Drug Monitoring Programs

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Abstract

Prescription Drug Monitoring Programs (PDMPs) are systems that collect and distribute information on controlled substances and can be accessed by healthcare providers and healthcare authorities. I estimate the effect that implementing a PDMP has on the overall opioid overdose death rate in a state, using data from 2000 to 2020 from all 50 states and the District of Columbia. The theoretical purpose of PDMPs is to regulate the distribution of opioids, which should lead to lower levels of opioid use and as a result, lower levels of opioid overdoses. I collect opioid overdose death rate data from the CDC Wonder Database, data on when PDMPs were implemented in each state, as well as other covariates to create panel data for every state-year pair. I use a panel data regression model with state and year fixed effects, and I estimate that states with a PDMPs that are operational are estimated to experience an average annual decrease of 1.063 opioid overdose deaths per 100,000 people.

JEL:

Key Words:

1. Introduction

The U.S. is currently in the midst of an opioid epidemic, which has been a growing issue over the past 20 years. Opioid overdose deaths have been rapidly increasing since 2000. Opioid overdose deaths rose from 21,089 in 2010 to 47,600 in 2017 (U.S. Department). There have been three waves of opioid overdose deaths, the first being in 1999 when there was a rise in prescription overdose deaths. The second wave started in 2010 due to a rapid increase in heroin overdoses. The third wave began in 2013 due to illicitly manufactured fentanyl and other synthetic opioids (Centers for Disease).

U.S. states and the federal government have taken various actions to fight the opioid overdose epidemic by identifying outbreaks, collecting data, and providing care to affected communities. Today, PDMPs are one of these strategies to combat the epidemic, and they are among the most promising state-level interventions to improve opioid prescribing and diversion. Today, PDMPs are electronic databases that track controlled substance prescriptions in a state and can be accessed by health authorities and healthcare providers. In this research paper, I estimate the effect that implementing a PDMP has on reducing the opioid overdose death rate in a state.

Other research has suggested that the implementation of PDMPs is effective at reducing the supply of prescription drugs, and is associated with a 3% decrease in annual morphine milligram equivalents per capita (Brady et al. 2014). The theory is that healthcare providers properly use the PDMPs and restrict the number of opioids they prescribe, specifically to those who already have received enough opioids for their condition. Not only has there been research to suggest that PDMPs reduce the number of opioids prescribed, but research has shown that PDMPs also reduce the prescription opioid overdose death rate (Cerda et al. 2021). In addition, research on the effect of PDMPs on the overall opioid overdose death rate has suggested that newly implemented programs are associated with lower rates (Patrick et al. 2017). However, findings are mixed, and some studies have found that PDMPs are not associated with decreases in the overdose mortality rate of prescription drugs as well as other drug overdoses (Nam et al. 2017). The mixed results are also demonstrated by a 2019 systematic literature review on the effectiveness of PDMPs in reducing opioid-related consequences which noted that only two out of 13 studies found significant results.

Based on my research of PDMPs, I believe that PDMPs are effective tools for helping healthcare providers make better prescriptions by reducing the number of prescriptions to those patients who appear to have already been prescribed enough opioids. I hypothesize that the implementation of PDMPs is associated with a reduction in the opioid overdose death rate in a state.

I collected data on the opioid overdose death rates in each state-year pair from 2000 to 2020 using the CDC Wonder database. Using information from the Prescription Drug Abuse Policy System (PDAPS), I found when the PDMP became operational in each state. To control for covariates in the panel data, I obtained data on the median incomes and poverty rates in each state-year pair from the United States Census Bureau. Data were also obtained on the percentage of white people, the unemployment rate, the percentage of people with a bachelor's degree or higher, and the average age from the IPUMS USA community survey.

Using this data, I construct a linear panel data regression model with fixed effects for both the state and year dimensions. The dependent variable in this model is the opioid overdose death rate in a state year pair. The variable of interest is an indicator variable equal to one if a state has a PDMP implemented in the given year.

In this paper, I first evaluate previous literature and research on the effectiveness of PDMPs. I then discuss the economic theory by which PDMPs are theorized to help reduce the opioid overdose death rate. I continue by describing the data that I collected for the regression equation and then I discuss the regression equation. Finally, I provide my results.

2. Literature Review

Earlier research on the effect of PDMPs on opioid overdose deaths provides conflicting evidence that states that have recently implemented PDMPs experience reduced opioid overdose deaths. Patrick et al. (2017) use time-series cross-sectional data and econometric methods to estimate the causal effect of PDMPs on opioid overdose rates. The econometric models used in this study include an interrupted time-series design with state-fixed effects to account for unmeasured variation at the state level and for time-varying state-level factors, with the state-year pair as the unit of analysis. The data comes from publicly available sources from 1999 to 2013 to determine whether implementation or different characteristics of a program were associated with decreases in opioid overdose deaths. The researchers conclude that a state newly implementing a program was predicted to have 1.55 fewer opioid-related overdose deaths per 100,000 people per year compared to a state without a program. The study uses robust econometric methods and appropriate data to estimate the causal effect of PDMPs on opioid overdose rates. They also examined the interaction of the implementation with time to discover that effect. One shortcoming of the study was that each source of data likely had errors, as opioid overdose-related deaths may be underreported if medical examiners do not have enough evidence of opioid use. Also, the authors acknowledge that it is possible that they did not include all important time-varying state-level factors that are confounding variables. This research answers the research question by providing empirical evidence of the impact of PDMPs on opioid overdose rates. The study results suggest that implementing PDMPs is associated with significant reductions in opioid-related death rates. Using econometric methods and appropriate data supports the conclusion that PDMPs are crucial in reducing opioid overdose rates and improving public health.

More recently, Cerda et al. (2021) explore the relationship between proactive reporting of state-level prescription drug monitoring programs (PDMPs) and county-level fatal prescription opioid overdoses. The authors use county-level data across 3,109 counties in 49 states from 2002 to 2016 to estimate the effect of PDMPs on opioid overdoses. The study employs Bayesian space-time models which control for differences in the population and opioid prescribing practices between states and over time. Linear distributed lag specifications were used to allow a linear progression of policy associations from instantaneous through 3-year-lagged effects. The results of the study suggest that electronic PDMPs are associated with a significant reduction in prescription opioid overdose deaths after three years. They found that electronic PDMP access was associated with a 2% increase in opioid overdose deaths after the first year but found there to be fewer opioid overdoses in the following three years. They found that proactive PDMPs were associated with fewer deaths attributed to natural or semi-synthetic opioids compared to states with weak PDMPs. They also concluded that state adoption of PDMPs was associated with fewer opioid deaths overall. Cerda et al. (2017) built on a previous study that used latent transition analysis by examining combinations of PDMP characteristics that were associated with the greatest change in prescription opioid overdose fatalities. They also examined the impact of state-level PDMPs on county-level fatal overdoses while accounting for within-state variation in the growth of fatal prescription opioid overdoes and spatial autocorrelation in overdose deaths. However, the shortcoming of the study is that they used certain coding in death certificates to identify the cause of death to construct the county-level overdose rates, which may not reliably identify the drugs involved in overdoses. Also, the study is not able to examine the causal mechanisms through which specific PDMP features affect the risk of prescription opioid overdose. The research provides evidence that state adoption of PDMPs was associated with fewer prescription opioid deaths overall. The authors provide evidence that proactive reporting PDMPs has a significant impact, compared to weak PDMPS, on reducing fatal prescription opioid overdoses at the county level.

Brady et al. (2014) investigate the effect of prescription drug monitoring programs (PDMPs) on dispensing prescription opioids in the United States. The authors use a multivariate analysis design to compare changes in the dispensing of prescription opioids before and after the implementation of PDMPs in each state and the District of Columbia from 1999 to 2008. The results of the study suggest that the implementation of PDMPs was associated with a 3% decrease in the annual morphine milligram equivalents (MMEs) per capita, which may lead to a reduction in the number of opioid overdoses. The researchers found that the effect of PDMPs on opioid prescriptions varied greatly across states, in some states the effect was negative and in others it was positive. The study provides valuable insights into the potential effectiveness of PDMPs in reducing the dispensing of prescription opioids, which is an important way in which PDMPs can reduce the number of opioid overdoses. The use of a difference-in-differences design allows the authors to control for other factors that may affect the dispensing of prescription opioids, such as changes in state policies. One shortcoming of the study is that it does not assess the potential unintended consequences of PDMPs, such as patients seeking opioids from other sources or engaging in more dangerous forms of drug use. This is an important consideration, as the impact of PDMPs on the opioid epidemic is likely to depend not only on the reduction in the dispensing of prescription opioids but also on the potential emergence of alternative sources of opioids. Also, the study does not investigate the effect that PDMPs have on causing people to switch from using prescription opioids to using opioids purchased illegally, which are usually more dangerous. Also, the study only uses data from 1999 to 2008, which is a relatively short time span. In terms of answering the research question, this study provides evidence that PDMPs may be an effective tool for reducing the dispensing of prescription opioids in the United States. The results suggest that PDMPs may play an important role in addressing the opioid epidemic by reducing the number of prescription opioids available for use. This is important because prescription opioids are often the reason why many people begin using opioids and develop addictions. Also, prescription opioids are sold to other people who do not have the prescription. The effect that PDMPs have on the number of prescriptions for opioids in a state is a vital question for investigating the effect of PDMPS on the number of opioid overdoses.

Nam et al. (2017) analyze the effect of PDMPS on the number of fatal drug overdose mortality rates in the United States. The authors used multivariate regression models with state and year fixed effects and state-specific linear time trends. The results break down the association of PDMPs with various types of drugs, and they found that PDMPs were not associated with a decrease in the overdose mortality rate of prescription opioids. The researchers found that they may be associated with increased overdose mortality rates in categories other than prescription opioids. Longer-standing PDMPs were associated with significantly increased mortality rates for legal narcotics and unspecified drugs and illicit drugs. The authors used state-fixed effects to allow each state to serve as a control group. Many state-level time-varying covariates that could be associated with drug overdoses and PDMP implementation were controlled for. This approach is a strong point in the research, as it allows for causal inference about the effect of PDMPs on overdose rates in each of the states. However, one shortcoming is that the authors do not account for other factors that may be affecting the number of overdoses, such as the availability of non-opioid pain medications or changes in law enforcement practices. Also, the authors do not break down the results to discuss the association between PDMPs and illegal opioids. The data in this study only covers the years from 1999 to 2014. This study does help to answer my specific research question by providing evidence that PDMPs may not be effective at reducing prescription opioid drug overdose deaths.

Rhodes et al. (2019) present a systematic review of the literature on the effectiveness of prescription drug monitoring programs (PDMPs) in reducing opioid-related harms and consequences. The authors reviewed a total of 22 studies that evaluated the impact of PDMPs on various outcomes, including opioid overdose, doctor shopping, and opioid prescription rates. The results of the review suggest that the effect that PDMPs have on opioid overdoses is unclear. Of 13 studies that reported on opioid-related adverse effects, only two found significant results, with one study finding that opioid overdoses increased after PDMP implementation and the other finding a decrease. The authors conducted a comprehensive systematic review of the literature, which is a strength of the paper. However, one shortcoming of the research is the limited consideration of contextual factors that may affect the effectiveness of PDMPs in reducing opioid overdoses. For example, the authors did not examine the role of state-level policies, such as those aimed at reducing the availability of opioids, in reducing opioid overdoses. This research answers the specific research question by suggesting that PDMPs are effective in reducing opioid overdose rates and doctor shopping, but more research is needed to determine their impact in the context of other state-level policies aimed at reducing the availability of opioids. The systematic review provides valuable information for policymakers and healthcare professionals considering the implementation of PDMPs to address the opioid epidemic.

Economic Model/Theory

PDMPs provide opioid prescribers with more information on the patients they are prescribing to and PDMPs improve prescribers' ability to identify patients who are more at risk of abusing or overdosing on opioids. The supply of prescription opioids is influenced by the cost of production, regulations, and government policies. PDMPs may limit the number of prescriptions that can be written for certain drugs or require doctors to follow stricter guidelines when prescribing. The theoretical purpose of PDMPs is to regulate the distribution of opioids and to reduce drug diversion, which would lead to a lower supply of prescription drugs overall, and specifically to those most at risk of abusing them. Economic theory suggests that having a lower supply of these drugs, as well as having fewer people exposed to the drugs in the first place, should lead to lower levels of opioid use and as a result, opioid overdoses. If people generally have less access to the drugs, they are less likely to become addicted to them, so the overall demand for opioids should decrease as well over time, which will ultimately result in a reduction in the number of opioid overdose deaths.

PDMPs may take time after their legalization and implementation before they start to influence the opioid overdose death rate. PDMPs may not be effective at reducing the overdose rates for those already abusing opioids before implementation, but they may lead to fewer people being exposed to the drugs in the future and may prevent many people who use the drugs from developing addictions. The assumptions of this model are that prescribers consider information from the PDMPs before prescribing opioids and that a significant amount of the opioids being used by the population come from prescriptions.

Based on the theory of supply and demand, it is expected that the opioid overdose death rates in a state should decrease after some period after the implementation of a PDMP in that given state. The time effect of the implementation of the PDMP on reducing the overdose death rate is unclear and may differ between states depending upon certain factors of the PDMPs.

3. Data and Methodology

Data Source

This analysis uses state-year-level data on the opioid death rate per 100,000 people from 2000 to 2020, which was obtained from the CDC Wonder Database. The opioid death rate will be the outcome variable in the model, and it will measure the level of opioid abuse in each state and year. From the CDC Wonder Database, the ICD-10 Codes that were selected as the multiple causes of death were T40.0-T40.4 and T40.6. We would expect there to be 21 years of data for the 50 states and the District of Columbia, resulting in 1,071 observations. However, there are some state-year combinations where there are not enough overdose deaths to find a reliable death rate, so there are 1,035 observations in the final dataset.

Using information from the Prescription Drug Abuse Policy System (PDAPS), an indicator variable was created to indicate whether or not there was an operational PDMP in place in a given state and year.

To control for covariates in the panel data, I obtained data on the median incomes and poverty rates in each state and year. This data was obtained from the United States Census Bureau. Data were also obtained on the percentage of white people, the unemployment rate, the percentage of people with a bachelor's degree or higher, and the average age for each state from 2000 to 2020. This data was all obtained from the IPUMS USA community survey. The percentages and estimates were calculated using the person weight variable, which indicates how many people in the US population are represented by a given person in the IPUMS sample.

Figure 1 shows the average overall opioid death rate across all 50 states and the District of Columbia each year. Figure 2 shows the quantiles of the opioid overdose death rates in selected years. In both figures, we can see that opioid death rates have rapidly increased over this time horizon.

Empirical Regression

The goal of this research paper is to estimate the effect that implementing PDMPs has on the opioid overdose death rate and to see how that effect may differ depending on the number of years after the PDMP was implemented. Given the differential timing in PDMP implementation, and that by 2013, Missouri was the only state without a PDMP, we will use a panel data model with state-year fixed effects to examine the effect of the implementation of a PDMP in a given state and year on the opioid overdose death rate. I use the panel data regression equation:

$$Y_{s,\,t} = \alpha_s + \gamma_t + \beta_1 PDMP_{s,\,t} + \sum_{k=1}^{K} \theta_k X^k_{s,\,t} + \epsilon_{s,\,t}$$

Where $Y_{s,\,t}$ is the opioid death rate for state *s* in time *t*, α_s are state-fixed effects, and γ_t are year-fixed effects. *PDMP* is a binary variable equal to 1 for a state in years after PDMP implementation and 0 otherwise. The vector of the covariates is included and contains the following variables: the median income, the poverty rate, the percentage of the population that is white, the unemployment rate, the percentage of the population with a bachelor's degree or higher, and the average age for each state from 2000 to 2020.

I expect the opioid overdose death rate to decrease after PDMP implementation. Therefore, I would expect the coefficient of *PDMP* to be negative, indicating a decrease in overdose deaths after PDMP implementation.

By including a fixed effects model with both year and state-fixed effects, the model controls for unobserved time-varying and state-specific confounders that could influence the opioid overdose death rate. The model includes the variable PDMP, which captures the immediate effect of PDMP implementation.

Additional investigation will include the interaction terms of PDMP with the covariates to explore how the effects of PDMP on the overdose death rate are associated with the various covariates. I also plan to investigate any potential leading and lagging impacts that implementing a PDMP may have on the opioid overdose rate. Also, I plan to investigate how other aspects of PDMPs, such as when they receive certain features, may impact the opioid overdose rate. I report the coefficient estimates and the robust standard errors in the panel data model.

4. Results

Table 1 displays my results from estimating the panel data regression equation with state and year-fixed effects. The dependent variable in the model is the opioid overdose death rate per 100,000 people in a state and year, and the standard errors are robust standard errors that are adjusted for heteroscedasticity. Column (1) of Table 1 displays the results of the regression without any covariates, but with state and year-fixed effects. The PDMP coefficient of -1.114 suggests that states with a PDMP that is operational are estimated to experience an average annual decrease of 1.114 opioid overdose deaths per 100,000 people. This coefficient is significant at a 5% level of significance. Using a robustness check of this estimate, Column (2) of Table 1 includes all the covariates. The additional control variables shrink the PDMP coefficient to -1.063, but the coefficient does remain statistically significant at the 5% level. The relatively small decrease in the magnitude of the coefficient of PDMP suggests that the fixed effects control for most differences between states and time periods.

5. Conclusion

Earlier research shows that PDMPs likely are effective at reducing opioid-related deaths as well as the number of opioids prescribed, however, the results of the various studies often conflict with each other. This paper attempts to provide another estimate of the effect that PDMPs have on the opioid overdose death rate by using different covariates, as well as using different interaction variables and aspects of PDMPs to explore the ways in which they are or are not effective. PDMPs provide healthcare providers with reliable information on the prescriptions of their patients, which likely leads to lower levels of opioid diversion and opioid misuse. To account for a wide time period, I account for demographic factors in each state and year, and I use state-level PDMP operation status as the treatment variable.

The preliminary results of my study suggest that states with operational PDMPs are expected to see reductions of about 1 opioid-related overdose per 100,000 people per year. For a state like California, with a population of about 39 million, this would mean that we would expect to see about 415 fewer opioid-related overdoses annually after a PDMP become operational. Future studies could improve upon the results of this paper by collecting more data on health-related covariates such as the number of naloxone medications provided or other opioid-related efforts in states.

Creating well-funded and well-functioning PDMPs is unlikely to solve the opioid epidemic, but the evidence of a significant reduction in the opioid overdose death rate after PDMP implementation is an economically significant reduction and demonstrates that PDMPs are an effective way at starting to combat this problem. Policymakers should consider improving funding for PDMPs and improving interstate operability. These results also suggest that other related efforts to combat the epidemic may also be worthwhile.

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Figure 1

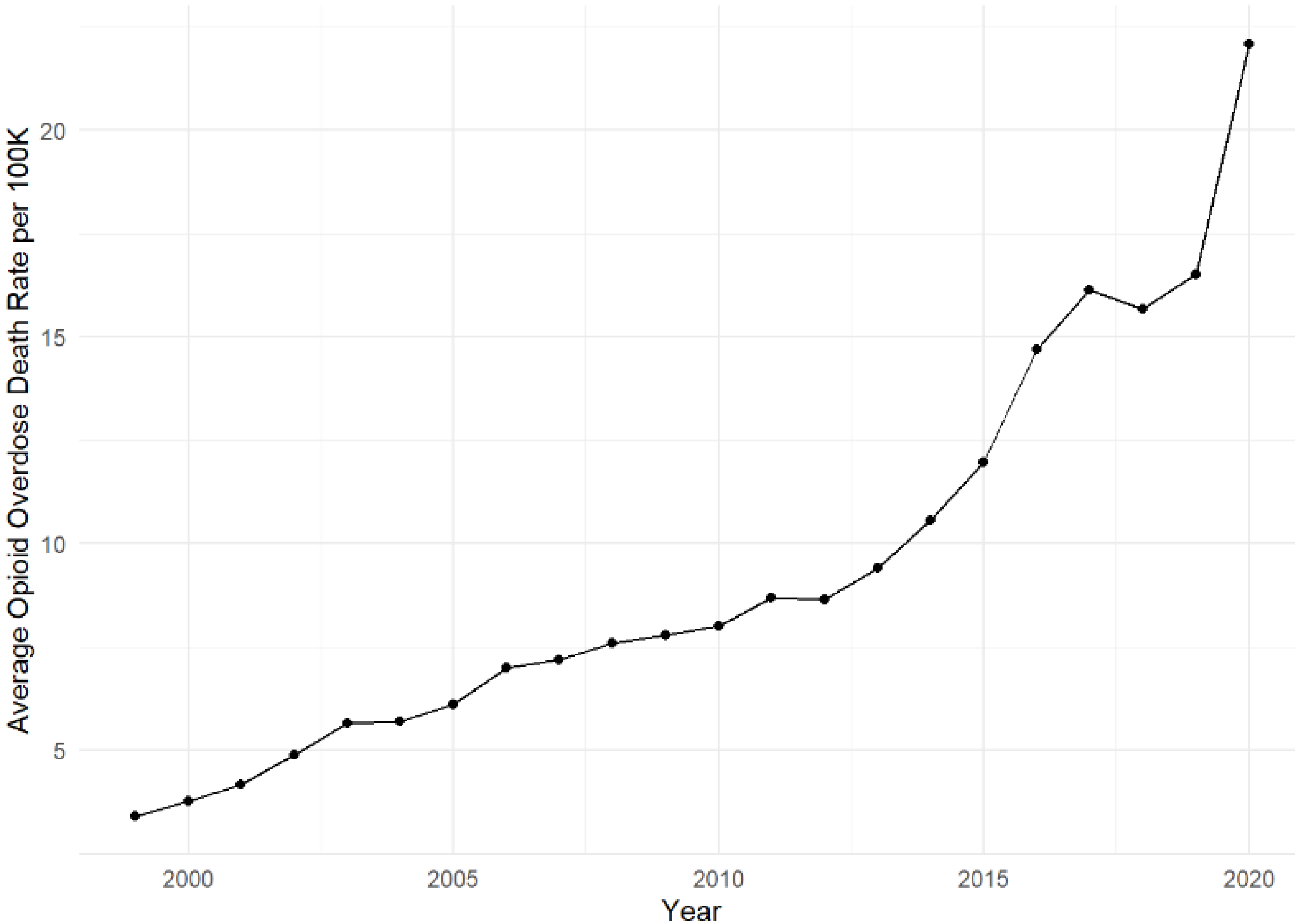
Average Opioid Overdose Death Rate per 100K
20
15
10
5
2000
2005
2010
2015
2020
Year

Figure 2

Quantiles of the Opioid Overdose Rate in Select Years

	5%	25%	50%	75%	95%
1999 - 2020	2.20	4.60	7.20	11.38	26.73
2000	0.92	2.20	3.30	4.93	9.12
2005	2.44	3.98	5.20	8.05	11.37
2010	3.68	5.25	7.05	9.75	14.17
2015	4.60	6.30	10.80	15.20	24.05
2020	6.45	12.25	22.30	29.05	42.00

Table 1:

	Dependent variable:	
	Overdose_Rate	
	(1)	(2)
PDMP	-1.114^{**}	-1.063^{**}
	(0.472)	(0.448)
AVG_AGE		1.527^{***}
		(0.483)
bachelors_percent		1.504^{***}
		(0.261)
median_income		0.00002
		(0.0001)
poverty_rate		0.149
		(0.119)
unemp_rate		0.015
		(0.178)
WHITE_PCT		0.178^{*}
		(0.106)
Constant	-1.589^{**}	-91.950^{***}
	(0.723)	(19.521)
Fixed Effects	Yes	Yes
Covariates	No	Yes
Observations	1,035	1,035
R^2	0.720	0.741
Adjusted R^2	0.699	0.721
Residual Std. Error	4.258 (df = 963)	4.102 (df = 957)
F Statistic	34.805^{***} (df = 71; 963)	35.619^{***} (df = 77; 957)

Note: *p<0.1; **p<0.05; ***p<0.01