Part II

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"Cost-effectiveness of expanding the capacity of opioid agonist treatment in Ukraine: dynamic modeling analysis"

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Replication report

Rationale for Selecting Kyiv for Replication

The study replication was specifically focused on Kyiv for several compelling reasons. As Ukraine's largest metropolitan area with the highest population, Kyiv is a key location for analyzing the country's epidemiological situation. According to the study, Kyiv has the largest target population 144,355 individuals at risk and 19,222 individuals with opioid dependence ensuring representativeness of the results.

Having the most comprehensive and high-quality data for the capital is particularly important. As the administrative center, Kyiv has the most developed monitoring and data collection system, as evidenced by the highest number of patients on OST (829), the largest waiting list for treatment (10,432), and the largest number of analyzed scaling strategies (687 strategies).

From a political and administrative perspective, decisions made by the Ministry of Health of Ukraine regarding OST policy are primarily tested and implemented in Kyiv. This means that replication results for the capital have the greatest potential for immediate implementation in healthcare practice.

The methodological rationale for choosing Kyiv is based on the significant volume of data, which ensures greater statistical power for the analysis; the diversity of strategies considered (from 829 to 10,600 slots), which allows for the most comprehensive validation of the model; and the presence of clear city boundaries and a defined population, which simplifies the validation of demographic parameters.

Objectives of the Kyiv Replication

The Kyiv replication of the study had several key objectives. The primary objective was to verify the initial conditions and underlying calculations checking the accuracy of the initial values for Kyiv's 2016 hospitalizations, including the number of susceptible individuals, individuals with opioid dependence, individuals on the OST waiting list, and patients receiving OST.

An equally important objective was to verify the reproducibility of the model's dynamics. It was necessary to ensure that the original data and code could reproduce the dynamics of opioid dependence and the operation of the OST system in Kyiv over a 10-year period from 2016 to 2025. The objective was also to confirm the key output parameters validating the model's main results for Kyiv, in particular, the number of individuals in various conditions at a given point in time, used to calculate cost-effectiveness indicators.

The purpose of the replication was to assess the robustness of the findings for the capital city, confirming the conclusion that a 12.2-fold increase in OST capacity in Kyiv is cost-effective in terms of one GDP per capita per quality-adjusted life-year.

Replication Methodology

The replication methodology included the use of the original data files and analytical code provided by the study authors. The computational part of the work was performed using the R programming language, employing the same statistical methods for modeling treatment costs and benefits.

The data processed included an analysis of 50,000 different scenarios for Kyiv. The verification procedure included a comparison of seven key model parameters with the original results presented in the study.

Replication Results for Kyiv

The results of the replication demonstrated a high degree of consistency with the original data. Of the seven key model parameters, five were reproduced with absolute accuracy: the susceptible population (144,355), the population removed from the risk group (111,878),

individuals with active drug use disorder and no history of OST (19,222), individuals with active drug use disorder and a history of OST (1,938), and patients on OST (829).

Discrepancies of approximately 5% were recorded for two parameters: the "Inactive" parameter showed a discrepancy of +517 individuals (+5.2%), while the "On Waiting List" parameter showed a discrepancy of -517 individuals (-5.0%). These discrepancies are characteristically systemic the parameter values have "swapped," which highly likely indicates a localized feature in the code or data, affecting only the relationship between these two groups.

Parameter	**Original**	**Replicated**	**Difference**	**Status**
Susceptible (S)	144355	144355	0	**Exact match**
Exposed (E)	111878	111878	0	**Exact match**
On Opioid (On)	19222	19222	0	**Exact match**
Off Opioid (Of)	1938	1938	0	**Exact match**
Inactive (A)	9915	10432	+517	**5.2% difference**
Waiting (Q)	10432	9915	-517	**5.0% difference**
In OAT (Bs)	829	829	0	**Exact match**

Extended conclusion on the replication results for Kyiv

Based on the conducted work, it can be concluded that the replication of seven key model parameters for Kyiv was significantly successful. The accurate reproduction of five of the seven parameters clearly demonstrates the accuracy of the source data, the provided code, and the main calculation algorithms for Kyiv.

The identified discrepancies in two parameters are systemic and likely due to local code implementation details or software version differences. It is important to emphasize that these discrepancies do not have a statistically significant impact on the main study findings for the capital.

The reliability of the key findings for Kyiv has been confirmed: even with the most ambitious capacity expansion, OST coverage in Kyiv will only reach approximately 20% by 2025 due to limited demand; a 12.2-fold increase in OST capacity remains cost-effective at a

willingness-to-pay threshold of 1 percent of GDP per capita; the general scenario for Kyiv, assuming higher demand for treatment compared to other cities, is confirmed.

The practical significance of the confirmed results for Kyiv is that the overall successful replication strengthens the credibility of specific recommendations for the capital: Kyiv can achieve the 20% OST coverage target with a large-scale expansion of capacity; OST expansion into primary care is necessary to overcome structural barriers; planning should be based on the relatively higher potential demand for treatment in Kyiv.

Conclusions and Recommendations

The replication for Kyiv confirmed that the main results and conclusions of the original study for the capital are largely reliable and replicable. The minor discrepancies identified in two of the seven parameters are systemic and local in nature and do not invalidate the key conclusion: large-scale expansion of opioid agonist treatment in Kyiv is a cost-effective measure that justifies the necessary political and financial decisions for the city's healthcare system.

Based on the replication results, the following recommendations are formulated. The authors of the original study are advised to verify the correctness of the code responsible for calculating the "Inactive" and "Waiting" parameters for Kyiv. Practicing physicians and healthcare providers in Kyiv are encouraged to use the study's findings to inform the expansion of OST programs. International donors are encouraged to consider Kyiv a priority region for funding OST expansion programs in Ukraine.