Deep Learning-Based Detection of Xylazine Exposure from Wound Imaging

Pranav Sompalle[1]; Abeed Sarker[2] PhD FAMIA; Jennifer Love[3] MD MSCR; Jeffrey Moon[4] MD; Anthony Spadaro[5] MD MPH; Rachel Wightman[6] MD FASAM; Jeanmarie Perrone[4] MD FASAM

Penn Medicine
Center for Addiction Medicine and Policy

Introduction

Xylazine is a veterinary sedative that has emerged as a **common adulterant** of illicitly-manufactured fentanyl.

Xylazine contributes to **ulcer development** and **other health effects**.

Xylazine-associated ulcers may progress to **severe tissue necrosis** and are **managed differently from alternative wounds**.

Clinical detection of xylazine exposure is difficult:
1. Xylazine testing is rarely available
2. Discrimination of xylazine-associated ulcers from alternative wounds is difficult.

Accurate prediction of xylazine exposure from wound imaging can serve to:
1. Identify potential xylazine exposure in a patient presenting with skin ulcers
2. Guide wound management strategies specific to the cause of ulcer/wound.

Objectives

Assess whether **deep learning-based methods** can be employed for **automatic classification of xylazine wound images**.

Methods

Figure 1 Study design and model training-testing protocol.

Dataset: All wound images (N=1791) were publicly-sourced and anonymized; N=78 images of confirmed xylazine-associated ulcers; N=1713 negative control images

Results

Model	All Images			Xylazine-Associated Wound Images	Negative Control Images
	Accuracy	Weighted-Average F1 Score	Macro-Average F1 Score	F1 Score	F1 Score
DenseNet121	0.97	0.96	0.73	0.47	0.98
ResNet	0.95	0.95	0.67	0.36	0.97
EfficientNetB0	**0.98**	**0.98**	**0.88**	**0.76**	**0.99**
SENet154	0.94	0.94	0.70	0.43	0.97

/ **/* (between ResNet and EfficientNetB0)

(McNemar's non-parametric significance test/z parametric significance test)

Table 1 Performance of trained models on test cohort according to accuracy and F1 scores.
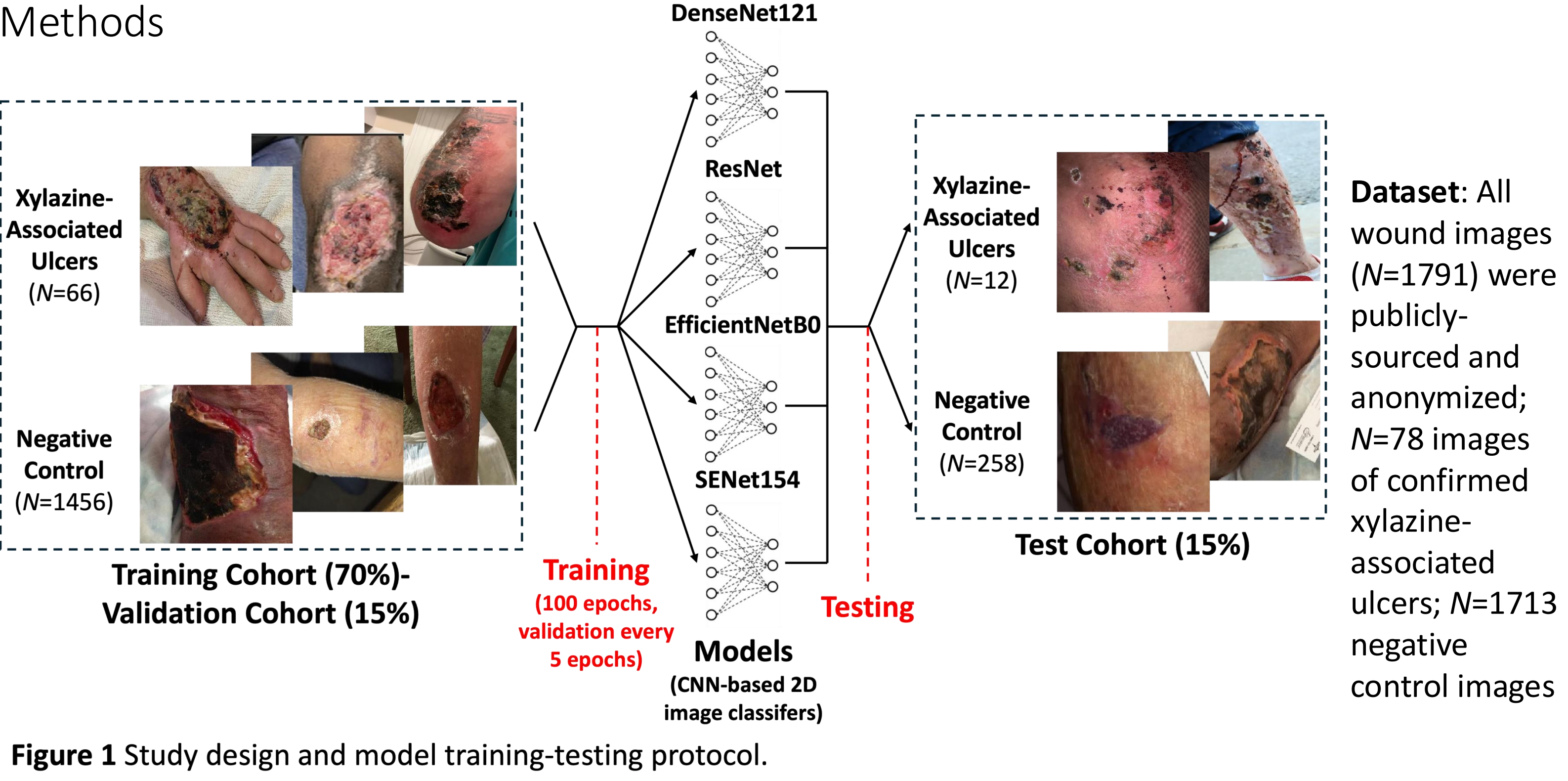
Conclusions

All models learned **features unique to xylazine-associated ulcers** and exhibit **high specificity**.

High variance in intra-class and macro-averaged **F1 scores distinguish models**.

EfficientNetB0 was the **most promising model**.

Deep learning in the evaluation of **wound imaging** may enable **accurate detection of xylazine exposure**, which can then enable the following:
- **specific wound care treatment**, including **antibiotic usage guidance**.
- targeted **substance use disorder-related care**.
- **geographic tracking** of emergence of wound complications in regions where xylazine's presence is lower.

Limitations

All models exhibit **low sensitivity**.

Images were determined to be xylazine-associated ulcers or not from **provided descriptions** and may **not represent the full spectrum of presentations**.
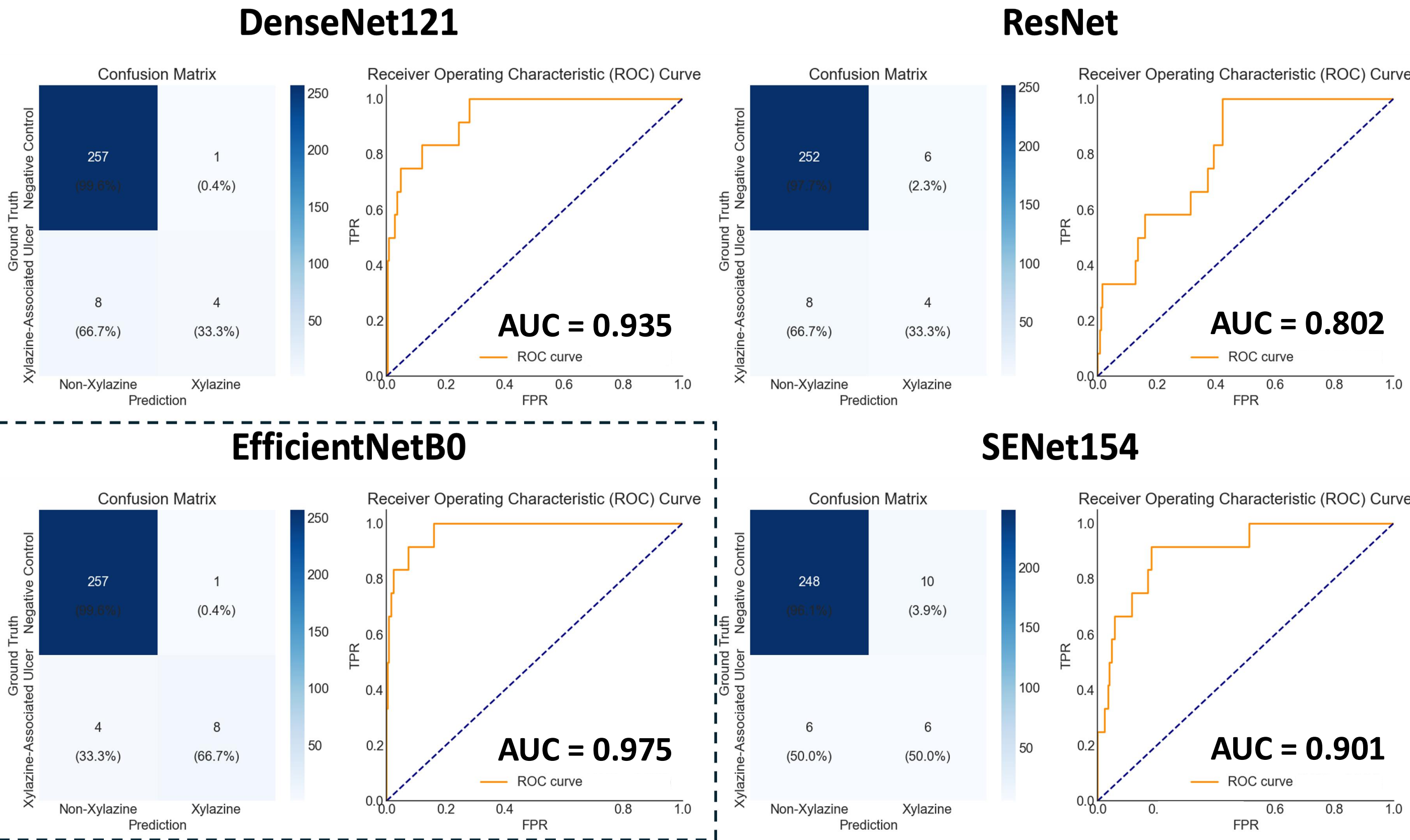
References

Spadaro, A., O'Connor, K., Lakamana, S., Sarker, A., Wightman, R., Love, J. S., & Perrone, J. (2023). Self-reported xylazine experiences: A mixed-methods study of Reddit subscribers. *Journal of Addiction Medicine, 17*(6), 691–694. https://doi.org/10.1097/ADM.0000000000001216

Dowton, A., Doernberg, M., Heiman, E., Barelli, P., Golden, M., Wang, H., Leventhal, J., Morford, K. L., & Sue, K. L. (2023). Recognition and treatment of wounds in persons using xylazine: A case report from New Haven, Connecticut. *Journal of Addiction Medicine, 17*(6), 739–741. https://doi.org/10.1097/ADM.0000000000001198

Perrone, J., Haroz, R., D'Orazio, J., Gianotti, G., Love, J., Salzman, M., Lowenstein, M., Thakrar, A., Klipp, S., Rae, L., Reed, M. K., Sisco, E., Wightman, R., & Nelson, L. S. (2024). National Institute on Drug Abuse Clinical Trials Network Meeting Report: Managing patients exposed to xylazine-adulterated opioids in emergency, hospital and addiction care settings. *Annals of Emergency Medicine, 84*(1), 20–28. https://doi.org/10.1016/j.annemergmed.2024.01.041

Oota, S. R., Rowtula, V., Mohammed, S., Liu, M., & Gupta, M. (2023). WSNet: Towards an effective method for wound image segmentation. In *2023 IEEE/CVF Winter Conference on Applications of Computer Vision (WACV)* (pp. 3233–3242). IEEE. https://doi.org/10.1109/WACV56688.2023.00325

Figure 2 Confusion matrices and Receiver Operating Characteristic (ROC) curves of trained models' predictions on test cohort.

DenseNet121 — AUC = 0.935
ResNet — AUC = 0.802
EfficientNetB0 — AUC = 0.975
SENet154 — AUC = 0.901

[1]School of Arts and Sciences at University of Pennsylvania, Philadelphia, PA; [2]Emory University School of Medicine, Atlanta, GA; [3]Icahn School of Medicine at Mt. Sinai, New York, NY; [4]Perelman School of Medicine at University of Pennsylvania, Philadelphia, PA; [5]Rutgers New Jersey Medical School, Newark, NJ; [6]Alpert Medical School at Brown University, Providence, RI; The authors have no disclosures relevant to this work.