertaining to passenger drug use, and whether there are unfulfilled needs in these supports. Interviewees reported physical health effects, mental health outcomes, and emotional impacts. Risk perceptions of passenger drug use were prevalent and may be exacerbated by outrage factors. Operators reported a lack of support from their agencies, and highlighted engineering controls as an effective intervention that is currently unfulfilled.

We then examined temporal and weather-related trends in drug use on transit, based on previous transit operator concerns that people who use drugs (PWUD) seek transit vehicles as shelter to escape from inclement weather. Using a dataset of drug use incidents reported by transit operators in King County, Washington, in 2022, we fit a Poisson regression model to understand the association between daily incident count and daily weather patterns. Reported drug use incidents showed clear temporal trends, with a higher frequency of incidents in winter and spring than in summer; April had the highest mean daily incident count of 7.3 incidents/day. Higher temperature was significantly associated with lower incident count (IRR: 0.96; 95% CI: 0.95, 0.97).

The work presented here highlights the impacts of drug use incidents on transit operators, and can help guide the development and timely deployment of interventions that can improve the work experiences of transit operators.

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Thank you to all my family and friends – I wouldn't have gotten here without you.

And most importantly, thank you to my partner, Dr. Alice Qiao, for keeping me sane so far, and for the support I know you'll continue to give me throughout my career.

Dedication

To a future of healthy work, for us, and for the generations that come after us.

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Chapter 1: Introduction

In recent years, trends in drug misuse in the United States have changed, including increasing prominence of synthetic opioids such as fentanyl and high rates of methamphetamine misuse.[1–5] In the Pacific Northwest, this drug use often occurs in public indoor spaces, such as public transit vehicles.[6] Transit systems are a vital component of a city's infrastructure, playing a crucial role in moving people throughout communities. In 2023, transit systems in Washington (WA) and Oregon (OR) states served over 280 million passenger trips.[7] As transit ridership increases and recovers to pre-pandemic rates,[8] ensuring the health and safety of both transit workers' and the riding public is crucial to provide safe and effective service to communities.

Research has shown potential secondhand exposure for transit operators to drugs smoked by riders.[9] In an exposure assessment of air and surfaces in public transit vehicles in the Pacific Northwest,[9] fentanyl residue was found in 25% of air samples and 46% of surface samples, while methamphetamine was found in all air samples and nearly all surface samples. Of note, one sample found in the passenger area in trains contained a fentanyl concentration higher than the 8-hr-time-weighted average (8-hr TWA) Threshold Limit Value (TLV) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH)[10] of 0.1 $\mu g/m^3$ in inhalable dust; however, the samples in this study were taken for 4 hours (and assumed to be representative of 8 hours), and sampled total dust rather than inhalable dust, affecting comparability to the ACGIH guideline. Given the high rate of drug detection and the presence of an air sample that exceeded an exposure guideline in this exposure assessment, these findings indicate a need for further investigation into the impacts that secondhand drug exposures have on transit operators.

Transit operators spend more hours in transit vehicles than riders and therefore may experience greater impacts to health due to secondhand exposure to passenger drug use. Operators have reported health outcomes related to drug incidents aboard their vehicles; some operators have needed to take time off from work and have filed for workers' compensation attributed to passenger drug use incidents.[11,12] Transit operators are already routinely exposed to other physical and psychosocial exposures that may negatively impact their health, such as long hours spent sitting,[13] seat vibration,[14] and high levels of work-related stress.[15] These exposures can be exacerbated by witnessing drug-related critical incidents at work such as overdoses, which can be distressing and therefore impact mental health.[16–18] Furthermore, passengers under the influence of drugs can display unpredictable behaviors, leading to potentially dangerous interactions between operators and passengers; in addition to the physical safety hazards posed by such interactions, passenger violence can exacerbate existing work-related stressors and impact mental health.[19–21] Reducing exposure to work-related stressors is not only important for operator health and safety,[22] but also for the community they serve, as operators are ultimately responsible for the safety of everyone on their vehicle.

In addition to the impacts on transit operators, risk perceptions of secondhand drug exposure, particularly fentanyl, remain high,[23–27] despite research indicating low risk of toxicity associated with secondhand exposures.[28] Perceived risk refers to an individual's beliefs about their vulnerability to a potential hazard, and is typically characterized by perceived risk severity (the believed magnitude of risk to health) and perceived risk susceptibility (the believed likelihood of exposure) to the hazard.[29] Research has yet to investigate perceived risk of drug exposures among transit operators, but in front-line workers who respond to opioid overdose incidents, there remains concern of exposure to fentanyl despite low risk of toxicity associated with

occupational exposures.[28] This has led to a phenomenon where the expectation of negative health effects results in real symptoms[26,30]; however, it remains unclear if these symptoms are directly caused by fentanyl toxicity.[31] Individuals' perceived risk is also influenced by outrage factors (i.e., emotional aspects of risk that influence how people perceive risk).[32] In the context of transit operators, outrage factors such as voluntariness (whether the exposure is imposed or voluntary), fairness (whether the exposure is equally distributed, or unique to a given population), process (whether employer decision-making seems fair to the worker, and decisions address worker concerns), and morality may impact transit operators' perceived risk of secondhand drug exposure.

Another study of first responders[33] found that despite low perceived exposure to fentanyl, first responders remained concerned about the potential for adverse health outcomes due to fentanyl exposure. Concern over potential exposure to drugs may contribute to increased stress among transit operators, who may feel unsafe at work.[6] This can increase the likelihood of burnout and job satisfaction, leading to attrition from the profession.[34] The fear of overdose from secondhand drug exposures may contribute to increased stress and adverse mental health outcomes among workers who are regularly exposed.[24–26] Research has shown that when workers perceive their workplace as having a poor safety climate and high health risk, job satisfaction decreases,[35,36] regardless of the actual health risk posed by the workplace. When workers perceive an unsafe work environment, workers are more likely to leave and exhibit symptoms consistent with stress, anxiety, and burnout.[37] Such an unsafe work environment can be deemed as an unethical work climate.[38] Research has indicated that ethical work climates are associated with higher job satisfaction.[39–41] Given the relationship between job satisfaction and health outcomes,[42–44] this unethical work climate of transit workers may have an impact on their well-being. Furthermore,

workers with lower job satisfaction due to unethical work climates are more likely to have intent to leave the job.[41]

Despite drug use occurring on transit, limited research has investigated how these incidents impact transit operators. Occupational research has suggested that perceived risk of a hazard, occupational stress, and job dissatisfaction can each independently increase intent to leave a job[45–48]; research has also shown that workers who have high occupational stress but high job satisfaction are less likely to want to leave.[46] However, such research has not been conducted in the context of transit operators and their exposure to drug use incidents. Higher rates of intent to leave can result in increased attrition and thus understaffing,[49] which can in turn cause remaining workers to experience increased job demands, stress, and burnout.[50–52] Such impacts can reduce remaining workers' ability to do their job,[53] which in the case of transit operators, can affect their ability to provide transportation to their communities. Therefore, it is important to investigate factors (such as perceived risk of health outcomes associated with passenger drug misuse on transit vehicles, perceived occupational stress, and job satisfaction) that may contribute to intent to leave among transit operators. Chapter 2 of this dissertation characterizes transit operators' perceived risk of secondhand drug exposures, perceived occupational stress, and job satisfaction, and investigates whether operators with higher perceived risk are more likely to express an intent to leave.

Chapter 3 of this dissertation presents a qualitative analysis of perceived risk, impacts, and interventions related to drug use incidents among transit operators. While Chapter 2 characterizes perceived risk and intent to leave, Chapter 3 considers how perceived risk relates to interventions, including both existing supports and unfulfilled needs of transit operators pertaining to drug use incidents. Research to date has also not investigated interventions to

reduce the impact that these drug use incidents have on transit operators. An analysis conducted by the U.S. Federal Transit Administration (FTA) on improving overall safety in transit systems found that the most prevalent interventions were focused on education, awareness, and surveillance.[54] Despite transit agencies reporting effectiveness of these interventions in improving overall safety, it is unclear if they are equally impactful in the context of drug misuse. In particular, these interventions do not eliminate the hazard itself, which per the hierarchy of controls for total worker health, is the most effective method to promote a hazard-free workplace.[55] Other interventions, such as improved security patrolling to remove disruptive passengers or barriers for the operator area,[54] do increase protection for transit operators from drug exposures; however, the impact on operator well-being of these interventions are still unclear in the context of drug misuse on transit vehicles.

Research has yet to characterize the frequency of drug use incidents on transit. Given the potential impacts to transit operator health and ability to do their job, as well as the potential impacts of these incidents on the riding public, understanding trends in drug use incidents on transit can be an effective starting point for informing interventions that reduce the prevalence of these drug use incidents on transit, ultimately protecting both transit operators and the riding public from exposure to these incidents. Despite trends suggesting that drug misuse is more likely in summer,[56–59] reports from transit operators have indicated that people who use drugs (PWUD) seek transit vehicles as shelter to escape from inclement weather,[6] potentially contributing to higher rates of drug use incidents on transit vehicles in periods of poorer weather. There is currently no research examining temporal and weather trends in drug use incidents on transit vehicles; Chapter 4 of this dissertation aims to address this gap in literature, by characterizing the frequency of drug use incidents on transit, and investigating its potential

relationship with weather factors such temperature, precipitation, wind speed, and daylight hours. The results of this study can help guide timely interventions to protect operators and the riding public on peak routes and times for drug use on transit.

This work provides a starting point for research investigating the impacts of drug exposures on transit workers. With drug misuse occurring frequently on public transit, promoting the health, safety, and well-being of this at-risk worker population is important to both occupational health and the communities who are served by these transit systems. This dissertation quantitatively investigates the relationship between transit operators' perceived risk of secondhand exposure to drugs and intent to leave their job (Chapter 2); qualitatively examines risk perceptions, impacts, and unfulfilled supports pertaining to drug use incidents on transit (Chapter 3); and characterizes the frequency of drug use incidents on transit vehicles in King County, Washington (USA), and whether temporal and weather factors have an association with the frequency of drug use incidents (Chapter 4).

Chapter 1 References

1. Addiction, Drugs, and Alcohol Institute. Washington state drug trends. 2023 [accessed 2022 Nov 15]. https://adai.washington.edu/wadata/stateMOP_cases.htm

2. Oregon Health Authority. Fentanyl Facts : Opioid Overdose and Misuse. 2024 [accessed 2023 Sep 12]. https://www.oregon.gov/oha/ph/preventionwellness/substanceuse/opioids/pages/fentanylfacts.aspx

3. Spencer MR, Garnett MF, Miniño AM. Drug Overdose Deaths in the United States, 2002-2022. 2023 [accessed 2024 Jul 18]. https://stacks.cdc.gov/view/cdc/135849

4. National Institute on Drug Abuse. Drug Overdose Death Rates | National Institute on Drug Abuse (NIDA). 2024 May 14 [accessed 2024 Jul 18]. https://nida.nih.gov/research-topics/trends-statistics/overdose-death-rates

5. Han B et al. Methamphetamine Use, Methamphetamine Use Disorder, and Associated Overdose Deaths Among US Adults. JAMA psychiatry. 2021;78(12):1329–1342. https://doi.org/10.1001/jamapsychiatry.2021.2588

6. Horcher G. Metro bus driver and local mayor describe increasing concern for riders from fentanyl fumes. KIRO 7 News Seattle. 2022 May 10 [accessed 2022 Nov 15]. https://www.kiro7.com/news/local/metro-bus-driver-local-mayor-describe-increasing-concern-riders-fentanyl-fumes/VPJL4GJG75HHFICZHGSS3VMO3E/

7. Federal Transit Administration. Complete Monthly Ridership (with adjustments and estimates) | FTA. 2023 Jul [accessed 2023 Sep 12]. https://www.transit.dot.gov/ntd/data-product/monthly-module-adjusted-data-release

8. Doyle T. Public Transportation Ridership Rises to More than 70 Percent of Pre-Pandemic Levels. American Public Transportation Association. 2022 [accessed 2023 Sep 12]. https://www.apta.com/news-publications/press-releases/releases/public-transportation-ridership-rises-to-more-than-70-percent-of-pre-pandemic-levels/

9. Beaudreau M et al. Assessing fentanyl and methamphetamine in air and on surfaces of transit vehicles. Journal of Occupational and Environmental Hygiene. 2025;0(0):1–11. https://doi.org/10.1080/15459624.2024.2444430

10. ACGIH. FENTANYL AND FENTANYL CITRATE, AS FENTANYL. ACGIH. 2023 Dec 11 [accessed 2024 Jan 15]. https://www.acgih.org/fentanyl-and-fentanyl-citrate/

11. Goodwillie K. Bus driver workers' compensation claims skyrocket as exposure to drugs increases. king5.com. 2023 Oct 30 [accessed 2025 Jan 4]. https://www.king5.com/article/news/local/bus-driver-workers-compensation-claims-exposure-drugs/281-c4ebac75-706f-4ccd-bdb5-7656c3c97baa

12. Harris J. Seattle bus driver says fentanyl smoke makes him sick; health dept. says it's no real risk. KOMO. 2023 Mar 6 [accessed 2025 Jan 4]. https://komonews.com/news/local/seattle-king-county-metro-bus-drivers-fentanyl-smoke-exposure-drugs-mental-public-health-department-transportation-substance-abuse-treatment-crime-homeless-crisis

13. Varela-Mato V et al. Time spent sitting during and outside working hours in bus drivers: A pilot study. Preventive Medicine Reports. 2016;3:36–39. https://doi.org/10.1016/j.pmedr.2015.11.011

14. Lewis CA, Johnson PW. Whole-body vibration exposure in metropolitan bus drivers. Occupational Medicine (Oxford, England). 2012;62(7):519–524. https://doi.org/10.1093/occmed/kqs096

15. Carrère S, Evans GW, Palsane MN, Rivas M. Job strain and occupational stress among urban public transit operators. Journal of Occupational Psychology. 1991;64(4):305–316. https://doi.org/10.1111/j.2044-8325.1991.tb00562.x

16. Alexander DA, Klein S. Ambulance personnel and critical incidents: impact of accident and emergency work on mental health and emotional well-being. The British Journal of Psychiatry: The Journal of Mental Science. 2001;178(1):76–81. https://doi.org/10.1192/bjp.178.1.76

17. Boland LL et al. Burnout and Exposure to Critical Incidents in a Cohort of Emergency Medical Services Workers from Minnesota. The Western Journal of Emergency Medicine. 2018;19(6):987–995. https://doi.org/10.5811/westjem.8.39034

18. Donnelly E. Work-related stress and posttraumatic stress in emergency medical services. Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors. 2012;16(1):76–85. https://doi.org/10.3109/10903127.2011.621044

19. Zhou B, Boyer R, Guay S. Dangers on the road: A longitudinal examination of passenger-initiated violence against bus drivers. Stress and Health: Journal of the International Society for the Investigation of Stress. 2018;34(2):253–265. https://doi.org/10.1002/smi.2779

20. Filho APG et al. Working Conditions of Bus Drivers in a Large Brazilian Metropolis. Procedia Manufacturing. 2015;3:2505–2509. (6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015). https://doi.org/10.1016/j.promfg.2015.07.512

21. Ferguson S et al. Australian bus drivers' perspectives of passenger hostility: A qualitative study. Journal of Workplace Behavioral Health. 2022;37(3):169–188. https://doi.org/10.1080/15555240.2022.2080687

22. Useche SA, Gómez V, Cendales B, Alonso F. Working Conditions, Job Strain, and Traffic Safety among Three Groups of Public Transport Drivers. Safety and Health at Work. 2018;9(4):454–461. https://doi.org/10.1016/j.shaw.2018.01.003

23. del Pozo B, Rich JD, Carroll JJ. Reports of accidental fentanyl overdose among police in the field: Toward correcting a harmful culture-bound syndrome. International Journal of Drug Policy. 2022;100:103520. https://doi.org/10.1016/j.drugpo.2021.103520

24. Beletsky L et al. Fentanyl panic goes viral: The spread of misinformation about overdose risk from casual contact with fentanyl in mainstream and social media. International Journal of Drug Policy. 2020;86:102951. https://doi.org/10.1016/j.drugpo.2020.102951

25. Attaway PR, Smiley-McDonald HM, Davidson PJ, Kral AH. Perceived occupational risk of fentanyl exposure among law enforcement. International Journal of Drug Policy. 2021;95:103303. https://doi.org/10.1016/j.drugpo.2021.103303

26. Winograd RP et al. Training to reduce emergency responders' perceived overdose risk from contact with fentanyl: early evidence of success. Harm Reduction Journal. 2020;17(1):58. https://doi.org/10.1186/s12954-020-00402-2

27. Taxel S. Fentanyl Facts and Fiction: A Safety Guide for First Responders. JEMS: EMS, Emergency Medical Services - Training, Paramedic, EMT News. 2019 [accessed 2022 Nov 15]. https://www.jems.com/operations/fentanyl-facts-and-fiction-a-safety-guide-for-first-responders/

28. Moss MJ et al. ACMT and AACT position statement: preventing occupational fentanyl and fentanyl analog exposure to emergency responders. Clinical Toxicology. 2018;56(4):297–300. https://doi.org/10.1080/15563650.2017.1373782

29. Rimal RN, Real K. Perceived Risk and Efficacy Beliefs as Motivators of Change: Use of the Risk Perception Attitude (RPA) Framework to Understand Health Behaviors. Human Communication Research. 2003;29(3):370–399. https://doi.org/10.1111/j.1468-2958.2003.tb00844.x

30. Colloca L. Nocebo effects can make you feel pain. Science (New York, N.Y.). 2017;358(6359):44. https://doi.org/10.1126/science.aap8488

31. Lynch MJ, Suyama J, Guyette FX. Scene Safety and Force Protection in the Era of Ultra-Potent Opioids. Prehospital Emergency Care. 2018;22(2):157–162. https://doi.org/10.1080/10903127.2017.1367446

32. Northwest Center for Public Health Practice. What Increases Outrage? | Introduction | Emergency Risk Communication. 2024 [accessed 2024 May 2]. https://www.nwcphp.org/docs/perrcolate/erc/section1/outrage.html

33. Thompson RA et al. Perceptions of opioid and other illicit drug exposure reported among first responders in the southeast, 2017 to 2018. Health Science Reports. 2021;4(3):e335. https://doi.org/10.1002/hsr2.335

34. Tse JLM, Flin R, Mearns K. Bus driver well-being review: 50 years of research. Transportation Research Part F: Traffic Psychology and Behaviour. 2006;9(2):89–114. https://doi.org/10.1016/j.trf.2005.10.002

35. Nielsen MB, Mearns K, Matthiesen SB, Eid J. Using the Job Demands-Resources model to investigate risk perception, safety climate and job satisfaction in safety critical organizations. Scandinavian Journal of Psychology. 2011;52(5):465–475. https://doi.org/10.1111/j.1467-9450.2011.00885.x

36. Shan B, Liu X, Gu A, Zhao R. The Effect of Occupational Health Risk Perception on Job Satisfaction. International Journal of Environmental Research and Public Health. 2022;19(4):2111. https://doi.org/10.3390/ijerph19042111

37. Laraqui O et al. Occupational risk perception, stressors and stress of fishermen. International Maritime Health. 2018;69(4):233–242. https://doi.org/10.5603/IMH.2018.0038

38. Victor B, Cullen JB. The Organizational Bases of Ethical Work Climates. Administrative Science Quarterly. 1988;33(1):101–125. https://doi.org/10.2307/2392857

39. Vitell SJ, Davis DL. The relationship between ethics and job satisfaction: An empirical investigation. Journal of Business Ethics. 1990;9(6):489–494. https://doi.org/10.1007/BF00382842

40. Joseph J, Deshpande SP. The Impact of Ethical Climate on Job Satisfaction of Nurses. Health Care Management Review. 1997;22(1):76–81.

41. Schwepker CH. Ethical climate's relationship to job satisfaction, organizational commitment, and turnover intention in the salesforce. Journal of Business Research. 2001;54(1):39–52. https://doi.org/10.1016/S0148-2963(00)00125-9

42. Yilmaz A. Burnout, job satisfaction, and anxiety-depression among family physicians: A cross-sectional study. Journal of Family Medicine and Primary Care. 2018;7(5):952–956. https://doi.org/10.4103/jfmpc.jfmpc_59_18

43. Faragher EB, Cass M, Cooper CL. The relationship between job satisfaction and health: a meta-analysis. Occupational and Environmental Medicine. 2005;62(2):105–112. https://doi.org/10.1136/oem.2002.006734

44. Salma U, Hasan M. Relationship between Job Satisfaction and Depression, Anxiety and Stress among the Female Nurses of Dhaka Medical College and Hospital, Bangladesh. Public Health Research. 2020;10:94–102. https://doi.org/10.5923/j.phr.20201003.02

45. Hellman CM. Job Satisfaction and Intent to Leave. The Journal of Social Psychology. 1997;137(6):677–689. https://doi.org/10.1080/00224549709595491

46. Jiang N et al. The Relationship Between Occupational Stress and Turnover Intention Among Emergency Physicians: A Mediation Analysis. Frontiers in Public Health. 2022 [accessed 2024 Aug 15];10. https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.901251/full. https://doi.org/10.3389/fpubh.2022.901251

47. McCaughey D et al. Examining workplace hazard perceptions & employee outcomes in the long-term care industry. Safety Science. 2015;78:190–197. https://doi.org/10.1016/j.ssci.2015.04.013

48. Elshaer IA. Social-psychological risk perception impacts on job insecurity and turnover intention: a mediation model using PLS-SEM technique. Cogent Psychology. 2024;11(1):2303219. https://doi.org/10.1080/23311908.2024.2303219

49. Wasserman JL, Padgett A, Do KK-A. Transit, Belabored: Issues and Futures for California's Frontline Transit Workforce. 2024 Feb 22 [accessed 2024 Aug 13]. https://escholarship.org/uc/item/2036z8c4. https://doi.org/10.7922/G2S180TK

50. Crawford ER, LePine JA, Rich BL. Linking job demands and resources to employee engagement and burnout: A theoretical extension and meta-analytic test. Journal of Applied Psychology. 2010;95(5):834–848. https://doi.org/10.1037/a0019364

51. Hudson CK, Shen W. Understaffing: An under-researched phenomenon. Organizational Psychology Review. 2015;5(3):244–263. https://doi.org/10.1177/2041386615576016

52. Hung J-Y, Fisher R, Gapp R, Carter G. Work-related stress impacts on the commitment of urban transit drivers. Journal of Management & Organization. 2012;18(2):220–230. https://doi.org/10.5172/jmo.2012.18.2.220

53. Park J. Work stress and job performance. Statistics Canada. 2007.

54. Federal Transit Administration. Responses to General Directive 24-1: Required Actions Regarding Assaults on Transit Workers. 2025 Jan 16 [accessed 2025 Jan 22]. https://www.transit.dot.gov/regulations-and-programs/safety/responses-general-directive-24-1-required-actions-regarding

55. CDC. Hierarchy of Controls. Total Worker Health. 2024 Jun 26 [accessed 2025 Jan 22]. https://www.cdc.gov/niosh/twh/php/hierarchy/index.html

56. Hensel M et al. Relationship between ambient temperature and severe acute poisoning by alcohol and drugs. Alcohol. 2021;94:57–63. https://doi.org/10.1016/j.alcohol.2021.04.001

57. Palamar JJ, Rutherford C, Keyes KM. Summer as a Risk Factor for Drug Initiation. Journal of General Internal Medicine. 2020;35(3):947–949. https://doi.org/10.1007/s11606-019-05176-3

58. Yoo E et al. Association between extreme temperatures and emergency room visits related to mental disorders: A multi-region time-series study in New York, USA. Science of The Total Environment. 2021;792:148246. https://doi.org/10.1016/j.scitotenv.2021.148246

59. Chang HH et al. Associations between short-term ambient temperature exposure and emergency department visits for amphetamine, cocaine, and opioid use in California from 2005 to 2019. Environment international. 2023;181:108233. https://doi.org/10.1016/j.envint.2023.108233

Chapter 2: Impacts of risk perceptions of secondhand exposure to drugs on intent to leave among transit operators

2.1 Introduction

With drug misuse of synthetic opioids and methamphetamines increasing in the USA,[1–5] research has shown potential secondhand exposure for transit operators to drugs smoked by riders.[6] Transit systems are a vital component of a city's infrastructure, playing a crucial role in moving people throughout communities. In 2023, transit systems in Washington (WA) and Oregon (OR) states served over 280 million passenger trips.[7] As transit ridership increases and recovers to pre-pandemic rates,[8] ensuring transit workers' safety and health is crucial to maintain safe and effective service to communities.

Risk perception of secondhand drug exposure, particularly fentanyl, remains high,[9–13] despite research indicating low risk of toxicity associated with secondhand exposures.[14] Perceived risk refers to an individual's beliefs about their vulnerability to a potential hazard, and is typically characterized by perceived risk severity (the believed magnitude of risk to health) and perceived risk susceptibility (the believed likelihood of exposure) to the hazard.[15] Front-line workers who respond to opioid overdose incidents remain concerned about fentanyl exposure despite low risks of toxicity.[14] This leads to a phenomenon where risk perceptions and expectations of negative health effects result in real health symptoms[12,16]; however, in the case of fentanyl exposure, it is unclear if these symptoms are due to fentanyl toxicity.[17] Research of first responders indicated that there are misconceptions about the hazards associated with brief contact with fentanyl; in one study, nearly 80% believed touching fentanyl could be fatal.[18] Another study of first responders found that despite low frequency of exposure to fentanyl, first responders remained

concerned about the potential for adverse health outcomes.[19] The psychosocial effects of these risk perceptions may be further exacerbated by increased job stress associated with witnessing or experiencing a traumatic opioid overdose event.[20]

Research has yet to assess risk perceptions of drug exposures among transit operators; most occupational drug exposure research focuses on first responders. Unlike first responders, who are called to respond to emergencies and arrive on scene with information regarding the situation from their dispatch, transit operators are already present when emergencies occur on their vehicle, are not necessarily expected to respond, and are likely less prepared to do so. Therefore, it reasons that their experiences and risk perceptions related to drug exposures are different than first responders.

Individuals' perceived risk is influenced by outrage factors (i.e., emotional aspects of risk that influence how people perceive risk).[21] In the context of transit operators, outrage factors such as voluntariness (whether the exposure is imposed or voluntary), fairness (whether the exposure is equally distributed, or unique to a given population), process (whether employer decision-making seems fair to the worker, and decisions address worker concerns), and morality may impact transit operators' perceived risk of secondhand drug exposure.

Despite drug use occurring on transit, limited research has investigated how these incidents impact transit operators. Research in other occupations has suggested a positive relationship between the perceived risk of a hazard and intent to leave the job[22,23]; however, research has yet to investigate this relationship among transit operators with regard to secondhand drug exposures. Occupational research has shown that when workers feel dissatisfied with their jobs, they are more likely to want to leave.[24,25] Occupational stress is also related to intent to leave, but research has also shown that workers who have high occupational stress but high job satisfaction

are less likely to want to leave.[25] Higher rates of intent to leave can result in increased attrition (through early departure or difficulty hiring for vacancies), leading to understaffing.[26] Understaffing can result in increased job demands and stress on remaining workers,[27,28] contributing to burnout.[29] Therefore, it is important to investigate factors (such as perceived risk of health outcomes associated with passenger drug misuse on transit vehicles) that may contribute to intent to leave among transit operators, as well as factors such as perceived occupational stress and job satisfaction that may impact these associations, and identify areas of intervention. Research has yet to investigate methods to change risk perceptions of drug exposures among transit operators, though one study among first responders indicated that providing brief trainings and educational resources regarding the risks of secondhand occupational exposure to drugs can be effective in changing risk perceptions and correcting misconceptions.[12]

This study characterized the perceived risk of secondhand drug exposures among transit operators and investigated whether operators with higher perceived risk are more likely to express an intent to leave. This study addressed the current literature gap regarding the impact of transit operators' risk perceptions, and investigates their intent to leave. We hypothesized that operators who perceived a higher risk due to secondhand drug exposures were more likely to express an intent to leave. We also hypothesized that operators with increased occupational stress and decreased job satisfaction were more likely to express an intent to leave. Understanding factors that contribute to transit operators' intent to leave and impact well-being can inform interventions that improve the work environment and experiences of these workers. This work also promotes worker voice, health self-advocacy, and workplace safety culture which are crucial components of worker well-being.[30,31] This study is also the first to explore transit operators'

experiences with drug misuse incidents and characterize the frequency of these incidents aboard transit vehicles.

2.2 Methods

We conducted a cross-sectional study from September 2023 to December 2023 designed to investigate the association between transit operators' risk perceptions of secondhand drug exposure and their intent to leave their job. We partnered with Amalgamated Transit Union (ATU), who represents transit workers across the USA and Canada.[32] In conjunction with ATU International and local ATU leadership, three ATU locals in WA (Seattle and Lynnwood) and OR (Portland) shared our survey with their membership. Transit operator perceived risk of secondhand drug exposure was assessed via survey. The survey also assessed perceived occupational stress, job satisfaction, intent to leave their job, workplace safety, and past experiences with passenger drug use on public transit.

Recruitment:

Survey participants: Each local sent the online survey link to their membership. Eligible respondents included actively-driving transit operators who were at least 18; eligibility was assessed in the first two questions of the survey. One local requested that the survey be available on paper at a union meeting; here, we administered paper copies in addition to promoting the link.

Participants were compensated with a $20 gift card upon survey completion. This study was determined to be exempt from review by the University of Washington Human Subjects Division.

Relationships of interest:

Informed by previous literature, we propose that perceived risk of secondhand exposure to drugs, perceived occupational stress, and job satisfaction are related to intent to leave. We propose that three confounders impact these relationships: passenger drug incidents, workplace safety, and individual demographic information; these confounders are further described below.

Data collection:

Before accessing the survey, participants read a description of the study and indicated that their participation was voluntary; subsequent entry into the survey was considered consent. This survey was administered online via REDCap (or via paper for one local) and included items and validated scales to measure variables of interest and potential confounders.

Six questions asked about perceived severity of and susceptibility to drug exposures, adapted from the Risk Perception Attitude Framework.[15] For all questions, responses were on a 5-point Likert scale. The two perceived susceptibility questions rated how operators felt about their risk of exposure to illicit drugs and the likelihood that they would get sick from this exposure (1=extremely low, 2=low, 3=neither high nor low, 4=high, 5=extremely high), while the four perceived severity questions asked operators to rate agreement with statements about their risk of getting sick or dying from exposure (1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree). Per the framework,[15] we scored perceived severity and perceived susceptibility as an average of the questions out of five, and subsequently scored perceived risk as the product of perceived severity and perceived susceptibility (highest possible perceived risk score=25).

To assess perceived occupational stress, the Perceived Occupational Stress Scale[33] was used. The Perceived Occupational Stress Scale is a validated measure to characterize work-related stress,

asking respondents to rate their agreement to four statements about work stress using Likert response options (1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree). The measure asks respondents whether their work is stressful, if thinking about work makes them feel tense, whether they feel pressured at work, and if their work has negative health effects. Per its established scoring conventions, a score of 3.50 or greater, averaged across the four questions, indicates high strain.[34] Research evaluating the psychometric properties of the Perceived Occupational Stress Scale confirms its high internal reliability (Cronbach's alpha = 0.82) and high test-retest reliability (correlation = 0.86).[33]

Job satisfaction was measured via one question. Operators rated how satisfied they were overall with their job (1=very unsatisfied, 2=unsatisfied, 3=satisfied, 4=very satisfied).

Intent to leave was assessed via one question that asks respondents if they are likely to leave their job within the next year (1=not at all likely, 2=somewhat likely, 3=very likely).

The survey also collected information on three confounders: experiences with drug use incidents, workplace safety, and individual demographic information. Operators were asked about past experiences with passenger drug use aboard their vehicles by rating how often they have observed passengers using drugs on their vehicle, and whether they have ever had a passenger aboard their vehicle require medical attention from emergency medical services due to a drug-related incident. Operators were also asked whether they had ever experienced a family member or friend overdosing on drugs. We measured self-efficacy among operators with two questions that asked them to rate (1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree) whether they believe they can confidently protect themselves from exposure to drugs, and if they believe there are things they can do to ensure they do not get sick due to exposure to passenger drug use. We also asked operators whether they had ever been provided

with guidance on what to do if a passenger uses drugs aboard their vehicle (yes/no). Workplace safety was assessed via two separate questions; the first asked operators to rate their overall perceived workplace safety on a 4-point Likert scale (1=very unsafe, 2=somewhat unsafe, 3=somewhat safe, 4=very safe), and the second question asked whether operators had been attacked by a passenger at work in the past year (yes/no). The survey also gathered demographic information (age, gender, and length of employment).

Analysis:

All analysis was conducted using R statistical software.[35] Survey data were first analyzed descriptively, tabulating means and proportions for the measures included in the survey. Measures were then stratified by each response option of intent to leave, and one-way ANOVAs (for continuous variables) and chi-square tests (for categorical variables) were used to compare values across the three intent to leave groups and identify significant differences. Perceived risk, perceived occupational stress, and job satisfaction were compared to each other using Pearson's correlation coefficients to determine if any were highly correlated.

To investigate the proposed relationships described earlier, we conducted a regression analysis using ordinal logistic regression models. We first fit individual base ordinal logistic regression models for intent to leave as the outcome, with each of the predictors of interest (i.e., one model for each of perceived risk, perceived occupational stress, and job stress as the predictor of interest). We then fit one complete ordinal logistic regression model for intent to leave including all three predictors of interest. Prior to including variables in our models, we checked for skewness and excluded variables that were heavily skewed. Throughout this analysis, we controlled for demographics (groups with $n<10$ were combined together), workplace safety, whether they had been attacked at work, whether they had been provided with guidance on

handling passenger drug use, the number of times operators had observed drug use on their vehicle, past experiences with passengers requiring medical attention due to drugs, and past experiences with family and friends overdosing. Robust standard errors were used to account for any heteroskedasticity. Variance inflation factors (VIFs) were calculated to check for multicollinearity; any variables with VIF>5 were excluded from the models. Responses with missing data (missing completely at random) for variables included in the model were excluded in the regression analysis. Odds ratios (ORs) were calculated by exponentiating the point estimates from the regression model; in an ordinal logistic regression, the OR reflects the odds of being in a higher outcome category associated with a one unit increase in exposure.

2.3 Results

Descriptive Statistics:

We recruited and surveyed 273 transit operators, of which paper copies were administered to 19 operators. The membership[37] across these three locals is approximately 11,000, but not all members would meet our survey inclusion criteria, making it challenging to estimate a survey response rate; though, we estimate it to be low. Demographic characteristics of surveyed transit operators (n=273) are summarized in Table 1. The sample was predominantly male (60.8%), with 112 operators (41.0%) over the age of 55. The majority of respondents were employed for 5 to 9 years (37.4%).

Table 2 outlines descriptive statistics for predictors and outcomes of interest, both overall and stratified by intent to leave responses. Operators had an average perceived risk score of 15.29 out of 25, with a perceived severity score of 3.46 out of 5 and a perceived susceptibility score of 4.30 out of 5. Transit operators had an average perceived occupational stress score of 3.88 (on a scale

of 1 to 5). 197 operators (72.2%) reported high perceived occupational stress (score ≥ 3.5). Average self-efficacy scores were low and heavily right-skewed among operators, (mean score of 4.57 out of 25).

While 129 operators (47.3%) reported they were not at all likely to leave, 93 operators (34.1%) reported they were somewhat likely, and 48 operators (17.2%) reported they were very likely to leave. 167 operators (61.2%) reported being somewhat or very satisfied with their job, with 102 operators (37.3%) indicated being somewhat or very unsatisfied with their job.

228 operators (83.5%) reported observing passenger drug use aboard their vehicle; 88 operators (32.2%) reported observing drug use 2-5 times per week; 95 operators (34.8%) reported a passenger requiring medical attention due to drug use aboard their vehicle; 166 operators (60.8% indicated not receiving guidance on handling passenger drug use incidents; and 101 operators (37.0%) have experienced a family or friend overdose due to drugs in the past.

When stratified by responses for intent to leave (Table 2), there were significant differences between response options in respondents' mean scores for perceived risk (higher scores among those more likely to leave), perceived occupational stress (higher scores among those more likely to leave), overall job satisfaction (lower scores among those more likely to leave), the frequency of observing drug use on transit (higher frequency among those more likely to leave), and self-efficacy (lower scores among those more likely to leave). Furthermore, when stratified by intent to leave responses, there were significant differences in the distribution of responses for satisfaction with employers' response to drug use on transit (lower satisfaction among those more likely to leave), overall workplace safety (lower workplace safety among those more likely to leave), and whether they had been attacked at work by a passenger (higher rate among those more likely to leave).

Perceived risk scores had a moderate positive correlation with perceived occupational stress scores (Pearson's R = 0.32) and a low negative correlation with job satisfaction (Pearson's R = -0.29). Perceived occupational stress scores and job satisfaction had a moderate negative correlation (Pearson's R = -0.43).

Regression Models:

In the base regression models (Table 3), we found that operators who reported higher perceived risk scores had significantly higher odds of expressing an intent to leave (OR: 1.08; 95% CI: 1.02, 1.14), such that a 1-unit increase in perceived risk score was associated with an 8% higher odds of being in the next higher category of intent to leave. Higher perceived occupational stress was also significantly associated with higher odds of intent to leave (OR: 2.21; 95% CI: 1.56, 3.22), while greater job satisfaction was significantly associated with lower odds of intent to leave (OR: 0.35; 95% CI: 0.25, 0.49). However, in the full regression model (Table 4), perceived risk was not significantly associated with intent to leave (OR: 1.04; 95% CI: 0.98, 1.12), while perceived occupational stress (OR: 1.63; 95% CI: 1.10, 2.43) and job satisfaction (OR: 0.41; 95% CI: 0.28, 0.59) remained significantly associated with intent to leave. Self-efficacy was excluded from models due to skewness.

2.4 Discussion

Transit operators' perceived risk of secondhand exposure to secondhand drugs was significantly positively associated with intent to leave in our base ordinal logistic regression model. Perceived risk scores of drug misuse among transit operators were on the higher range of scores per the Risk Perception Attitude framework[15]; in particular, operators had high mean perceived susceptibility scores, indicating that operators felt they were highly susceptible to health effects

due to drug misuse aboard their vehicles. In our base ordinal logistic regression model, we found that these perceived risk scores were significantly associated with intent to leave, suggesting that operators who felt they were at a greater risk due to drug use on their vehicles were more likely to consider leaving their job.

Consistent with literature in other occupational settings,[24,25] our regression analyses showed that transit operators with higher perceived occupational stress and lower job satisfaction were significantly more likely to express an intent to leave. In our full regression model, the inclusion of perceived occupational stress and job satisfaction attenuated the relationship between perceived risk and intent to leave, such that the relationship between perceived risk and intent to leave was no longer significant; this is likely due to the observed low to moderate correlation between these predictors. These findings may suggest a pathway where perceived occupational stress and job satisfaction mediate the relationship between perceived risk and intent to leave, such that higher perceived risks of health effects due to exposure to drug use are related to increased perceived occupational stress and decreased job satisfaction, which in turn are related to intent to leave. While the cross-sectional nature of this study prevented us from assessing this potential mediation, future research with longitudinal data should aim to elucidate these pathways, which can help better understand how perceived risk of secondhand exposure to drugs can impact transit operators. To our knowledge, this study was the first to investigate the association between risk perceptions related to passenger drug misuse and intent to leave among transit operators. These results build on previous literature that have identified possible relationships between perceived risks and intent to leave,[22,23] and between stress, job satisfaction, and intent to leave.[24,25]

The findings of this study highlight the importance of perceived risk; however, it remains unclear what specific factors contribute to perceived risk. While this survey does not thoroughly capture all factors that may contribute to perceived risk, we did find that operators reported low self-efficacy scores. If operators feel that they cannot protect themselves from the health risks posed by secondhand exposure to drugs, this may increase outrage.[38] Research on perceived risk has postulated that perceived risk is influenced by the hazard itself, as well as outrage factors surrounding the hazard[38]; therefore, increased outrage can increase perceived risk. While eliminating passenger drug misuse on transit would be the most effective solution to create a safer workplace,[39] interventions that target outrage factors may be beneficial in changing perceived risk, and possibly mental health, through improved job satisfaction and decreased stress and intent to leave.

Although not a primary aim, it was notable that this study captured transit operators' experiences with passenger drug misuse. The majority of operators indicated that they observed passengers using drugs more than once a week, highlighting the prevalence of this issue across public transit in the Pacific Northwest. Previous research has found that operators in the Pacific Northwest are at risk of exposure to secondhand drug residue from passenger drug use.[6] Per the hierarchy of controls,[39] eliminating a hazard is the most effective method to protect workers from its health effects; therefore, it is of public health importance to reduce passenger drug use on transit vehicles. Doing so not only protects operators from secondhand exposure to drug residue, but also reduces workplace stress, as observing drug use incidents at work can be distressing.[40]

It was also notable that 34.8% of operators reported experiencing passengers on their vehicle requiring medical attention from EMS; these situations may be particularly distressing and can have adverse mental health effects.[41–43] Therefore, while reducing the frequency of such

distressing incidents should be prioritized, providing mental health supports for operators who experience such events not only promotes the well-being of operators, but may also reduce the impact that such incidents have on operators, which can in turn reduce intent to leave.

The majority of operators in our study reported receiving no guidance on how to handle passenger drug use incidents, and our regression results indicated that receiving trainings did not significantly impact intent to leave. Research has shown that brief trainings regarding the risks of secondhand occupational exposure to drugs can be effective in increasing knowledge and changing risk perceptions about secondhand drug exposures.[12] Future research should investigate the types of guidance and trainings currently provided to transit operators, and how these trainings can be changed to better address operators' needs.

Open and transparent risk communication to workers,[44] from sources of information that workers trust,[45] can be effective in changing risk perceptions. Additionally, communication from leadership on how concerns about passenger drug use are being addressed, and worker engagement in this process, can help workers feel validated and reduce outrage.[38] Future research should seek a deeper understanding of operators' risk perceptions of exposure to drug use and their unfulfilled workplace support needs (for example, via focus groups and qualitative interviews), which can inform further interventions that change these risk perceptions and reduce its impacts.

This study only surveyed transit operators, and not other types of transit workers, who may have different work experiences. The majority of respondents in this study were bus drivers, who often have more passenger interaction when compared to other types of transit operators; therefore, the attitudes reflected by this study may not be generalizable to other transit operators with different levels of passenger interaction. Survey respondents were recruited via their union

and only within the Pacific Northwest; therefore, the findings of this study may not be generalizable to operators affiliated with different unions or in different regions. Despite these concerns with generalizability, our sample was demographically consistent with national trends in gender and age of transit operators.[46,47] Additionally, 37.0% of respondents indicated experiencing a family or friend overdose due to drugs in the past, which is only a slightly higher rate than in the general U.S. population (32%).[48] This consistency with the larger population improved the generalizability of this study.

This survey was cross-sectional, and therefore only reflects attitudes at the time of the survey. Due to the cross-sectional nature of this survey, it is unable to identify causal relationships. This survey relies on self-report and is therefore prone to reporting bias, as respondents may not accurately recall or report past events or experiences.

2.5 Conclusions

Given the importance of transit operators to the communities they serve, investigating the impacts of transit operators' experiences with passenger drug use incidents is crucial to promote their workplace safety and health, especially as increasing drug misuse on transit in the Pacific Northwest[1–5] creates potential for operators' secondhand exposure.[6] We found that perceived risk of drug exposures, perceived occupational stress, and job satisfaction have an impact on operator intent to leave. Operator turnover can potentially be reduced by increasing supports that target risk perceptions of drugs. Furthermore, operators routinely experience drug use incidents on their vehicles, which can be distressing. Reducing the occurrence of drug use on transit and providing supports such as mental health resources can further benefit operators by reducing stress and improving job satisfaction.

Chapter 2 Tables

Table 1: Characteristics of surveyed transit operators (n=273)

		n (%)
Gender	Female	66 (24.2%)
	Male	166 (60.8%)
	Other/Prefer not to answer	34 (12.5%)
	Missing	7 (2.5%)
Age	18-25	0
	26-34	22 (8.1%)
	35-44	68 (24.9%)
	45-54	65 (23.8%)
	55+	112 (41.0%)
	Missing	6 (2.2%)
Union Affiliation	Seattle	215 (78.8%)
	Portland	27 (9.9%)
	Lynnwood	20 (7.3%)
	Other/Missing	11 (4.0%)
Current job	Bus driver	230 (84.2%)
	Light Rail, Subway, or Streetcar Operator	39 (14.3%)
	Other Transit Operator	4 (1.5%)
Length of employment	<1 year	6 (2.2%)
	1-4 years	51 (18.7%)
	5-9 years	102 (37.4%)
	10-14 years	32 (11.7%)
	15-19 years	29 (10.6%)
	>20 years	53 (19.4%)

Table 2: Descriptive statistics: overall, and stratified by intent to leave responses

Predictor	**Overall (n=273)**	**Stratified by Intent to Leave**		
		Not at all likely (n=129; 47.3%)	**Somewhat likely (n=93; 34.1%)**	**Very likely (n=47; 17.2%)**
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Perceived risk*	15.29 (5.18)	14.09 (4.95)	15.48 (4.84)	17.95 (5.28)
Perceived severity*	3.46 (0.86)	3.30 (0.81)	3.48 (0.85)	3.80 (0.90)
Perceived susceptibility*	4.30 (0.76)	4.12 (0.82)	4.38 (0.69)	4.67 (0.57)
Perceived Occupational Stress**	3.88 (0.89)	3.58 (0.95)	4.01 (0.78)	4.45 (0.54)
Number of times observing drug use on vehicle per week over past year***	2.36 (1.55)	2.18 (1.61)	2.37 (1.44)	2.83 (1.55)
Overall workplace safety**	1.90 (0.82)	2.15 (0.81)	1.80 (0.79)	1.37 (0.64)
Overall job satisfaction**	2.64 (0.86)	2.97 (0.79)	2.51 (0.76)	1.98 (0.79)
Self-efficacy***	4.57 (5.07)	5.19 (5.32)	4.56 (4.82)	2.87 (4.36)
	n (%)	*n (%)*	*n (%)*	*n (%)*
Distribution of Perceived Occupational Stress Scores^				
High (≥3.50)	197 (72.2%)	85 (65.8%)	70 (75.3%)	44 (93.6%)
Low (<3.50)	65 (23.8%)	44 (34.1%)	17 (18.3%)	3 (6.4%)
Job Satisfaction Responses^				

Very unsatisfied	32 (11.7%)	8 (6.0%)	10 (10.3%)	14 (27.5%)
Somewhat unsatisfied	70 (25.6%)	17 (12.8%)	31 (32.0%)	21 (41.2%)
Somewhat satisfied	131 (48.0%)	73 (54.9%)	47 (48.5%)	11 (21.6%)
Very satisfied	36 (13.2%)	29 (21.8%)	5 (5.2%)	1 (2.0%)
Satisfied with response to drug use aboard vehicles^				
Very unsatisfied	204 (74.7%)	79 (59.4%)	78 (80.4%)	46 (90.2%)
Somewhat unsatisfied	40 (14.7%)	32 (24.1%)	7 (7.2%)	0
Somewhat satisfied	19 (7.0%)	10 (7.5%)	8 (8.2%)	1 (2.0%)
Very satisfied	6 (2.2%)	6 (4.5%)	0	0
Overall workplace safety responses^				
Very unsafe	101 (37.0%)	30 (22.6%)	39 (40.2%)	32 (62.7%)
Somewhat unsafe	103 (37.7%)	54 (40.6%)	35 (36.1%)	12 (23.5%)
Somewhat safe	61 (22.3%)	41 (30.8%)	18 (18.6%)	1 (2.0%)
Very safe	6 (2.2%)	4 (3.0%)	1 (1.0%)	1 (2.0%)
Number of times observing rider drug use on vehicle over past year				
0 times	45 (16.5%)	26 (19.5%)	12 (12.4%)	6 (11.8%)
< 1 per week	47 (17.2%)	26 (19.5%)	17 (17.5%)	4 (7.8%)
1 per week	34 (12.5%)	16 (12.0%)	13 (13.4%)	5 (9.8%)
2-5 times per week	88 (32.2%)	34 (25.6%)	35 (36.1%)	16 (31.4%)
5-10 times per week	31 (11.4%)	14 (10.5%)	8 (8.2%)	9 (17.6%)
> 10 times per week	28 (10.3%)	13 (9.8%)	8 (8.2%)	7 (13.7%)
Attacked at work by a passenger^				
Yes	73 (26.7%)	25 (18.8%)	29 (29.9%)	18 (35.3%)
No	199 (72.9%)	104 (78.8%)	64 (66.0%)	29 (56.9%)

Provided guidance about what to do if a passenger uses drugs (responded yes)	103 (37.7%)	49 (36.8%)	33 (34.0%)	20 (39.2%)
Passenger requiring medical attention (responded yes)	95 (34.8%)	47 (35.3%)	26 (26.8%)	21 (41.2%)
Family/friends OD (responded yes)	101 (37.0%)	49 (36.8%)	30 (30.9%)	22 (43.1%)

Missing data is not included; as such, percentages may not sum to 100%.

*Significant differences in perceived risk were detected between those who were not at all likely and very likely to leave, and those who were somewhat likely and very likely to leave, but not those who were not at all likely and somewhat likely to leave. Significant differences in perceived severity were only detected between those who were not at all likely and very likely to leave. Significant differences in perceived susceptibility were detected between those who were not at all likely and somewhat likely to leave, and those who were not at all likely and very likely to leave, but not those who were somewhat likely and very likely to leave

**Significant differences were detected between all response options for intent to leave.

***Significant differences were only detected between those who indicated being not at all likely and very likely to leave.

^Indicates significant differences in the distribution of proportions between intent to leave response options.

Table 3: Base ordinal logistic regression models for intent to leave, with overall perceived risk, perceived occupational stress, and job satisfaction as the predictor of interest respectively

Predictors	**Overall perceived Risk (n=249)**		**Perceived Occupational Stress (n=249)**		**Job Satisfaction (n=254)**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Predictor of interest	**1.08**	**1.02, 1.14**	**2.21**	**1.56, 3.22**	**0.35**	**0.25, 0.49**
Family/Friend Overdose (yes/no)	1.19	0.70, 2.01	0.92	0.53, 1.59	1.09	0.63, 1.88
Passenger required medical attention (yes/no)	**1.80**	**1.01, 3.26**	**1.97**	**1.09, 3.62**	**1.91**	**1.05, 3.54**
Number of times observing drug use on transit	1.03	0.85, 1.26	1.13	0.93, 1.38	1.10	0.90, 1.34
Length of Employment (years)	1.00	0.81, 1.23	0.98	0.80, 1.22	1.02	0.83, 1.26
Overall workplace safety	**0.49**	**0.34, 0.70**	**0.56**	**0.37, 0.79**	**0.56**	**0.38, 0.80**
Attacked at work by a passenger (REF: No)	**1.93**	**1.11, 3.38**	1.68	0.94, 2.96	1.68	0.94, 3.00
Provided guidance to handle drug incidents (yes/no)	1.15	0.68, 1.95	1.23	0.72, 2.10	1.54	0.89, 2.67
Age (age categories)	1.03	0.76, 1.40	0.89	0.65, 1.21	0.85	0.62, 1.17
Gender (REF: Male)						
Female	0.68	0.37, 1.24	0.84	0.45, 1.56	0.75	0.40, 1.39
Other	0.54	0.24, 1.17	0.50	0.22, 1.10	0.53	0.23, 1.17

Bold indicates $p<0.05$.

Table 4: Full ordinal logistic regression models for intent to leave

Predictors	**OR**	**95% CI**
Overall Perceived Risk	1.04	0.98, 1.12
Perceived Occupational Stress	**1.63**	**1.10, 2.43**
Job Satisfaction	**0.41**	**0.28, 0.59**
Family/Friend Overdose (yes/no)	0.87	0.49, 1.54
Passenger required medical attention (yes/no)	**1.96**	**1.05, 3.70**
Number of times observing drug use on transit	1.04	0.84, 1.28
Length of Employment (years)	1.08	0.86, 1.35
Overall workplace safety	**0.64**	**0.43, 0.96**
Attacked at work by a passenger (REF: No)	1.80	0.98, 3.29
Provided guidance to handle drug incidents (yes/no)	1.67	0.94, 2.97
Age (age categories)	0.81	0.58, 1.12
Gender (REF: Male)		
Female	0.75	0.39, 1.44
Other	0.55	0.24, 1.24

Bold indicates $p<0.05$.

Chapter 2 References

1. Addiction, Drugs, and Alcohol Institute. Washington state drug trends. 2023 [accessed 2022 Nov 15]. https://adai.washington.edu/wadata/stateMOP_cases.htm

2. Oregon Health Authority. Fentanyl Facts : Opioid Overdose and Misuse. 2024 [accessed 2023 Sep 12]. https://www.oregon.gov/oha/ph/preventionwellness/substanceuse/opioids/pages/fentanylfacts.aspx

3. Spencer MR, Garnett MF, Miniño AM. Drug Overdose Deaths in the United States, 2002-2022. 2023 [accessed 2024 Jul 18]. https://stacks.cdc.gov/view/cdc/135849

4. National Institute on Drug Abuse. Drug Overdose Death Rates | National Institute on Drug Abuse (NIDA). 2024 May 14 [accessed 2024 Jul 18]. https://nida.nih.gov/research-topics/trends-statistics/overdose-death-rates

5. Han B et al. Methamphetamine Use, Methamphetamine Use Disorder, and Associated Overdose Deaths Among US Adults. JAMA psychiatry. 2021;78(12):1329–1342. https://doi.org/10.1001/jamapsychiatry.2021.2588

6. Beaudreau M et al. Assessing fentanyl and methamphetamine in air and on surfaces of transit vehicles. Journal of Occupational and Environmental Hygiene. 2025;0(0):1–11. https://doi.org/10.1080/15459624.2024.2444430

7. Federal Transit Administration. Complete Monthly Ridership (with adjustments and estimates) | FTA. 2023 Jul [accessed 2023 Sep 12]. https://www.transit.dot.gov/ntd/data-product/monthly-module-adjusted-data-release

8. Doyle T. Public Transportation Ridership Rises to More than 70 Percent of Pre-Pandemic Levels. American Public Transportation Association. 2022 [accessed 2023 Sep 12]. https://www.apta.com/news-publications/press-releases/releases/public-transportation-ridership-rises-to-more-than-70-percent-of-pre-pandemic-levels/

9. del Pozo B, Rich JD, Carroll JJ. Reports of accidental fentanyl overdose among police in the field: Toward correcting a harmful culture-bound syndrome. International Journal of Drug Policy. 2022;100:103520. https://doi.org/10.1016/j.drugpo.2021.103520

10. Beletsky L et al. Fentanyl panic goes viral: The spread of misinformation about overdose risk from casual contact with fentanyl in mainstream and social media. International Journal of Drug Policy. 2020;86:102951. https://doi.org/10.1016/j.drugpo.2020.102951

11. Attaway PR, Smiley-McDonald HM, Davidson PJ, Kral AH. Perceived occupational risk of fentanyl exposure among law enforcement. International Journal of Drug Policy. 2021;95:103303. https://doi.org/10.1016/j.drugpo.2021.103303

12. Winograd RP et al. Training to reduce emergency responders' perceived overdose risk from contact with fentanyl: early evidence of success. Harm Reduction Journal. 2020;17(1):58. https://doi.org/10.1186/s12954-020-00402-2

13. Taxel S. Fentanyl Facts and Fiction: A Safety Guide for First Responders. JEMS: EMS, Emergency Medical Services - Training, Paramedic, EMT News. 2019 [accessed 2022 Nov 15]. https://www.jems.com/operations/fentanyl-facts-and-fiction-a-safety-guide-for-first-responders/

14. Moss MJ et al. ACMT and AACT position statement: preventing occupational fentanyl and fentanyl analog exposure to emergency responders. Clinical Toxicology. 2018;56(4):297–300. https://doi.org/10.1080/15563650.2017.1373782

15. Rimal RN, Real K. Perceived Risk and Efficacy Beliefs as Motivators of Change: Use of the Risk Perception Attitude (RPA) Framework to Understand Health Behaviors. Human Communication Research. 2003;29(3):370–399. https://doi.org/10.1111/j.1468-2958.2003.tb00844.x

16. Colloca L. Nocebo effects can make you feel pain. Science (New York, N.Y.). 2017;358(6359):44. https://doi.org/10.1126/science.aap8488

17. Lynch MJ, Suyama J, Guyette FX. Scene Safety and Force Protection in the Era of Ultra-Potent Opioids. Prehospital Emergency Care. 2018;22(2):157–162. https://doi.org/10.1080/10903127.2017.1367446

18. Persaud E, Jennings CR. Pilot Study on Risk Perceptions and Knowledge of Fentanyl Exposure Among New York State First Responders. Disaster Medicine and Public Health Preparedness. 2020;14(4):437–441. https://doi.org/10.1017/dmp.2019.95

19. Thompson RA et al. Perceptions of opioid and other illicit drug exposure reported among first responders in the southeast, 2017 to 2018. Health Science Reports. 2021;4(3):e335. https://doi.org/10.1002/hsr2.335

20. Chiu S, Wiegand DM, Broadwater K, Li JF. Interim report: evaluation of occupational exposures to opioids, mental health symptoms, exposure to traumatic events, and job stress in a city fire department. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2019. https://www.cdc.gov/niosh/hhe/reports/pdfs/2018-0015b.pdf. https://doi.org/10.26616/NIOSHHHE20180015b

21. Northwest Center for Public Health Practice. What Increases Outrage? | Introduction | Emergency Risk Communication. 2024 [accessed 2024 May 2]. https://www.nwcphp.org/docs/perrcolate/erc/section1/outrage.html

22. McCaughey D et al. Examining workplace hazard perceptions & employee outcomes in the long-term care industry. Safety Science. 2015;78:190–197. https://doi.org/10.1016/j.ssci.2015.04.013

23. Elshaer IA. Social-psychological risk perception impacts on job insecurity and turnover intention: a mediation model using PLS-SEM technique. Cogent Psychology. 2024;11(1):2303219. https://doi.org/10.1080/23311908.2024.2303219

24. Hellman CM. Job Satisfaction and Intent to Leave. The Journal of Social Psychology. 1997;137(6):677–689. https://doi.org/10.1080/00224549709595491

25. Jiang N et al. The Relationship Between Occupational Stress and Turnover Intention Among Emergency Physicians: A Mediation Analysis. Frontiers in Public Health. 2022 [accessed 2024 Aug 15];10. https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.901251/full. https://doi.org/10.3389/fpubh.2022.901251

26. Wasserman JL, Padgett A, Do KK-A. Transit, Belabored: Issues and Futures for California's Frontline Transit Workforce. 2024 Feb 22 [accessed 2024 Aug 13]. https://escholarship.org/uc/item/2036z8c4. https://doi.org/10.7922/G2S180TK

27. Hudson CK, Shen W. Understaffing: An under-researched phenomenon. Organizational Psychology Review. 2015;5(3):244–263. https://doi.org/10.1177/2041386615576016

28. Hung J-Y, Fisher R, Gapp R, Carter G. Work-related stress impacts on the commitment of urban transit drivers. Journal of Management & Organization. 2012;18(2):220–230. https://doi.org/10.5172/jmo.2012.18.2.220

29. Crawford ER, LePine JA, Rich BL. Linking job demands and resources to employee engagement and burnout: A theoretical extension and meta-analytic test. Journal of Applied Psychology. 2010;95(5):834–848. https://doi.org/10.1037/a0019364

30. Darbra RM, Crawford JFE, Haley CW, Morrison RJ. Safety culture and hazard risk perception of Australian and New Zealand maritime pilots. Marine Policy. 2007;31(6):736–745. https://doi.org/10.1016/j.marpol.2007.02.004

31. Marshall TM. Risk perception and safety culture: Tools for improving the implementation of disaster risk reduction strategies. International Journal of Disaster Risk Reduction. 2020;47:101557. https://doi.org/10.1016/j.ijdrr.2020.101557

32. ATU. Our Work. Amalgamated Transit Union. [accessed 2023 Mar 14]. https://www.atu.org/union/our-work

33. Marcatto F et al. The Perceived Occupational Stress Scale: A brief tool for measuring workers' perceptions of stress at work. European Journal of Psychological Assessment. 2022;38(4):293–306. https://doi.org/10.1027/1015-5759/a000677

34. Marcatto F, Di Blas L, Ferrante D. Diagnostic utility of the Perceived Occupational Stress Scale. European Journal of Psychological Assessment. 2023 Sep 6 [accessed 2024 Aug 4]. http://offcampus.lib.washington.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=pdh&AN=2024-08302-001&site=ehost-live. https://doi.org/10.1027/1015-5759/a000789

35. R Core Team. R: A Language and Environment for Statistical Computing. 2025. https://www.R-project.org

36. Rosseel Y. lavaan: An R Package for Structural Equation Modeling. Journal of Statistical Software. 2012;48:1–36. https://doi.org/10.18637/jss.v048.i02

37. Center for Union Facts. Union Facts. Union Facts. 2025 [accessed 2025 Mar 19]. https://www.unionfacts.com/

38. Sandman PM. Responding to Community Outrage: Strategies for Effective Risk Communication. AIHA; 1993.

39. National Institute for Occupational Safety and Health. Hierarchy of Controls. 2022 Apr 28 [accessed 2024 Dec 17]. https://www.cdc.gov/niosh/learning/safetyculturehc/module-3/2.html

40. Kovaleski J, Vaccarelli J. "It's scary. It's unsafe": Drug use still rampant on RTD property, Denver7 Investigates learns. Denver 7 Colorado News (KMGH). 2023 Jun 10 [accessed 2024 Oct 12]. https://www.denver7.com/news/investigations/its-scary-its-unsafe-drug-use-still-rampant-on-rtd-property-denver7-investigates-learns

41. Alexander DA, Klein S. Ambulance personnel and critical incidents: impact of accident and emergency work on mental health and emotional well-being. The British Journal of Psychiatry: The Journal of Mental Science. 2001;178(1):76–81. https://doi.org/10.1192/bjp.178.1.76

42. Boland LL et al. Burnout and Exposure to Critical Incidents in a Cohort of Emergency Medical Services Workers from Minnesota. The Western Journal of Emergency Medicine. 2018;19(6):987–995. https://doi.org/10.5811/westjem.8.39034

43. Donnelly E. Work-related stress and posttraumatic stress in emergency medical services. Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors. 2012;16(1):76–85. https://doi.org/10.3109/10903127.2011.621044

44. Pastides H. Managing measurable and perceived risk in the occupational setting. The Journal of Ambulatory Care Management. 1994;17(2):44–52. https://doi.org/10.1097/00004479-199404000-00007

45. Siegrist M, Cvetkovich G. Perception of hazards: the role of social trust and knowledge. Risk Analysis: An Official Publication of the Society for Risk Analysis. 2000;20(5):713–719. https://doi.org/10.1111/0272-4332.205064

46. Bureau of Labor Statistics. Employed persons by detailed industry and age. Bureau of Labor Statistics. 2024 [accessed 2025 Feb 5]. https://www.bls.gov/cps/cpsaat18b.htm

47. Bureau of Labor Statistics. Employed persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity. Bureau of Labor Statistics. 2024 [accessed 2025 Feb 5]. https://www.bls.gov/cps/cpsaat11.htm

48. Kennedy-Hendricks A et al. Experience of Personal Loss Due to Drug Overdose Among US Adults. JAMA Health Forum. 2024;5(5):e241262. https://doi.org/10.1001/jamahealthforum.2024.1262

Chapter 3: Impacts and workplace needs of transit operators related to passenger drug misuse on transit vehicles

3.1 Introduction

Transit operators are an essential component of a city's transportation infrastructure, providing safe and reliable transportation for the communities they serve. With drug misuse occurring on public transit vehicles in the Pacific Northwest (USA), recent research has shown that transit operators are at risk of secondhand exposure to drug residue.[1] Operators have reported feeling sick, have required time off from work, and have filed for workers' compensation due to exposure to drug misuse on transit.[2,3] Witnessing drug-related critical incidents at work such as overdoses can also be distressing for transit operators, who are not trained medical professionals and therefore should not be expected to intervene during such incidents. These experiences can adversely impact operator mental health.[4–6] Furthermore, these drug misuse incidents pose a safety risk to operators, as passengers under the influence of drugs can display unpredictable behaviors, leading to potentially dangerous interactions between operators and passengers.

In addition to the impacts of secondhand exposure to drug misuse, public risk perception of secondhand exposure to drugs remains high.[7–11] Concern over potential exposure to drugs may contribute to increased stress among transit operators, who may feel unsafe at work[12]; this can increase the likelihood of burnout and reduce job satisfaction, leading to attrition.[13] The fear of overdose or other adverse health outcomes from secondhand exposure to illicit drugs may contribute to increased stress and adverse mental health outcomes among exposed workers[8–10]; however, risk perception theory states that those who are exposed less might be more likely to experience stress and adverse mental health outcomes, as the exposure feels more unfamiliar[14].

Research has shown that when workers perceive their workplace as having a poor safety climate and high health risk, job satisfaction decreases,[15,16] regardless of the actual health risk posed by the workplace. When workers perceive an unsafe work environment, they are more likely to leave and exhibit symptoms consistent with stress, anxiety, and burnout.[17] Outrage factors (i.e., emotional aspects of risk that influence how people perceive risk) can also impact individuals' perceived risk[18]; in the context of secondhand drug exposures on transit, factors such as controllability (whether the exposure is in one's control or someone else's control), process (how trustworthy and fair employer decision-making seems to the worker, and whether decisions address worker concerns), and fairness (whether the exposure is distributed among everyone, or unique to the worker or worker population), may impact transit operators' risk perceptions.

Transit operators are routinely exposed to other physical and psychosocial exposures that may negatively impact their health, such as long hours spent sitting,[19] seat vibration,[20] high levels of work-related stress,[21] high job demands with little latitude (i.e., worker autonomy over decision-making at work),[21,22] and an expectation to be on time.[23] Previous literature has highlighted that transit operators experience workplace violence and inadequate social support, which can lead to burnout and negatively impact wellbeing.[24,25] The presence of drug misuse on transit vehicles can exacerbate these existing occupational psychosocial stressors among transit operators.[4–6] Reducing exposure to work-related stressors is not only important for operator health and safety,[26] but also for the community they serve, as operators are ultimately responsible for the safety of passengers on their vehicle.

Research has yet to evaluate interventions that reduce the impacts of drug misuse incidents on transit operators. In 2024, the U.S. Federal Transit Administration (FTA) issued a general directive to investigate the overall safety of transit workers in urban transit systems.[27] While this

directive was not specific to drug misuse on transit, results from this directive identified safety interventions most commonly being adopted by transit agencies across the country, many of which may be applicable to reduce the impacts of drug-related incidents. The most prevalent interventions in the FTA report were focused on increased education, awareness, and surveillance.[28] While these interventions may be impactful in the context of drug misuse, they do not explicitly eliminate the hazard itself, which is the most effective method to promote a hazard-free workplace.[29] The FTA report identified other interventions that have lower rates of implementation, such as protective barriers for the operator area or improved security patrolling to remove disruptive passengers[28]; these interventions do provide increased protection for transit operators from secondhand drug exposures. However, like the other interventions, it remains unclear whether these interventions result in improved well-being for operators in the context of drug misuse on transit vehicles.

This study qualitatively explored transit operators' experiences with passenger drug use in the Pacific Northwest (USA), and characterized the impacts that passenger drug use has on transit operators. We investigated risk perceptions related to exposure to passenger drug use, and whether outrage factors such as controllability, fairness, and process were relevant themes that impacted these risk perceptions.[18] Furthermore, we explored whether transit operators believe that existing methods of reducing the impacts of drug misuse on transit vehicles are acceptable, and if operators believe that further interventions are needed to protect both themselves and the riding public. The findings of this study can identify transit operators' workplace needs and help inform potential interventions that can subsequently be evaluated for effectiveness in reducing the impacts of drug use incidents on operators.

3.2 Methods

We conducted a qualitative study designed to investigate the experiences of transit operators as they pertain to passenger drug use. This study was conducted in conjunction with the Amalgamated Transit Union (ATU), which represents transit workers across the United States and Canada.[30] We recruited 19 transit operators from three ATU union locals in Washington and Oregon states. Recruited transit operators participated in a semi-structured interview that asked about impacts, risk perceptions, existing workplace supports, and unfulfilled needs of transit operators related to passenger drug use. The portion of the interview guide that focused on workplace supports and unfulfilled needs was developed using the National Institute for Occupational Safety and Health's (NIOSH) hierarchy of controls[29,31] as a framework.

Recruitment:

Locals: In conjunction with the ATU International and leadership at ATU locals, we recruited two locals in Washington State (Seattle and Lynnwood) and one local in Oregon (Portland) into our study.

Survey participants: Potential transit operator participants were identified by a survey gauging their interest in our study that was shared by each local's leadership to their membership. Eligibility criteria were assessed in the first two questions of the online survey, and included transit operators who were at least 18 years old and were actively driving. Via the survey, operators were asked to self-select into the participant pool, and every operator in the participant pool was contacted via email for recruitment. Operators who responded to our email were considered recruited; subsequent snowball sampling with the same recruitment email was used to

increase sample size.[32] Upon recruitment, participants provided informed consent and were informed that no personally identifiable information would be made publicly available.

Participants in this study were compensated with a $20 gift card upon completion of interviews. This study was determined to be exempt from review by the University of Washington's Human Subjects Division as it was deemed minimal risk.

Data Collection:

This study used semi-structured interviews (approximately 40 minutes) of transit operators (one interview per operator) asking about experiences with passenger drug use, the impacts they have experienced from passenger drug, risk perceptions related to secondhand exposure to drug use, existing workplace guidance and supports related to passenger drug use, and workplace needs.

Interviews were guided by an interview guide (Appendix 1), part of which was developed using the NIOSH hierarchy of controls[29,31] as a framework. Given the semi-structured nature of interviews in this study, the interview guide provided flexibility for the interviewer to follow up on responses provided by the interviewee at the interviewer's discretion. Interviews were conducted over Zoom, and were recorded and transcribed with the consent of the interviewee.

Data Analysis:

Interview transcripts were downloaded from Zoom, and data were cleaned for transcribing errors. Data collected from interview transcripts were analyzed thematically. Data were analyzed using a deductive strategy based in a constructionist paradigm (i.e., that participant experiences, events, meanings, and realities are based on societal factors),[33] using previously described methods of conceptual qualitative research.[34,35] Analysis began deductively for initial code development, using a starting codebook that incorporated the hierarchy of controls[31] as a

framework. Interview transcripts were examined for trends in risk perceptions, impacts due to passenger drug use incidents on transit vehicles, supports pertaining to passenger drug use, and needs of transit operators.

Transcripts were split-coded by two independent coders. Initially, 20% of transcripts (n=4) were independently co-coded by the two coders, and codes were compared. Differences in coding were identified and resolved via open discussion between the coders[36]; less than 5% of codes differed between coders, and was always due to one coder missing a code for an excerpt, rather than the coders applying different codes to an excerpt. Then, the remaining transcripts (n=15) were divided between the two coders and coded independently. Coders subsequently discussed any areas of confusion in independently coded transcripts to ensure accurate application of the codebook. All discussions between coders throughout this process allowed for refinement of code definitions, which were memorialized into the codebook. Dedoose qualitative data analysis software[37] was used to maintain organization of this codebook and its codes, allowing for easier sorting of codes and its corresponding data. Upon completion of coding of all interview transcripts, the two coders collaboratively developed key themes from codes, by examining frequently applied codes and frequently co-occurring codes.

3.3 Results

Study Participants:

Table 1 summarizes work characteristics of the interviewed operators. Of the 19 interviewees, 13 (68.4%) worked in King County, WA; 3 (15.8%) worked in Snohomish County, WA; and 3 (15.8%) worked in Portland, OR. The majority of interviewed operators were solely coach drivers (73.7%). Eight operators (42.1%) were employed for 5 to 9 years, which was the most

prevalent length of employment among interviewees. No demographic information was collected from interviewees to preserve confidentiality.

Table 2 summarizes key themes that emerged across interviews. Themes were categorized by research objectives: understand characteristics of the job, characterize transit operators' experiences with passenger drug use incidents, investigate risk perceptions and impacts associated with drug use incidents, and explore existing supports and unfulfilled needs pertaining to drug use incidents on transit. These themes are explored here, with the inclusion of quotes from interviewees to provide richer descriptions of their experiences.

Understand characteristics of the job:

Job satisfaction:

Overall, transit operators reported satisfaction with their job, with many operators saying that they "*like their job*" or they "*enjoy their work.*" For many transit operators, a primary appeal of the job was that they were in a position of service where they could help their community. Some operators gave other reasons for enjoying their work, such as the pay and benefits, or positive passenger interactions. Despite overall job satisfaction, operators still identified aspects of their work that they disliked. Many operators said that negative interactions with passengers were one of the downsides of their work, with one operator describing, "*I have personally been assaulted, been spit at, had stuff thrown at me.*" Operators also identified their employer as a dislike about their job, with operators describing that they felt replaceable, and that agencies "*pretend that nothing's wrong in their system*", or that the priority is to "*keep service rolling.*" Operators mentioned fear of punitive retaliation from management if they reported work-related incidents and concerns.

Transit operators are responsible for the safety and well-being of passengers:

Throughout interviews, operators said that being a transit operator involves a lot more than operating a vehicle. Interviewees said that they are ultimately responsible for the safety of their passengers and assessing the risks posed by hazards on and outside their vehicle, with one operator describing: "*sensing what's going to happen in front of you and we're keeping an eye out on those individuals who will just step out in front of traffic… just make sure that you're going to keep everybody safe. And that's my first priority, is to make sure everyone's safe.*" When asked about instances of passenger violence or drug use on vehicles, one operator said that he did not feel that he should be solely responsible for evaluating risk, describing, "*I would have liked to see supervisors, instead of telling me to fill out a report, to actually come down and assess the situation.*" This also highlights the lack of existing support for operators, and that having someone physically show up to provide support could improve operators experiences, especially considering that operators are in a potentially physically vulnerable position regarding these passenger interactions.

Operators' protectiveness over the safety and well-being of their passengers was also evident in their descriptions of feeling care and compassion for their passengers, especially for those who are following rules, with one operator calling for enforcement of the law: "*because you got to protect the other passengers too.*" When asked about passenger drug use, another operator described, "*If other passengers are exposed, then I obviously am going to immediately say something,*" later saying, "*I say something because I see other passengers feel uncomfortable when they see it.*" Some operators said they go out of their way to try to care for their passengers, with one operator describing, "*I would put their food up on the dash to keep it warm or to cook*

it… the less fortunate who didn't get hot meals, they were kind and didn't cause me any problems. I would offer them to do that."

Characterize transit operators' experiences with passenger drug use incidents:

Agencies do not care about operators:

Throughout interviews, operators said that agencies prioritize continuing service over operator safety and well-being. Operators feel a lack of empathy from management and feel that management does not treat their health impacts due to drug exposures as real. As a result, operators feel invalidated, disrespected, and intentionally misled. When asked about seeking help from management, one operator described, "*They discipline us to suspend us, bully us into just driving the bus and not caring if anybody was being assaulted or if anybody was in trouble.*" Furthermore, operators experienced not receiving support from their employers, who prioritized passengers over operators, even when those passengers used drugs while riding transit vehicles.

Frequency of observed drug use:

When asked how often they observed passengers using drugs on their vehicle, interviewee responses varied. Ten operators said they have daily experiences with passenger drug use, some of which were multiple times a day, while eight operators said they rarely or never observe passenger drug use. Three operators said that the frequency of observed drug use has changed, either due to switching routes or declining drug use rates. One operator described the differences in the frequency of drug use on transit vehicles based on the location: "*I'm no longer in Seattle, I'm on Vashon Island now… I've been here a year now and I have not encountered it once. In Seattle, I would venture to say daily.*"

Interviewees also said that they are not always able to observe drug use incidents occurring. One operator described, "*I don't recall explicitly seeing people using drugs on my bus; but that's not to say that they don't. The problem is you're trying to navigate the bus and taking your eyes off the road to watch what passengers are doing is a precarious exercise.*" Another operator described that "*if it's not active use, you're seeing paraphernalia*", suggesting that there is evidence of drug use even if the actual incident goes unnoticed.

Seniority protects operators from drug use incidents:

Through the majority of interviews, operators highlighted the role of seniority in protecting against potential incident related impacts and improving well-being, as senior operators have more choice in their routes, thereby allowing them to avoid routes and times when passenger drug use is more likely to occur. When talking about passengers using drugs on her vehicle, one senior operator, who had been employed for eight years, described, "*I'm so extremely blessed and grateful that I don't have to pick routes where I see it every day because I don't think I would stay a bus driver.*" In contrast, an operator who had only been employed for 1 year described, "*I worked the late shift because I'm low seniority, so I'm out till two o'clock in the morning… And at some point, the only people on your train are the houseless and the addicted*."

One operator, who is also involved in advocating for operator safety, described the impact of seniority:

> "*[Low seniority drivers] are driving these routes through the middle of the night that have real challenges with people that are just riding around on their bus doing drugs or doing alcohol… So unfortunately, the guy at the low end who is just coming in, he's going to get exposed to all of this chaos. And a lot of them don't survive. I tell you, they quit within three months or even three weeks.*"

Varying opinions on the value of reporting:

When asked whether they report passenger drug use incidents on their vehicle, interviewees had varying opinions on the value of reporting incidents. Many operators would previously report incidents diligently per guidelines, but eventually "*stopped bothering because there was no point – nothing was going to happen.*" One operator described her experience with the ineffectiveness of reporting incidents:

> "*In the beginning I filled out everything - security incidents, safety incidents. Any kind of incident I could fill out, I was filling them all out and reporting them. But get this – every single one of them that I filled out I never got an answer, never got any kind of an answer, never got my paper back… Never got a single response… We're all sick and tired of filling out papers when nothing gets done.*"

Reporting incidents also seemed to be a hassle for operators, with some noting that the reports take too long and the online system is slow, making it particularly burdensome to do after the end of an eight-hour shift.

Despite these concerns, about half of interviewees still said they report incidents. One operator described going out of his way to find incidents and report them:

> "*More than once, I found lots of remnants from drug use syringes… One day, there would be anywhere from 10 to 30 people, partying and sleeping on… And I intentionally took that work for six months after the shift every day. I would go in, I'd get on the computer, and I'd write two to three reports on what was happening out there.*"

Investigate risk perceptions and impacts associated with drug use incidents:

Perceived severity and susceptibility of drug exposures:

Interviewees expressed both perceived severity and perceived susceptibility related to drug use incidents. An operator said that "*every time [there is a drug use incident] is dangerous*" and that

even for operators who experience fewer incidents, they "*ratchet up in severity.*" Operators expressed concern over the effects that these exposures have on the health of riders. One operator said:

> "*If you look at the studies of the residue from methamphetamines, that stuff stays on there for a long time. It's not the easiest thing to get rid of. So, there's always those concerns of having to go to the back or anywhere and touch anything on the bus. Most of us don't even want to leave the driver compartment because we're afraid of touching something.*"

Controllability, process, and age of victims:

Outrage factors were themes of interest. Among the most common outrage factors discussed by interviewees was controllability, with operators describing "*the feeling that you are trapped*" and feeling like a "*hostage having to breathe it in.*" One operator described, "*It would make me mad because I knew that there's nothing I could do.*"

Process was another outrage factor discussed by interviewees, in particular that management does not acknowledge passenger drug use as a problem, and therefore does not intervene to stop/prevent it. An operator said:

> "*I would like management chiefs, superintendents, the general managers – take it more serious than what they did… They're sitting in their offices and not boots on the ground, and they have no idea what we're going through. They hear it, but they don't know for sure, and they didn't do anything. It would have been nice to have some support. For them to protect this.*"

Operators also called for operator involvement in company conversations and decision-making regarding passenger drug use.

The age of passengers who may be exposed to secondhand drug residue was mentioned repeatedly throughout interviews, highlighting again how operators feel protective of their passengers. Many operators said there is potential for vulnerable populations such as children and the elderly to be exposed to secondhand drug residue. One operator described an overdose

incident she witnessed in which a man with children overdosed and was resuscitated, expressing concern for the well-being of the children.

Physical and mental health impacts:

Interviewees reported both physical and mental health impacts attributed to passenger drug use. Physical health impacts were primarily short-term impacts, directly after a passenger drug use incident, such as shortness of breath, feeling sick, headaches, and dizziness. In some incidents, operators described requiring medical attention and time off work due to these short-term impacts. Some operators also reported experiencing long-term physical health impacts which they said were related to passenger drug uses, such as high blood pressure due to the stress of handling these incidents, long-term respiratory difficulties, and trouble sleeping.

More than half of interviewees said they had experienced long-term mental health outcomes. Stress, related to repeatedly experiencing passenger drug use aboard vehicles, was the most common. Operators described work-related anxiety due to concern over dealing with drug use incidents; for some operators, this anxiety was severe enough to warrant anti-anxiety medication prescriptions. One operator described his mental health impacts and needing to take time off, "*I thought several times this isn't the job for me. I can't do this mental stress anymore. I have taken FMLA [Family and Medical Leave Act] for anxiety and stress and it was hard.*" Another operator described that he "*would wake up dreading going to work*" and that he "*became a recluse.*"

Emotional impacts:

The majority of interviewees said they had emotional impacts related to passenger drug use. Short-term impacts included anger and frustration that these incidents are occurring. In the long-

term, operators described feeling hypervigilant, mentally distraught, less empathetic, and more negative towards society. One operator said, "*I used to love working for the bus and streetcar and [then] it was demoralizing… It cost me years and years of peace and tranquility.*" Another operator described, "*I started not liking myself because I was losing that compassion and empathy and it was changing me.*"

Explore existing supports and unfulfilled needs pertaining to drug use incidents on transit:

Operators take safety into their own hands:

Many interviewees described taking safety into their own hands to protect themselves from secondhand exposure to drugs, because of the lack of support from management and the inadequacy of existing supports (such as increases in the number of available security personnel). Some operators have opted to buy their own personal protective equipment (PPE) such as respirators; however, one operator who purchased a P100 respirator described being told by management that she was "*not allowed to wear that respirator.*"

A light rail operator said, "*I bring a roll of masking tape and I literally tape off my air vents,*" in an effort to reduce her inhalation exposure to drugs.

One operator described multiple ways in which she protects herself:

> "*I have figured out that I am the only one that's going to take care of me in these situations… I mean, there isn't immediate help, so what I have learned is to take care of myself. I carry an N95 mask on me close by, within reach so I can just pop it on, and I found that that actually seems to help… I've also gotten to the point where I don't really care what the control center says. If I need to take care of myself, if I need to stop, if I need to get off the train – I'm going to do it. So I've gotten pretty bold about protecting myself because I know that there really isn't anybody else that's going to. I'm sort of out there on my own… Another way I protect myself is blocking off the area directly behind my cab. I carry these chains that we can use to block it off. I'll use caution tape if I have to. And I do that to protect myself, at least from that real close contact.*"

Many operators have sought professional mental healthcare services to help them deal with the impacts of repeatedly observing drug use incidents. While some peer-to-peer counselling services exist within transit agencies, operators reported these services to be ineffective and inefficient, noting a lack of adequate staffing.

Call for engineering controls:

Across interviewees, there was a resounding call for engineering controls. Coach operators repeatedly mentioned the need for a physical barrier to protect them from passengers. Per operators, there has been "*talks about putting in a shield*" or "*implementing safety doors.*" Other coach operators described their preference for a completely enclosed operator cabin.

There was also a call for better ventilation controls, primarily among light rail operators, who are already in a completely enclosed operator cabin. One operator described the ventilation in light rail vehicles:

> "*One of the designs of the trains is all the positive air pressure that comes into the car vents itself out through the [operator] cabin. So there are louvers that shut to minimize the amount of air that comes from the cabin, but they don't work on the Japanese trains… With the Japanese trains, you had to literally turn the air conditioning system off which meant the train would get really cold and you'd get complaints.*"

3.4 Discussion

This study is the first to qualitatively characterize transit operators' experiences with passenger drug use and its impacts on operator health and well-being. Operators told us they experience drug use incidents frequently on their vehicles, and these exposures can result in a range of impacts, including physical health symptoms, mental health effects, and emotional impacts. The shared experience of these impacts in our interviewees highlights the need for intervention, not only to promote the occupational health and well-being of this worker group, but also to reduce

turnover due to these impacts and ensure that transit systems can continue to provide effective service to communities.

A novel finding of this study was that operators with seniority are able to select routes and regions with lower perceived risk of exposure, leaving newer operators at disproportionately higher risk of experiencing passenger drug use incidents. Interviewed operators indicated that newer operators are also less likely to advocate for themselves for fear of being fired, potentially contributing to higher rates of turnover among newer transit operators, which was also reported by interviewees. Therefore, newer operators may particularly benefit from targeted supports and interventions to reduce passenger drug use on higher-risk routes. Interviewed operators said that employers do not acknowledge the impact that drug use incidents have on operators, despite their frequent occurrence on transit vehicles in the Pacific Northwest. Operators told us this results in their feeling invalidated and disrespected by their management. Operators said they are less likely to report safety incidents occurring on their vehicle when they do not believe that they will receive timely help. It is possible that this lack of reporting leads to a cyclical issue: as employers receive fewer reports, they intervene less, contributing to increased operator frustration; future research should investigate this potential issue further. Operators told us that lack of support is one reason they feel they must handle incidents on their own, putting their personal safety at risk. Future research should aim to identify evidence-based workplace supports that would most benefit transit operators.

Interviewed operators told us about how they perceive the risk of exposure to secondhand drugs, and our thematic analysis found common outrage factors shared across interviewees. As risk perceptions can impact health, specifically mental health,[17] it is important to intervene on factors contributing to risk perceptions. Outrage over process (how trustworthy and fair employer

decision-making seems to the worker, and whether decisions address worker concerns) can be reduced if management actively aims to address operator safety concerns regarding passenger drug use, and includes operators in decision-making regarding operator safety. Research has shown that promoting employee participation in workplace safety committees and inclusion in the safety process can be effective to improve occupational health and safety.[38] Thematic analysis of interviews also found operators experience outrage over controllability. Facilitating resources that operators can access to protect themselves from exposure (e.g., company-provided PPE, timely responses from supportive security to remove drug users from vehicles) can help operators feel like they have agency to prevent or reduce their exposure.

This study is also the first to assess the acceptability of existing supports provided to transit operators in the context of passenger drug use. While some supports such as increased security exist, operators reported that they still have unfulfilled needs, leading operators to take steps to protect themselves. Within the hierarchy of controls,[31] eliminating a hazard is the most effective method of hazard control and should therefore be prioritized; public health in the United States has also long supported smoke-free workplaces.[39] However, most operators reported using PPE (i.e., respirators) or administrative controls (e.g., security) to protect themselves from exposure to passenger drug use, which are less effective hazard controls per the hierarchy of controls.[31] Engineering controls, such as the enclosed driver cabin or improved ventilation that transit operators identified in these interviews, are considered more effective hazard controls.[31] If passenger drug use on transit vehicles cannot be fully eliminated, then implementing engineering controls, which would need to be properly evaluated for effectiveness and acceptability, could help reduce transit operators' secondhand exposure to passenger drug use. The implementation of such engineering controls could also have impacts on mental health, as research has also

shown that when employers are perceived to be responsive to worker health and safety concerns, workers experience reduced adverse mental health outcomes associated with workplace safety climate.[40] However, engineering controls would not protect passengers, and would not reduce the mental health and emotional impacts associated with witnessing drug use incidents. Further research should investigate the implementation of hazard controls in transit systems, and evaluate which specific methods of control are most effective in reducing operators' exposure to passenger drug use and its impacts.

3.5 Limitations

Qualitative research is inherently prone to subjectivity[41]; it is not possible to separate interpretive work from the researcher doing the work. However, we mitigated our bias by using strategies to improve credibility and transferability.[42] Reflexivity (i.e., acknowledging personal biases)[42] helped us improve the credibility of this work.[43] Additionally, by using multiple coders, we reduced the likelihood that the perspectives of one researcher clouded the experiences of interviewees. Due to its small sample size and unequal representation from the three union locals, the findings of this study may be difficult to generalize to a larger population. In addition, the recent emergence of fentanyl as a commonly misused drug,[44,45] in conjunction with its higher prevalence in Western United States, may mean that the rest of the American population may not have previously experienced these types of issues. Despite these limitations, by using rich, thick descriptions (i.e., detailed descriptions of interviewee experiences),[46] transferability is promoted, as readers are provided with adequate contextual information to consider for themselves how this work may be transferable to other situations or settings.[42,43,46] This work is likely impacted by the healthy worker effect,[47] and therefore may underestimate the severity of experiences of newer transit operators.

3.6 Conclusions

Transit operators are essential in providing transportation to the communities they serve. With passenger drug use on transit putting operators at risk of secondhand exposures, it is important to investigate the impacts of these exposures, and identify unfulfilled needs of operators pertaining to these passenger drug use incidents. Interviewees told us that these incidents result in physical health, mental health, and emotional impacts on transit operators. Furthermore, operators told us they feel unsupported by management and that existing supports are inadequate, and called for the implementation of engineering controls. Understanding these impacts and unfulfilled needs can help inform future research to evaluate interventions that address these concerns and improve the work experience of transit operators, ultimately ensuring that operators can continue providing safe and reliable service to their communities.

Chapter 3 Tables

Table 1: Work characteristics of interviewed transit operators (n=19)

		n (%)
Union Affiliation	Seattle	13 (68.4%)
	Portland	3 (15.8%)
	Lynnwood	3 (15.8%)
Vehicle type	All coaches (40ft and 60ft coaches)	12 (63.2%)
	40ft coach only	2 (10.5%)
	Light rail or streetcar only	2 (10.5%)
	Coaches and light rail/streetcar	3 (15.8%)
Length of employment	<5 years	2 (10.5%)
	5-9 years	8 (42.1%)
	10-14 years	2 (10.5%)
	15-19 years	2 (10.5%)
	>20 years	5 (26.3%)

Table 2: Key themes from interviews of transit operators (n=19), categorized by research objectives

Research objectives	Key themes identified	Interpretation and recommendations
Understand characteristics of job	1. Job satisfaction 2. Transit operators are responsible for the safety and well-being of passengers	Overall, operators are satisfied with their jobs. Many operators feel a sense of responsibility for their passengers and communities.
Characterize transit operators' experiences with passenger drug use incidents	1. Agencies do not care about operators 2. Frequency of observed drug use 3. Seniority protects operators from drug use incidents 4. Varying opinions on the value of reporting	Despite transit operators reporting frequent drug use incidents, they feel unsupported and invalidated by their employers, with some operators feeling that reporting these incidents to management has become ineffective. Promoting operator participation in workplace safety[38] may help increase trust between operators and management. Future research should aim to identify evidence-based interventions that employers can adopt to protect transit operators from these incidents.
Investigate risk perceptions and impacts associated with drug use incidents	1. Perceived severity and susceptibility of drug exposures 2. Controllability, process, and age of victims 3. Physical and mental health impacts 4. Emotional impacts	Transit operators reported being impacted by drug use incidents. Risk perceptions, which can be exacerbated by outrage factors, can impact health[17]. Facilitating resources that operators can access to protect themselves can help operators feel like they have agency to reduce their exposure, which could change risk perceptions and reduce impacts.
Explore existing supports and unfulfilled needs pertaining to drug use incidents on transit	1. Operators take safety into their own hands 2. Call for engineering controls	Despite some existing supports, transit operators have unfulfilled needs. Future research should aim to evaluate potential interventions to reduce the impacts of these drug use incidents on transit operators.

Chapter 3 References

1. Beaudreau M et al. Assessing fentanyl and methamphetamine in air and on surfaces of transit vehicles. Journal of Occupational and Environmental Hygiene. 2025;0(0):1–11. https://doi.org/10.1080/15459624.2024.2444430

2. Goodwillie K. Bus driver workers' compensation claims skyrocket as exposure to drugs increases. king5.com. 2023 Oct 30 [accessed 2025 Jan 4]. https://www.king5.com/article/news/local/bus-driver-workers-compensation-claims-exposure-drugs/281-c4ebac75-706f-4ccd-bdb5-7656c3c97baa

3. Harris J. Seattle bus driver says fentanyl smoke makes him sick; health dept. says it's no real risk. KOMO. 2023 Mar 6 [accessed 2025 Jan 4]. https://komonews.com/news/local/seattle-king-county-metro-bus-drivers-fentanyl-smoke-exposure-drugs-mental-public-health-department-transportation-substance-abuse-treatment-crime-homeless-crisis

4. Alexander DA, Klein S. Ambulance personnel and critical incidents: impact of accident and emergency work on mental health and emotional well-being. The British Journal of Psychiatry: The Journal of Mental Science. 2001;178(1):76–81. https://doi.org/10.1192/bjp.178.1.76

5. Boland LL et al. Burnout and Exposure to Critical Incidents in a Cohort of Emergency Medical Services Workers from Minnesota. The Western Journal of Emergency Medicine. 2018;19(6):987–995. https://doi.org/10.5811/westjem.8.39034

6. Donnelly E. Work-related stress and posttraumatic stress in emergency medical services. Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors. 2012;16(1):76–85. https://doi.org/10.3109/10903127.2011.621044

7. del Pozo B, Rich JD, Carroll JJ. Reports of accidental fentanyl overdose among police in the field: Toward correcting a harmful culture-bound syndrome. International Journal of Drug Policy. 2022;100:103520. https://doi.org/10.1016/j.drugpo.2021.103520

8. Beletsky L et al. Fentanyl panic goes viral: The spread of misinformation about overdose risk from casual contact with fentanyl in mainstream and social media. International Journal of Drug Policy. 2020;86:102951. https://doi.org/10.1016/j.drugpo.2020.102951

9. Attaway PR, Smiley-McDonald HM, Davidson PJ, Kral AH. Perceived occupational risk of fentanyl exposure among law enforcement. International Journal of Drug Policy. 2021;95:103303. https://doi.org/10.1016/j.drugpo.2021.103303

10. Winograd RP et al. Training to reduce emergency responders' perceived overdose risk from contact with fentanyl: early evidence of success. Harm Reduction Journal. 2020;17(1):58. https://doi.org/10.1186/s12954-020-00402-2

11. Taxel S. Fentanyl Facts and Fiction: A Safety Guide for First Responders. JEMS: EMS, Emergency Medical Services - Training, Paramedic, EMT News. 2019 [accessed 2022 Nov 15]. https://www.jems.com/operations/fentanyl-facts-and-fiction-a-safety-guide-for-first-responders/

12. Horcher G. Metro bus driver and local mayor describe increasing concern for riders from fentanyl fumes. KIRO 7 News Seattle. 2022 May 10 [accessed 2022 Nov 15]. https://www.kiro7.com/news/local/metro-bus-driver-local-mayor-describe-increasing-concern-riders-fentanyl-fumes/VPJL4GJG75HHFICZHGSS3VMO3E/

13. Tse JLM, Flin R, Mearns K. Bus driver well-being review: 50 years of research. Transportation Research Part F: Traffic Psychology and Behaviour. 2006;9(2):89–114. https://doi.org/10.1016/j.trf.2005.10.002

14. Slovic P. Perception of Risk. Science. 1987;236(4799):280–285. https://doi.org/10.1126/science.3563507

15. Nielsen MB, Mearns K, Matthiesen SB, Eid J. Using the Job Demands-Resources model to investigate risk perception, safety climate and job satisfaction in safety critical organizations. Scandinavian Journal of Psychology. 2011;52(5):465–475. https://doi.org/10.1111/j.1467-9450.2011.00885.x

16. Shan B, Liu X, Gu A, Zhao R. The Effect of Occupational Health Risk Perception on Job Satisfaction. International Journal of Environmental Research and Public Health. 2022;19(4):2111. https://doi.org/10.3390/ijerph19042111

17. Laraqui O et al. Occupational risk perception, stressors and stress of fishermen. International Maritime Health. 2018;69(4):233–242. https://doi.org/10.5603/IMH.2018.0038

18. Northwest Center for Public Health Practice. What Increases Outrage? | Introduction | Emergency Risk Communication. 2024 [accessed 2024 May 2]. https://www.nwcphp.org/docs/perrcolate/erc/section1/outrage.html

19. Varela-Mato V et al. Time spent sitting during and outside working hours in bus drivers: A pilot study. Preventive Medicine Reports. 2016;3:36–39. https://doi.org/10.1016/j.pmedr.2015.11.011

20. Lewis CA, Johnson PW. Whole-body vibration exposure in metropolitan bus drivers. Occupational Medicine (Oxford, England). 2012;62(7):519–524. https://doi.org/10.1093/occmed/kqs096

21. Carrère S, Evans GW, Palsane MN, Rivas M. Job strain and occupational stress among urban public transit operators. Journal of Occupational Psychology. 1991;64(4):305–316. https://doi.org/10.1111/j.2044-8325.1991.tb00562.x

22. Bowles NP, McEwen BS, Boutin-Foster C. Trouble in transit: Organizational barriers to workers' health. American Journal of Industrial Medicine. 2017;60(4):350–367. https://doi.org/10.1002/ajim.22701

23. Chung Y-S, Wu H-L. Stress, strain, and health outcomes of occupational drivers: An application of the effort reward imbalance model on Taiwanese public transport drivers. Transportation Research Part F: Traffic Psychology and Behaviour. 2013;19:97–107. https://doi.org/10.1016/j.trf.2013.03.002

24. Ferguson S et al. Australian bus drivers' perspectives of passenger hostility: A qualitative study. Journal of Workplace Behavioral Health. 2022;37(3):169–188. https://doi.org/10.1080/15555240.2022.2080687

25. Couto MT, Lawoko S. Burnout, workplace violence and social support among drivers and conductors in the road passenger transport sector in Maputo City, Mozambique. Journal of Occupational Health. 2011;53(3):214–221. https://doi.org/10.1539/joh.l10102

26. Useche SA, Gómez V, Cendales B, Alonso F. Working Conditions, Job Strain, and Traffic Safety among Three Groups of Public Transport Drivers. Safety and Health at Work. 2018;9(4):454–461. https://doi.org/10.1016/j.shaw.2018.01.003

27. Federal Transit Administration. General Directive 24-1: Required Actions Regarding Assaults on Transit Workers. Federal Register. 2024 Sep 25 [accessed 2025 Jan 22]. https://www.federalregister.gov/documents/2024/09/25/2024-21923/general-directive-24-1-required-actions-regarding-assaults-on-transit-workers

28. Federal Transit Administration. Responses to General Directive 24-1: Required Actions Regarding Assaults on Transit Workers. 2025 Jan 16 [accessed 2025 Jan 22]. https://www.transit.dot.gov/regulations-and-programs/safety/responses-general-directive-24-1-required-actions-regarding

29. CDC. Hierarchy of Controls. Total Worker Health. 2024 Jun 26 [accessed 2025 Jan 22]. https://www.cdc.gov/niosh/twh/php/hierarchy/index.html

30. ATU. Our Work. Amalgamated Transit Union. [accessed 2023 Mar 14]. https://www.atu.org/union/our-work

31. National Institute for Occupational Safety and Health. Hierarchy of Controls. 2022 Apr 28 [accessed 2024 Dec 17]. https://www.cdc.gov/niosh/learning/safetyculturehc/module-3/2.html

32. Parker C, Scott S, Geddes A. Snowball Sampling. SAGE Research Methods Foundations. 2019 Sep 9 [accessed 2025 Mar 3]. http://methods.sagepub.com/foundations/snowball-sampling

33. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3(2):77–101. https://doi.org/10.1191/1478088706qp063oa

34. Morse JM, Mitcham C. Exploring Qualitatively-derived Concepts: Inductive—Deductive Pitfalls. International Journal of Qualitative Methods: ARCHIVE. 2002;1(4):28–35.

35. Guest G, MacQueen K, Namey E. Applied Thematic Analysis. SAGE Publications, Inc.; 2012. https://methods.sagepub.com/book/applied-thematic-analysis. https://doi.org/10.4135/9781483384436

36. Chinh B, Zade H, Ganji A, Aragon C. Ways of Qualitative Coding: A Case Study of Four Strategies for Resolving Disagreements. In: Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery; 2019. p 1–6.

(CHI EA '19). https://dl.acm.org/doi/10.1145/3290607.3312879. https://doi.org/10.1145/3290607.3312879

37. Dedoose Version 9.0.17, cloud application for managing, analyzing, and presenting qualitative and mixed method research data. 2021. http://dedoose.com/

38. O'Toole MF. Successful Safety Committees: Participation Not Legislation. Journal of Safety Research. 1999;30(1):39–65. https://doi.org/10.1016/S0022-4375(98)00061-9

39. CDC. Tobacco use in the workplace. Substance use and work. Substance Use and Work. 2025 Jan 30 [accessed 2025 May 22]. https://www.cdc.gov/niosh/substance-use/tobacco/index.html

40. Hurtado DA et al. Safety Responsiveness and Psychological Distress Among Health Care Workers During COVID-19 (2020–2022) in the Pacific Northwest. American Journal of Public Health. 2024;114(Suppl 2):204–212. https://doi.org/10.2105/AJPH.2024.307582

41. Glesne C. Becoming Qualitative Researchers: An Introduction, 5th Edition. Pearson; 2016.

42. Ahmed SK. The pillars of trustworthiness in qualitative research. Journal of Medicine, Surgery, and Public Health. 2024;2:100051. https://doi.org/10.1016/j.glmedi.2024.100051

43. Merriam SB. Qualitative Research: A Guide to Design and Implementation. John Wiley & Sons; 2009.

44. Addiction, Drugs, and Alcohol Institute. Washington state drug trends. 2023 [accessed 2022 Nov 15]. https://adai.washington.edu/wadata/stateMOP_cases.htm

45. CDC. SUDORS Dashboard: Fatal Drug Overdose Data. Overdose Prevention. 2024 Feb 26 [accessed 2024 Aug 23]. https://www.cdc.gov/overdose-prevention/data-research/facts-stats/sudors-dashboard-fatal-overdose-data.html

46. Geertz C. The Interpretation Of Cultures. Basic Books; 1973.

47. Eisen EA, Picciotto S, Robins JM. Healthy Worker Effect Based in part on the article "Healthy worker effect" by Ellen A. Eisen and James M. Robins, which appeared in the Encyclopedia of Environmetrics. In: Encyclopedia of Environmetrics. American Cancer Society; 2013. https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470057339.vah007.pub2. https://doi.org/10.1002/9780470057339.vah007.pub2

Chapter 4: Weather-related trends in drug use incidents aboard transit vehicles

4.1 Introduction

Over the past decade, trends in drug misuse in the United States have changed, including increasing prominence of fentanyl misuse in the Pacific Northwest.[1–4] In Washington State, this drug use often occurs in public indoor spaces, such as public transit vehicles.[5] Reports from transit operators and data from transit agencies have indicated that these drug use incidents occur regularly on public transit vehicles.[5,6] Previous research has shown that drug use on transit vehicles creates potential for transit operators and the riding public to experience secondhand exposures to these drugs.[7] It is therefore necessary to understand and intervene on factors that contribute to drug use aboard transit vehicles.

Research has shown that drug use in the United States tends to be more prevalent during periods of warmer temperatures.[8] Data from the Washington State Department of Health has indicated that from 2019 to 2023, drug-related emergency department visits and emergency medical services responses peaked during the second and third quarters of the year, aligning with the warmer months of the year.[9] These trends may be due to increased access to drugs and a higher rate of drug use initiation during summer.[10]

Despite these trends, transit operators have indicated concern that people who use drugs (PWUD) seek transit vehicles as shelter to escape from inclement weather,[5] which could result in higher rates of drug use incidents on transit vehicles in periods of poorer weather conditions. While research has yet to investigate if there is a relationship between inclement weather and drug use incident frequency on transit vehicles, it is well-documented that unhoused populations

are simultaneously more likely to seek shelter in colder weather[11] and disproportionately impacted by substance misuse.[12–14] Without access to safe consumption sites,[15] it is possible that PWUD will use on transit vehicles during periods of low temperatures, high precipitation, or high wind speeds. It is also possible that in winter months with less daylight, transit vehicles provide a well-lit environment to facilitate drug consumption.

While ridership on transit vehicles experienced a sharp decline between 2020 and 2022 due to the COVID-19 pandemic, these rates have been increasing since 2022 and have been restored to pre-pandemic rates.[16,17] As drug misuse has also increased during this time, examining trends in drug use incidents on transit vehicles in 2022 can be an effective starting point in informing policy interventions to protect transit operators and public health. To date, there is no research characterizing temporal and weather-related factors that contribute to the frequency of drug use incidents on transit vehicles. This information can help guide targeted interventions to protect operators and the riding public on higher risk routes during peak times for drug use on transit.

This study characterizes the frequency of drug use incidents on public transit vehicles in King County, Washington (USA) in 2022, and investigates temporal and weather factors that may be associated with the frequency of drug use incidents, such as daylight hours, temperature, precipitation, and wind speed. We hypothesized that on days with fewer daylight hours (i.e. winter months rather than summer months), drug use is more likely to occur on transit vehicles, as vehicles provide a well-lit environment to facilitate drug consumption. Furthermore, we hypothesized that PWUD are more likely to use drugs on transit vehicles during poorer weather conditions (lower temperatures, higher wind speeds, and more precipitation). To date, no research has investigated how weather and daylight conditions relate to drug use incident frequencies, and the results of this study can guide the timely interventions that reduce the

occurrence of drug use on transit vehicles, therefore protecting operators and the riding public from secondhand exposures.

4.2 Methods

Dataset:

This study used a dataset of drug use incidents reported by transit operators in King County, Washington in 2022 (n=1,518), which includes details about each incident (date, vehicle type, security incident type, incident time, and a free-text description of the security incident). This dataset was provided to researchers by a transit company in King County, Washington.

We used this dataset to tabulate the daily frequency of incidents from January 1 to December 31, 2022. Using publicly available weather data,[18] we identified the temperature (daily maximum and daily minimum), precipitation (quantity of rain/melted snow/snow/ice/hail), and average wind speed on each day in 2022 in King County, taken from one weather station at Boeing Field in central King County. Average daily temperature was calculated as the mean of the daily maximum and daily minimum temperature. We also collected daylight hours data for 2022 from the National Centers for Environmental Information.[19] These variables were selected to test the hypothesis that low temperatures, high precipitation, high wind speeds, and a lack of daylight outdoors are associated with higher rates of drug use incidents on transit vehicles. The final dataset for analysis consisted of date, number of incidents, temperature values, quantities for precipitation, wind speed, and daylight hours; these variables are summarized in Table 1.

Analysis:

All data analysis was conducted using R statistical software.[20] Data were first analyzed descriptively. We geographically mapped data using the incident coordinates provided in the

dataset and visually inspected the map for overall trends in incident occurrence. We visually depicted the trends in daily frequency of reported incidents by plotting the number of incidents reported each day. We developed summary tables, including total counts, means, standard deviations, and ranges for the number of reported incidents per day, and trends in daily weather and daylight conditions.

We developed scatterplots with smooth locally estimated scatterplot smoothing (LOESS) lines to visually examine the relationship between the frequency of incidents per day and a) average daily temperature, b) precipitation, c) wind speed, and d) daylight hours. This also helped check for linearity, to determine if data transformations (such as log-transformations) were needed. Weather variables were compared to each other using Pearson's correlation coefficients to determine if any were highly correlated.

We ran Poisson regression models for the daily count of reported drug use incidents in 2022. First, we conducted bivariate models for each weather variable (average daily temperature, wind speed, precipitation, and daylight hours). Then, we developed a full model, in which we included average daily temperature, wind speed, precipitation, and daylight hours as covariates. In all models, we controlled for the day of week to account for variability in transit service hours on weekends, using the weekday with the most incidents as the reference group. The average weekday ridership for each month, collected from publicly available data published by the transit agency,[17] was included as a log-transformed offset term in all models, thereby accounting for potential differences in ridership count in different months. Offset terms are not estimated by the model, but rather standardize the incident count data across differing ridership numbers [21,22]. Variance inflation factors (VIFs) were calculated to check for multicollinearity; any variables with VIF>5 were excluded from the model. Coefficients from the regression model were

exponentiated to calculate incidence rate ratios (IRR), which reflects the change in incident counts per day associated with a one-unit increase in the predictor of interest.

4.3 Results

From January 1 to December 31, 2022, 1,518 drug misuse incidents were reported (mean daily incident count = 4.2 incidents/day). Figure 1 depicts a map of all reported incidents in the dataset that contained geographical coordinates data (n=1,504). One coach route, between Tukwila and Federal Way, had disproportionately more incidents, accounting for 31.8% of all reports in 2022 (483 incidents); however, two other routes in South King County and one route in North King County also had over 50 incidents each.

Figure 2 shows a time-series plot of daily reported incident counts, and Table 2 summarizes reported incident counts by month. The highest number of incidents was reported in April (n=219), with an average daily count of 7.3 incidents. The lowest number of incidents was reported in December (n=40), with an average daily count of 1.3 incidents. Table 3 summarizes weather and daylight conditions by month. Daylight and temperature values were highest in summer months and lowest in winter months, while wind was highest in winter and spring and precipitation was highest in winter.

Scatterplots of daily incident counts versus weather and daylight conditions, with smooth LOESS curves and the 95% confidence intervals, are shown in Figure 3; these plots also include a linear model for comparison. Temperature had a slightly negative relationship with incident count such that there were fewer incidents with increasing temperatures, while wind speed had a slightly positive relationship with incident count. These scatterplots show that, for the most part, the linearity assumption is met, suggesting that no transformations were needed.

Correlation coefficients showed a strong correlation between temperature and daylight (r=0.71), and a moderate correlation between wind speed and precipitation (r=0.31); all other variables showed weak correlation.

Table 4 shows results from our bivariate Poisson regression models. Higher temperature was significantly associated with lower incident count, such that a 1 degree Fahrenheit increase in temperature was associated with a 2% decrease in the expected reported drug use incident count (IRR: 0.98; 95% CI: 0.98, 0.99). Wind speed was significantly associated with higher incident counts, such that a 1 mph increase in wind speed was associated with a 25% increase in the expected reported drug use incident count (IRR: 1.25; 95% CI: 1.05, 1.47). Table 5 shows results from our full Poisson regression model. Accounting for other covariates, higher temperature remained significantly associated with lower incident count (IRR: 0.96; 95% CI: 0.95, 0.97); however, wind speed was no longer significantly associated with incident count (IRR: 1.02; 95% CI: 1.00, 1.04), indicating that the variance attributed to wind speed in the bivariate model was explained by the other weather variables. In the full model, number of daylight hours was significantly associated with higher incident counts, such that a 1 hour increase in daylight hours was associated with a 14% increase in the expected reported drug use incident count (IRR: 1.14; 95% CI: 1.11, 1.17). All variables in the model had VIF<5, suggesting no concern for multicollinearity.

4.4 Discussion

One coach route accounted for nearly a third of all reported drug use incidents. While this specific route and its characteristics are unique to King County, WA, the existence of drug use hotspots is common in other major cities in the United States.[23] Therefore, it is likely that other

cities exhibit similar patterns in drug use on transit, where specific routes experience disproportionately higher rates of drug use.

Reported drug use incidents in 2022 in King County demonstrate clear temporal trends, with April being the peak month for reports to be filed. While December had the lowest counts, it is possible that this is due to underreporting during the holiday season. Aside from this deviation in December, we observed clear trends with the highest incident counts in spring, and the lowest counts in late summer, suggesting potential seasonal trends in reporting drug use. In our regression model, we found that daylight hours were significantly positively associated with drug use incident counts. While this aligns with the temporal trends, it contrasts our hypothesis, as we expected that on darker days, PWUD would be more likely to use drugs in well-lit areas like transit vehicles, which would be reflected through increased reports on those days. It is unclear whether increased daylight hours are a cause of increased incident counts, or if another unmeasured variable (such as increased drug availability in summer[10]) is the reason for the association between daylight and incident counts.

Consistent with transit operator reports, we found that the number of reported drug use incidents were related to weather conditions. Scatterplots of incident counts against weather conditions showed that wind speed had a positive relationship with incident counts, supporting our hypothesis that, as outdoor windspeeds increase, it would be more difficult to smoke drugs, driving PWUD indoors and onto transit. Temperature was negatively related with incident counts, which supports our hypothesis that, as the outdoor temperature is colder, PWUD prefer to use drugs in indoor spaces such as transit vehicles, which are warmer. While warmer spring months showed a peak in the raw count of reported drug use incidents, when accounting for ridership, our regression model showed that the IRR of drug use incidents on board transit is

higher in colder months when all other weather covariates were controlled for. In our regression model, we found that temperature had a significant association with incident counts, where a 1 degree Fahrenheit increase in temperature corresponded to a 4% decrease in the expected drug use incident count for the same amount of ridership. In July 2022, which had the highest daily temperature in 2022, comparing the hottest day in the month (average temperature of 80.0°F) to the coldest day in the month (average temperature of 56.0°F), we could expect up to 96% higher reported drug use incident counts on colder days than warmer days in the same month, if all other weather conditions remain unchanged. This highlights the need to focus interventions on colder days, as these are the days where there is the highest risk of drug use incidents on transit vehicles, assuming the reporting is an appropriate proxy measure for actual use.

Research conducted by the U.S. Federal Transit Administration (FTA) found that 68% of urban transit systems were in need of interventions to reduce safety risks towards workers[24]; while this study was focused on general safety, many of its findings remain applicable to passenger drug misuse incidents. Across transit agencies in the United States, the most prevalent interventions were focused on increased education, awareness, and surveillance.[24] While these interventions may be impactful, they do not explicitly eliminate the hazard itself in the context of passenger drug misuse incidents, which per the hierarchy of controls is the most effective method to promote a hazard-free workplace.[25] The FTA report identified other interventions that have lower rates of implementation, such as protective barriers for the operator area or improved security patrolling to remove passengers that pose a risk[24]; these interventions do reduce the likelihood of exposure to the hazard from the workplace, and when implemented, exhibit high rates of effectiveness.[24] These interventions can also protect the riding public from secondhand exposures, and create a safer transit environment overall.

Transit operators are not equipped to handle drug use incidents on board their vehicle; however, it remains important that interventions to protect operators and the riding public are implemented without further stigmatizing PWUD. While it is not possible to intervene on the weather, it is possible to intervene on the need for PWUD to escape inclement weather. Per the hierarchy of controls,[26] eliminating a hazard is the most effective control; this means removing drug use from transit vehicles. Therefore, on days with low temperatures and inclement weather, proactive efforts to redirect PWUD to other forms of shelter can reduce the likelihood of drug use incidents on transit. However, research has shown that arresting PWUD is not an effective solution, as these traditional policing methods are associated with higher risks of future overdoses.[27] Instead, providing access to programs that move PWUD to treatment pathways rather than incarceration have been shown to have greater effectiveness in decreasing future drug use.[28]

PWUD who are unhoused in King County, WA ,currently have limited recourse to seek shelter. Safe consumption sites may provide alternatives for PWUD who seek shelter, while also offering medical professionals and resources for those who use drugs.[29] Despite social stigma and governmental pushback over the implementation of safe consumption sites,[29] these sites have been shown to reduce mortality risks and reduce harm to PWUD.[30–32] Similarly, promoting shelters for the unhoused that adopt harm reduction strategies can be useful for PWUD who want to escape inclement weather. Housing First initiatives, which aim to provide shelter to unhoused populations without any conditions regarding substance misuse, have been shown to be successful in reducing rates of homelessness, while not increasing rates of substance misuse.[33] While there are no safe consumption sites and few harm reduction shelters in King County, the promotion and development of such sites may be highly impactful in reducing the frequency of drug use on transit vehicles. Such interventions can not only improve the well-being of transit

operators and the safety of passengers, but can also reduce drug overdoses in the community by providing access to medical care for PWUD,[30–32] aligning with public health goals in King County, Washington State, and the United States.[34,35]

This work provides a starting point for research that investigates the relationship between weather and drug use on transit. The clear temporal trends can inform transit operators and their employers on when to deploy interventions such as increased personal protective equipment or increased security. Furthermore, as temperature had a clear relationship with incident counts, efforts to reduce drug use on transit can be focused more on days with lower temperatures. In sum, the results here provide another tool to guide policy and interventions that reduce drug use on transit and protect both transit operators and the riding public.

4.5 Limitations

This study has some limitations. As this study only uses data from King County, WA, the findings of this study may not be generalizable to transit systems in different regions, where trends in drug misuse on transit vehicles and its relationship to weather may vary. While we had access to a number of weather-related variables, all weather data was taken from one weather station in King County, as other weather stations did not have complete sets of data. Given that weather trends can vary in different regions of King County, this may have impacted our ability to develop a more accurate regression model. Our analysis also does not consider weather and daylight at the specific time of the incident; given that weather can change during the day, it is possible that these drug misuse incidents occur on transit during moments of inclement weather (e.g. brief rain) or in the evening (when there is less daylight and colder), even if the average daily values reflect a lack of inclement weather.

Furthermore, our initial dataset was likely affected by underreporting, as there is no way to ensure that transit operators notice or report incidents. Operators on busier routes may have greater difficulty spotting drug use incidents, and those on routes where drug misuse is prevalent might opt to not report every incident. This study also does not consider variables other than weather and daylight that may the frequency of drug misuse on transit vehicles. These factors likely impacted the estimates from our regression model.

4.6 Conclusions

This study is the first to describe drug use incident trends on transit vehicles in King County, and investigate the relationship between weather and daylight conditions and incident counts. Our study found temporal trends in drug use incident frequency, and that temperature is likely related to drug use incident counts, supporting our hypothesis that lower outdoor temperatures are associated with greater drug use on transit vehicles. The findings here provide direction for transit operators and transit agencies on when and where to focus interventions that reduce drug use incidents (e.g. increasing security) and reduce operator and public exposure to secondhand drug use (e.g. using personal protective equipment).

Chapter 4 Tables and Figures

Table 1: Summary of variables included in analysis

Variable	Calculation (if applicable)	Source
Daily count of drug use incidents	Count per day	Dataset of drug incidents
Latitude and longitude of incident	Provided from source	Dataset of drug incidents
Time and date of incident	Provided from source	Dataset of drug incidents
Average daily temperature (F)	Mean of daily maximum and daily minimum temperature	[18]
Precipitation (in)	Provided from source	[18]
Average wind speed (mph)	Provided from source	[18]
Daylight hours (h)	Provided from source	[19]
Average weekday ridership every month	Provided from source	[17]

Table 2: Distribution of drug incident counts by month in King County (n=1,518)

Month	N	Lowest daily count	Highest daily count	Mean daily count	SD	Average Weekday Ridership
January	138	1	10	4.5	2.4	225,823
February	184	1	15	6.6	3.5	224,220
March	174	1	11	5.6	2.4	269,788
April	219	2	20	7.3	3.8	285,295
May	188	1	15	6.1	3.2	297,991
June	132	0	10	4.4	2.6	300,354
July	76	0	6	2.5	1.8	304,012
August	63	0	6	2	1.6	302,169
September	89	0	9	3	2.7	319,372
October	104	0	11	3.4	2.6	333,731
November	101	0	9	3.4	2.3	312,201
December	40	0	6	1.3	2	269,780

Table 3: Weather and daylight by month in King County in 2022

Month	Avg. Daily Temp (F)	Daily Precipitation (inches)	Avg. Wind Speed (mph)	Daylight (h)
	Range **Mean (SD)**	**Range** **Mean (SD)**	**Range** **Mean (SD)**	**Range** **Mean (SD)**
January	25.0 – 49.5 41.0 (5.0)	0 – 1.3 0.1 (0.3)	0 – 12.3 4.4 (2.9)	8.5 – 9.5 9.0 (0.3)
February	30.0 – 51.5 42.5 (5.2)	0 – 1.4 0.1 (0.3)	2.0 – 10.1 5.1 (2.4)	9.6 – 11.0 10.3 (0.4)
March	37.0 – 57.0 47.4 (4.4)	0 – 0.4 0.1 (0.1)	1.1 – 9.6 4.8 (2.1)	11.1 – 12.8 11.9 (0.5)
April	40.5 – 59.5 47.7 (4.5)	0 – 0.4 0.1 (0.1)	2.9 – 14.5 6.5 (2.8)	12.9 – 14.4 13.7 (0.5)
May	46.0 – 60.5 53.2 (3.9)	0 – 0.5 0.1 (0.1)	1.8 – 12.1 5.2 (2.4)	14.5 – 15.7 15.2 (0.4)
June	54.5 – 75.5 61.7 (5.1)	0 – 0.9 0.1 (0.2)	2.0 – 9.4 4.6 (1.8)	15.7 – 16.0 15.9 (0.1)
July	56.0 – 80.0 68.9 (5.9)	0	2.9 – 7.6 4.3 (1.1)	15.0 – 15.9 15.5 (0.3)
August	63.0 – 79.5 69.9 (4.0)	0	2.7 – 8.5 4.6 (1.4)	13.4 – 14.9 14.2 (0.5)
September	59.0 – 71.0 64.8 (2.9)	0	1.8 – 10.5 4.2 (1.8)	11.7 – 13.3 12.5 (0.5)
October	47.0 – 66.0	0 – 0.6	1.1 – 12.3	10.0 – 11.7

	57.0 (5.9)	0.1 (0.1)	4.3 (2.9)	10.8 (0.5)
November	33.5 – 50.5	0 – 1.0	0.7 – 12.5	8.8 – 10.0
	41.2 (3.4)	0.2 (0.3)	4.2 (2.9)	9.3 (0.4)
December	20.5 – 51.0	0 – 1.0	0.4 – 12.1	8.4 – 8.7
	38.8 (6.9)	0.2 (0.2)	4.9 (3.2)	8.5 (0.1)

Table 4: Bivariate Poisson regression models for drug use incident count (n=365 days)

Predictors	**IRR**	**95% CI**
Average daily temperature (F)	**0.98**	**0.98, 0.99**
Precipitation (inches)	1.23	0.95, 1.56
Average wind speed (mph)	**1.25**	**1.05, 1.47**
Hours of daylight	1.01	0.99, 1.03

Bold indicates $p<0.05$.

Table 5: Full Poisson regression model for drug use incident count (n=365 days)

Predictors	**IRR**	**95% CI**
Average daily temperature (F)	**0.96**	**0.95, 0.97**
Precipitation (inches)	1.01	0.76, 1.33
Average wind speed (mph)	1.02	1.00, 1.04
Hours of daylight	**1.14**	**1.11, 1.17**
Day of week (REF: Friday)		
Monday	0.96	0.80, 1.15
Tuesday	0.98	0.81, 1.17
Wednesday	0.84	0.69, 1.01
Thursday	0.89	0.74, 1.08
Saturday	0.91	0.75, 1.10
Sunday	1.01	0.84, 1.22

Bold indicates $p<0.05$.

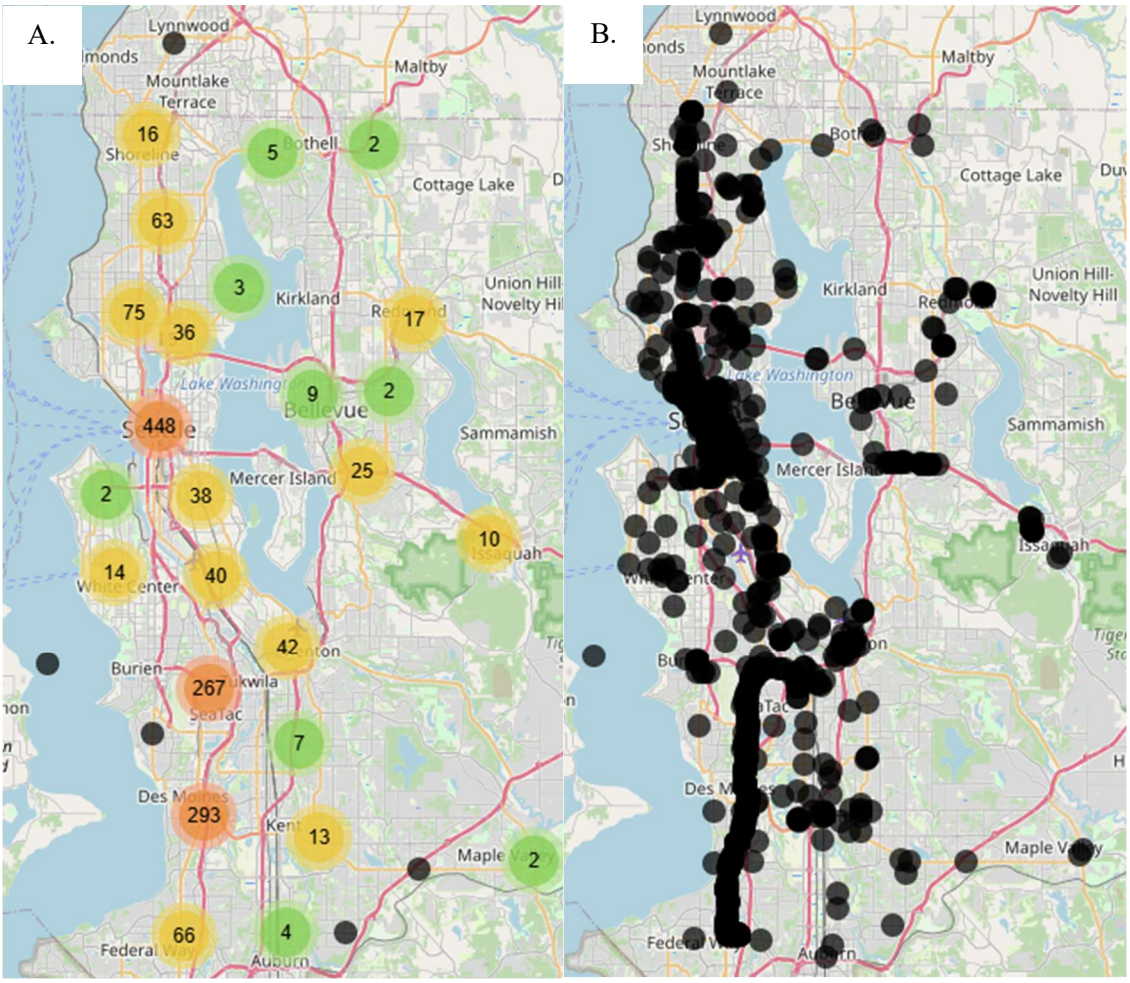

Figure 1: Map of drug use incidents in King County, WA (n=1,504). Panel A shows incidents clustered by location; B shows every incident as an independent data point

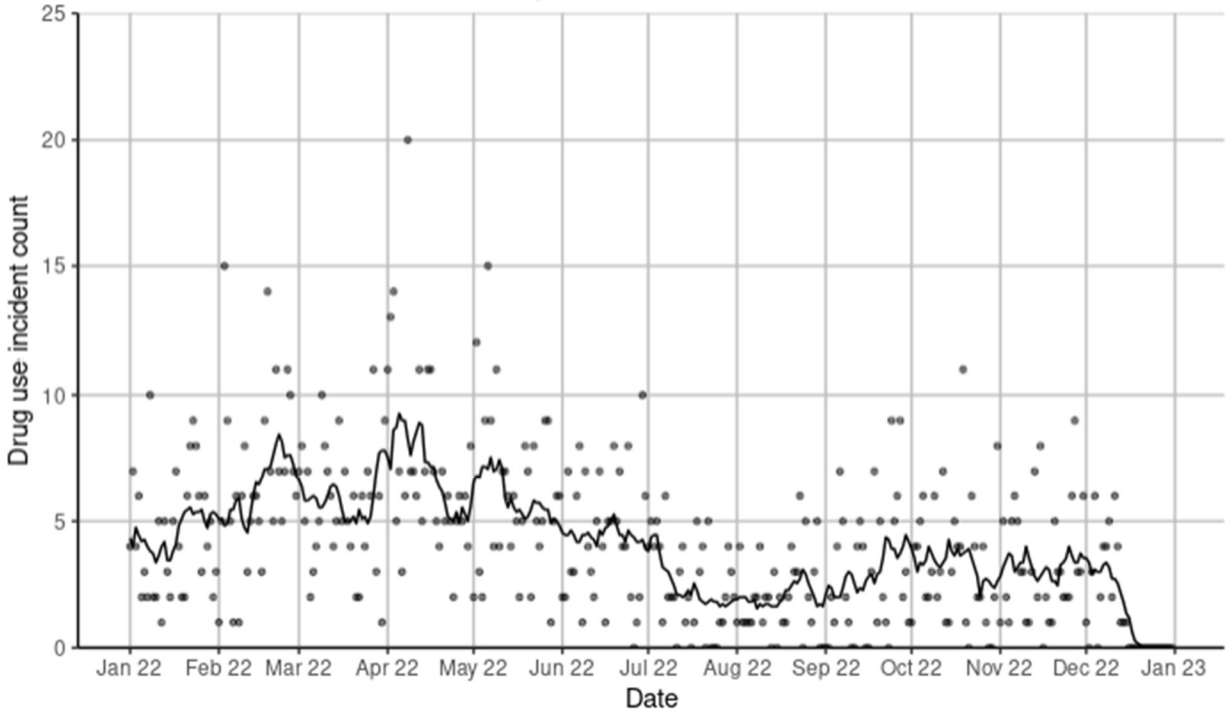

Figure 2: Time-series plot of daily reported drug incident counts in King County in 2022 (n=1,518)

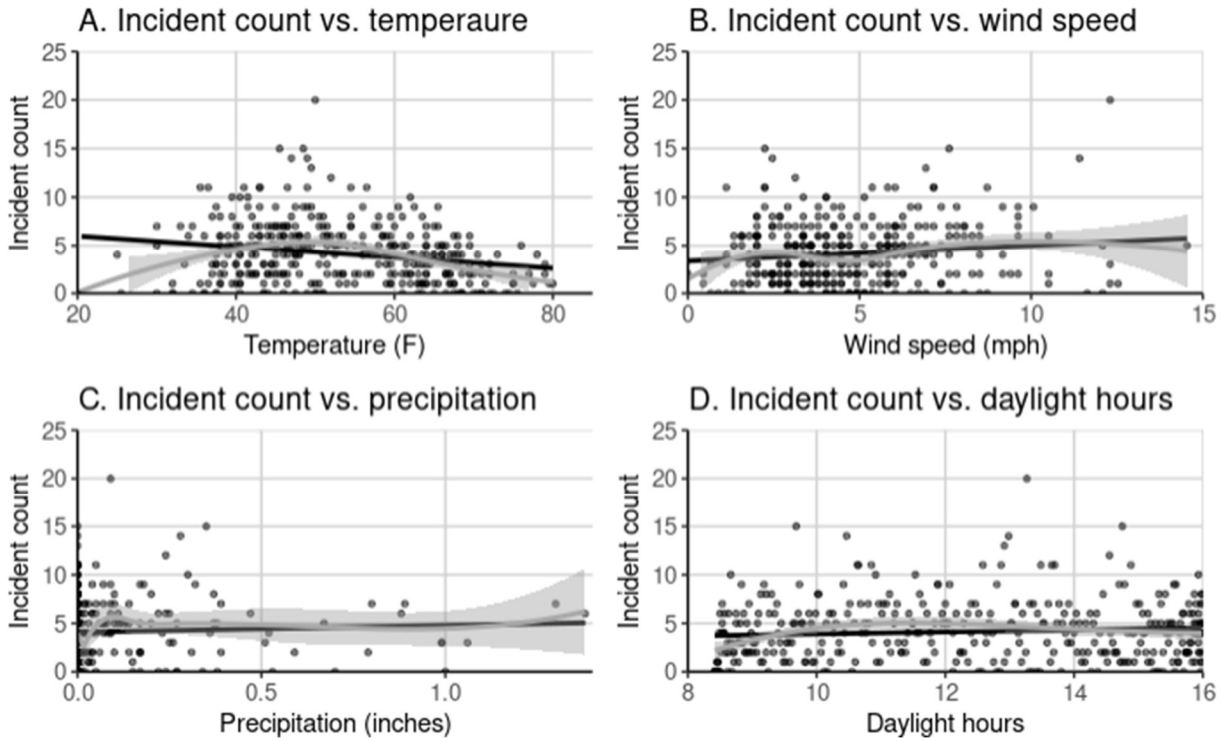

Figure 3: Scatterplots with smooth LOESS curves of daily incident counts vs. weather and daylight conditions in King County in 2022. Shaded region represents 95% confidence intervals. Gray line represents the smooth LOESS curve, while black line represents a linear model for comparison

Chapter 4 References

1. Addiction, Drugs, and Alcohol Institute. Washington state drug trends. 2023 [accessed 2022 Nov 15]. https://adai.washington.edu/wadata/stateMOP_cases.htm

2. Oregon Health Authority. Fentanyl Facts : Opioid Overdose and Misuse. 2024 [accessed 2023 Sep 12]. https://www.oregon.gov/oha/ph/preventionwellness/substanceuse/opioids/pages/fentanylfacts.aspx

3. National Institute on Drug Abuse. Drug Overdose Death Rates | National Institute on Drug Abuse (NIDA). 2024 May 14 [accessed 2024 Jul 18]. https://nida.nih.gov/research-topics/trends-statistics/overdose-death-rates

4. CDC. SUDORS Dashboard: Fatal Drug Overdose Data. Overdose Prevention. 2024 Feb 26 [accessed 2024 Aug 23]. https://www.cdc.gov/overdose-prevention/data-research/facts-stats/sudors-dashboard-fatal-overdose-data.html

5. Horcher G. Metro bus driver and local mayor describe increasing concern for riders from fentanyl fumes. KIRO 7 News Seattle. 2022 May 10 [accessed 2022 Nov 15]. https://www.kiro7.com/news/local/metro-bus-driver-local-mayor-describe-increasing-concern-riders-fentanyl-fumes/VPJL4GJG75HHFICZHGSS3VMO3E/

6. Harris J. Seattle bus driver says fentanyl smoke makes him sick; health dept. says it's no real risk. KOMO. 2023 Mar 6 [accessed 2025 Jan 4]. https://komonews.com/news/local/seattle-king-county-metro-bus-drivers-fentanyl-smoke-exposure-drugs-mental-public-health-department-transportation-substance-abuse-treatment-crime-homeless-crisis

7. Beaudreau M et al. Assessing fentanyl and methamphetamine in air and on surfaces of transit vehicles. Journal of Occupational and Environmental Hygiene. 2025;0(0):1–11. https://doi.org/10.1080/15459624.2024.2444430

8. Chang HH et al. Associations between short-term ambient temperature exposure and emergency department visits for amphetamine, cocaine, and opioid use in California from 2005 to 2019. Environment international. 2023;181:108233. https://doi.org/10.1016/j.envint.2023.108233

9. Washington State Department of Health. Opioid and Drug Use Data. 2025 Jan 6 [accessed 2025 Feb 1]. https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn/opioids/overdose-dashboard

10. Palamar JJ, Rutherford C, Keyes KM. Summer as a Risk Factor for Drug Initiation. Journal of General Internal Medicine. 2020;35(3):947–949. https://doi.org/10.1007/s11606-019-05176-3

11. Corinth K, Lucas DS. When warm and cold don't mix: The implications of climate for the determinants of homelessness. Journal of Housing Economics. 2018;41:45–56. https://doi.org/10.1016/j.jhe.2018.01.001

12. Miler JA et al. What treatment and services are effective for people who are homeless and use drugs? A systematic 'review of reviews.' PLOS ONE. 2021;16(7):e0254729. https://doi.org/10.1371/journal.pone.0254729

13. Fazel S, Geddes JR, Kushel M. The health of homeless people in high-income countries: descriptive epidemiology, health consequences, and clinical and policy recommendations. The Lancet. 2014;384(9953):1529–1540. https://doi.org/10.1016/S0140-6736(14)61132-6

14. Linton SL, Celentano DD, Kirk GD, Mehta SH. The longitudinal association between homelessness, injection drug use, and injection-related risk behavior among persons with a history of injection drug use in Baltimore, MD. Drug and alcohol dependence. 2013;132(3):457–465. https://doi.org/10.1016/j.drugalcdep.2013.03.009

15. Strike C, Watson TM. Losing the uphill battle? Emergent harm reduction interventions and barriers during the opioid overdose crisis in Canada. The International Journal on Drug Policy. 2019;71:178–182. https://doi.org/10.1016/j.drugpo.2019.02.005

16. Doyle T. Public Transportation Ridership Rises to More than 70 Percent of Pre-Pandemic Levels. American Public Transportation Association. 2022 [accessed 2023 Sep 12]. https://www.apta.com/news-publications/press-releases/releases/public-transportation-ridership-rises-to-more-than-70-percent-of-pre-pandemic-levels/

17. King County Metro. The Dash. 2025 [accessed 2025 Apr 13]. https://app.powerbigov.us/view?r=eyJrIjoiZDMwMWExOTMtOTY3ZC00MTU5LTgxMDgtODM4MTZiYTExMzJkIiwidCI6ImJhZTUwNTlhLTc2ZjAtNDlkNy05OTk2LTcyZGZlOTVkNjljNyJ9

18. National Oceanic and Atmospheric Administration. Past Weather by Zip Code - Data Table. 2025 [accessed 2025 Mar 11]. https://www.climate.gov/maps-data/dataset/past-weather-zip-code-data-table

19. National Centers for Environmental Information. Climate Data Online (CDO). 2025 [accessed 2025 Mar 11]. https://www.ncei.noaa.gov/cdo-web/

20. R Core Team. R: A Language and Environment for Statistical Computing. 2025. https://www.R-project.org

21. Frost G et al. Occupational exposure to asbestos and mortality among asbestos removal workers: a Poisson regression analysis. British Journal of Cancer. 2008;99(5):822–829. https://doi.org/10.1038/sj.bjc.6604564

22. Armstrong BG, Gasparrini A, Tobias A. Conditional Poisson models: a flexible alternative to conditional logistic case cross-over analysis. BMC Medical Research Methodology. 2014;14(1):122. https://doi.org/10.1186/1471-2288-14-122

23. Des Jarlais DC et al. Potential geographic "hotspots" for drug-injection related transmission of HIV and HCV and for initiation into injecting drug use in New York City, 2011-2015, with

implications for the current opioid epidemic in the US. PLoS ONE. 2018;13(3):e0194799. https://doi.org/10.1371/journal.pone.0194799

24. Federal Transit Administration. Responses to General Directive 24-1: Required Actions Regarding Assaults on Transit Workers. 2025 Jan 16 [accessed 2025 Jan 22]. https://www.transit.dot.gov/regulations-and-programs/safety/responses-general-directive-24-1-required-actions-regarding

25. CDC. Hierarchy of Controls. Total Worker Health. 2024 Jun 26 [accessed 2025 Jan 22]. https://www.cdc.gov/niosh/twh/php/hierarchy/index.html

26. National Institute for Occupational Safety and Health. Hierarchy of Controls. 2022 Apr 28 [accessed 2024 Dec 17]. https://www.cdc.gov/niosh/learning/safetyculturehc/module-3/2.html

27. Zhang A et al. The relationship between police contacts for drug use-related crime and future arrests, incarceration, and overdoses: a retrospective observational study highlighting the need to break the vicious cycle. Harm Reduction Journal. 2022;19(1):67. https://doi.org/10.1186/s12954-022-00652-2

28. Korchmaros JD, Bentele KG, Granillo B, McCollister K. Costs, Cost Savings, and Effectiveness of a Police-led Pre-arrest Deflection Program. University of Arizona, Southwest Institute for Research on Women; 2022. https://sirow.arizona.edu/sites/sirow.arizona.edu/files/DefProg_Outcomes_Report_2022_final.pdf

29. Zhu DT, Bajaj SS, Kerr T. Supervised safe consumption sites — lessons and opportunities for North America. The Lancet Regional Health – Americas. 2024 [accessed 2025 Feb 20];39. https://www.thelancet.com/journals/lanam/article/PIIS2667-193X(24)00216-3/fulltext. https://doi.org/10.1016/j.lana.2024.100889

30. Levengood TW et al. Supervised Injection Facilities as Harm Reduction: A Systematic Review. American Journal of Preventive Medicine. 2021;61(5):738–749. https://doi.org/10.1016/j.amepre.2021.04.017

31. Kennedy MC, Karamouzian M, Kerr T. Public Health and Public Order Outcomes Associated with Supervised Drug Consumption Facilities: a Systematic Review. Current HIV/AIDS Reports. 2017;14(5):161–183. https://doi.org/10.1007/s11904-017-0363-y

32. Magwood O et al. The effectiveness of substance use interventions for homeless and vulnerably housed persons: A systematic review of systematic reviews on supervised consumption facilities, managed alcohol programs, and pharmacological agents for opioid use disorder. PLOS ONE. 2020;15(1):e0227298. https://doi.org/10.1371/journal.pone.0227298

33. Baxter AJ, Tweed EJ, Katikireddi SV, Thomson H. Effects of Housing First approaches on health and well-being of adults who are homeless or at risk of homelessness: systematic review and meta-analysis of randomised controlled trials. Journal of Epidemiology and Community Health. 2019;73(5):379–387. https://doi.org/10.1136/jech-2018-210981

34. Public Health – Seattle & King County. Overdose prevention and response - King County, Washington. 2024 [accessed 2025 Feb 20]. https://www.kingcounty.gov/en/dept/dph/health-safety/safety-injury-prevention/overdose-prevention-response

35. Washington State Health Care Authority. State Opioid and Overdose Response (SOOR) plan. 2025 [accessed 2025 Feb 20]. https://www.hca.wa.gov/about-hca/programs-and-initiatives/behavioral-health-and-recovery/state-opioid-and-overdose-response-soor-plan

Chapter 5: Conclusion

The work presented here is among the first to examine passenger drug use incidents on transit vehicles in the Pacific Northwest, and is the first to highlight the prevalence of drug use incidents on transit vehicles in the Pacific Northwest and its impact on transit operators. Risk perceptions of secondhand exposure to drugs are high among operators, and in conjunction with job dissatisfaction and perceived occupational stress, can increase intent to leave. Operators reported physical health, mental health, and emotional impacts associated with passenger drug use incidents on their vehicle. Despite some existing supports, transit operators reported unfulfilled needs pertaining to these drug use incidents, calling for implementation of additional controls. Drug use incidents occur routinely on transit vehicles, especially during colder weather conditions and on specific routes.

Given that transit operators are essential in providing safe and effective transit to their communities, it is important to promote their workplace health and well-being, and reduce the impact that these drug use incidents have on operator turnover. Follow-up research should investigate these impacts further, using longitudinal data that tracks operators from the start of their employment; this can elucidate the impacts of repeated exposure to drug use incidents over the course of transit operators' employment.

These findings also underscore the need for interventions to protect operators from both the risk of secondhand exposure to drugs,[1] as well as the mental health and emotional impacts of witnessing potentially distressing drug use incidents.[2–5] However, with no research to date evaluating interventions in the context of these drug use incidents, it is necessary to assess the effectiveness of interventions that control transit operators' secondhand exposure to drugs, such

as changes to ventilation or protective barriers, prior to their implementation. Furthermore, as it is of public health importance to create smoke-free workplaces,[6] the findings on the prevalence of drug use incidents on transit underscore the need for elimination of drug use on transit and interventions that create a safer workplace climate for operators. Future research should investigate methods to redirect PWUD to safe alternative forms of shelter. Such research can inform policies that promote harm reduction strategies in shelters for PWUD. Ultimately, the work presented here provides a starting point for future research that aims to reduce transit operators' exposure to drug use incidents and its impacts.

Chapter 5 References

1. Beaudreau M et al. Assessing fentanyl and methamphetamine in air and on surfaces of transit vehicles. Journal of Occupational and Environmental Hygiene. 2025;0(0):1–11. https://doi.org/10.1080/15459624.2024.2444430

2. Alexander DA, Klein S. Ambulance personnel and critical incidents: impact of accident and emergency work on mental health and emotional well-being. The British Journal of Psychiatry: The Journal of Mental Science. 2001;178(1):76–81. https://doi.org/10.1192/bjp.178.1.76

3. Boland LL et al. Burnout and Exposure to Critical Incidents in a Cohort of Emergency Medical Services Workers from Minnesota. The Western Journal of Emergency Medicine. 2018;19(6):987–995. https://doi.org/10.5811/westjem.8.39034

4. Donnelly E. Work-related stress and posttraumatic stress in emergency medical services. Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors. 2012;16(1):76–85. https://doi.org/10.3109/10903127.2011.621044

5. Kovaleski J, Vaccarelli J. “It’s scary. It’s unsafe”: Drug use still rampant on RTD property, Denver7 Investigates learns. Denver 7 Colorado News (KMGH). 2023 Jun 10 [accessed 2024 Oct 12]. https://www.denver7.com/news/investigations/its-scary-its-unsafe-drug-use-still-rampant-on-rtd-property-denver7-investigates-learns

6. CDC. Tobacco use in the workplace. Substance use and work. Substance Use and Work. 2025 Jan 30 [accessed 2025 May 22]. https://www.cdc.gov/niosh/substance-use/tobacco/index.html

Appendix 1: Qualitative semi-structured interview guide

Interview Questions:

Let me start by asking you a few basic background questions.

1. What agency and union local are you affiliated with?
2. How long have you been a transit operator or transit driver?
3. What type of vehicle do you typically operate?
4. To kick things off, briefly, I'd love to hear a bit about your experiences generally as a transit operator. Is there anything you particularly like or dislike about your job?

Now, I'd like to home in a bit on your experiences with passengers using drugs aboard your vehicle.

5. How often have you experienced passengers using drugs aboard your vehicle?
    a. Follow-up (if they have not experienced): Have you heard about this from other operators?
    b. Follow-up (if they have not experienced): Why do you think you haven't experienced it?
6. Typically, on a day-to-day basis, what does drug use on your vehicle look like?
    a. In the moments that these incidents happen, how does that make you feel?
    b. Do you typically report these incidents? Why/why not?
    c. If these incidents happen repeatedly, how has this affected you long-term, both during and outside of work? Physically and mentally?
7. Thinking back to when you first started your job to today, how would you describe the impact that passenger drug use has had on you during this time?
8. Have you had any particular instances with passengers using drug that were particularly noteworthy?
    a. Probes:
        i. What happened?
        ii. What are you supposed to do when this happens? What did you actually do?
            1. If they don't align: Why do you do something different from guidelines?
        iii. How did you feel?
    b. How has that one instance changed you, both in and out of work?

Now let's shift gears a bit. I want to ask you about the kinds of supports you get or don't get regarding passenger drug use.

9. What kind of help or supports do you currently get regarding passenger drug use?
    a. Probes:
        i. Are there any supports you get from your employer or union before these incidents happen that help prepare or protect you?
            1. Do you feel that these supports are working?
            2. Is there anything you feel your employer or union could do before these incidents happen that they don't currently do, that could have better prepared or protected you?
        ii. Are there any supports you get that are helpful to you during these incidents?
            1. Do you feel that these supports are working?
            2. Is there anything else you feel could be helpful to you during these incidents that isn't currently offered?
        iii. Are there any supports you get that are helpful for you after dealing with a drug use incident?
            1. Do you feel that these supports are working?
            2. Is there anything else you feel could be helpful to you after dealing with a drug use incident that isn't currently offered?

Finally, to wrap up this interview, is there anything else you'd like to share about your experiences with passenger drug use?