

The cost of the opioid crisis to the U.S Healthcare System

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World Journal of Biology Pharmacy and Health Sciences, 2026, 25(02), 101-115

Publication history: Received on 20 December 2025; revised on 03 February 2026; accepted on 05 February 2026

Article DOI: <https://doi.org/10.30574/wjbphs.2026.25.2.0092>

Abstract

This study examines the financial burden of the opioid crisis on the United States healthcare system using a system-oriented, multivariate empirical framework. Drawing on survey data from 387 healthcare facilities and professionals, the study models Financial Cost Pressure as a function of opioid-related demand, emergency department burden, treatment capacity and access, hospital response strategies, reporting and surveillance timeliness, workforce and operational strain, drug market complexity, community and social determinants, and analytics and early warning readiness. Results indicate that opioid-related demand and emergency department burden are the strongest drivers of cost pressure, while workforce strain, reporting challenges, drug market complexity, and adverse social conditions further amplify financial burden. In contrast, greater treatment capacity, stronger hospital response strategies, and improved analytic readiness significantly mitigate system-level costs. The model explains 63 per cent of financial cost pressure. By integrating epidemic dynamics and institutional capacity, the study provides evidence on sustained healthcare costs.

Keywords: Opioid Crisis; U.S Healthcare System; Financial Cost Pressure; Emergency Department Burden; Multivariate Empirical Framework

1. Introduction

The opioid crisis constitutes a significant and enduring public health emergency in the United States, with extensive implications for population health, healthcare systems, and national economic performance. The problem has increased in complexity and lethality via successive waves marked by prescription opioids, heroin, synthetic opioids like fentanyl, and the rise of polysubstance use (Ciccarone, 2019, 2021). The shift to highly potent illicit synthetic opioids has fundamentally changed overdose risk profiles and increased demands on emergency, inpatient, and long-term care services (Jalal & Burke, 2021; Rosenblum et al., 2020). Consequently, U.S. healthcare systems have encountered increasing usage pressures, encompassing emergency department visits, hospitalisations, treatment for opioid use disorder (OUD), and management of opioid-related comorbidities (Blanco et al., 2020; Judd et al., 2023). These pressures result in significant budgetary burdens that encompass not just clinical care but also public health surveillance, long-term therapy, and systemic capacity limitations (Florence et al., 2021; The White House, 2025).

The opioid problem presents complex economic and operational difficulties to healthcare delivery systems beyond mortality. Inconsistent overdose surveillance and death reporting across countries hinder health systems' capacity to allocate resources effectively and respond proactively to emerging hotspots (Fliss et al., 2021; Boslett et al., 2020). Progress in spatiotemporal modelling and machine learning techniques has enhanced the forecasting of overdose trends; however, their incorporation into standard healthcare planning is still constrained (Campo et al., 2020; Marks et al., 2021a; Sumetsky et al., 2021). Additionally, social and structural characteristics, such as socioeconomic vulnerability, barriers to healthcare access, and community-level risk settings, persist in influencing opioid-related morbidity and systemic costs (Adejumo, 2024; Blanco et al., 2020). As the crisis evolves and varies geographically,

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healthcare systems must manage escalating direct medical costs alongside the indirect effects of postponed care, recurrent hospitalisations, and diminished workforce capacity (Florence et al., 2021; Murphy, 2020).

This study is fundamentally based on three interrelated theoretical frameworks to elucidate how opioid usage leads to persistent and increasing healthcare system expenses. Health Economics Theory, specifically the economic burden and cost-of-illness framework, elucidates how chronic diseases and substance use disorders incur direct medical expenses, indirect productivity losses, and systemic inefficiencies (Grossman, 1972). Secondly, Systems Dynamics Theory offers a paradigm for comprehending feedback loops, time delays, and nonlinear interactions in healthcare and pharmaceutical markets that exacerbate long-term systemic stress (Forrester, 1961). The Social Determinants of Health Theory highlights how social, economic, and environmental factors influence susceptibility to opioid usage and determine healthcare demand (Marmot & Wilkinson, 2005). Systems Dynamics Theory serves as the principal framework for this study, as it effectively encapsulates the evolving, multi-wave characteristics of the opioid epidemic and its recursive impacts on healthcare utilisation and costs, a methodology robustly endorsed by extensive modelling efforts in the opioid literature (Lim et al., 2022; Marks et al., 2021b). This theoretical integration facilitates a thorough understanding of how epidemiological dynamics, societal determinants, and healthcare system responses collectively influence cost trajectories across time.

A substantial amount of work has empirically measured the economic burden of opioid usage and assessed the cost-effectiveness of specific therapies. Previous research quantifies significant national economic burdens associated with opioid use disorder (OUD) and fatal overdoses, primarily resulting from healthcare costs and diminished productivity (Florence et al., 2021; Murphy, 2020). Modelling studies have evaluated hospital-centric tactics and pharmacological interventions, underscoring potential cost-effectiveness dependent on certain assumptions (Barocas et al., 2022; Onuoha et al., 2021; Beaulieu et al., 2021). Policy-oriented modelling has also forecasted epidemic trajectories to guide national responses (Lim et al., 2022; Marks et al., 2021b). Nevertheless, a significant portion of the current literature is disjointed, concentrating on isolated interventions, particular demographics, or specific cost categories, failing to deliver a cohesive, system-wide evaluation of how changing epidemic dynamics result in persistent financial strains on the U.S. healthcare system (Patton et al., 2022; Barman & Mukesh, 2025). This study addresses this gap by providing a comprehensive, theory-informed assessment of the cost of the opioid crisis to the U.S. healthcare system, explicitly integrating epidemic dynamics, healthcare utilisation pathways, and economic burden evidence. The novelty of this study lies in its system-level synthesis of epidemiological evolution, healthcare demand pressures, and cost implications, thereby extending beyond intervention-specific evaluations to offer a holistic understanding of healthcare system exposure. Guided by this objective, the study addresses the following research questions: (1) What are the major healthcare system cost components attributable to the opioid crisis in the United States? (2) How have evolving epidemic dynamics shaped healthcare utilisation and cost trajectories over time? and (3) To what extent do current empirical estimates and modelling approaches adequately capture the full healthcare system burden of the opioid crisis?

2. Literature Review

The research regarding the opioid crisis and its impact on the healthcare system is based on complementing theoretical frameworks that elucidate how substance use disorders result in persistent economic and institutional strains. Health Economics Theory characterises opioid use disorder as a chronic illness that incurs substantial direct medical expenses, indirect productivity losses, and enduring systemic inefficiencies, therefore positioning opioid misuse as a significant contributor to the escalation of healthcare costs and fiscal pressure. This viewpoint is evident in national cost-of-illness studies that highlight the magnitude and duration of healthcare expenditures and productivity losses associated with opioids (Florence et al., 2021; Murphy, 2020). Systems Dynamics Theory enhances this comprehension by emphasising feedback loops, temporal delays, and nonlinear relationships among drug supply, demand, treatment capacity, and overdose results. Extensive modelling studies indicate that epidemic waves and market transitions, such as the move to illicit synthetic opioids generate cyclical effects that exacerbate healthcare use and long-term system strain (Ciccarone, 2019, 2021; Lim et al., 2022). The Social Determinants of Health Theory enhances these viewpoints by highlighting how socioeconomic vulnerabilities, structural disparities, and community factors influence susceptibility to opioid usage and consequent healthcare needs. Empirical research indicates that social and environmental risk variables substantially affect opioid-related morbidity and mortality, consequently exacerbating gaps in healthcare usage and financial burdens (Adejumo, 2024; Blanco et al., 2020). Collectively, these theoretical views offer a cohesive framework for comprehending the opioid crisis as a dynamic, socially ingrained, and economically costly issue that exerts continual strain on healthcare institutions.

Empirical research has thoroughly investigated the epidemiological dynamics of the opioid crisis and its effects on health outcomes and system capacity. Ciccarone (2019) examined the supply and demand factors contributing to the

U.S. opioid overdose crisis through a narrative and analytical synthesis, concluding that successive epidemic waves signify structural alterations in drug markets that exacerbate overdose risk and healthcare need. Ciccarone (2021) examined the emergence of illegal fentanyl and stimulants in a subsequent study, indicating a fourth wave marked by polysubstance use, which complicates clinical care and escalates the usage of emergency and inpatient services. Jalal and Burke (2021) employed epidemiological modelling to examine the influence of carfentanil on overdose mortality trends, revealing that highly potent synthetic opioids precipitate sudden increases in overdose fatalities, consequently elevating acute care utilisation and healthcare costs associated with mortality. Rosenblum et al. (2020) analysed alterations in the drug market utilising data from Ohio drug crime laboratories. They determined that swift alterations in drug composition compromise early warning systems, therefore constraining healthcare system readiness and fostering reactive, costly care practices.

Numerous studies have concentrated on predictive analytics and surveillance to enhance healthcare system responses. Boslett et al. (2020) utilised enhanced death certificate coding and statistical prediction methodologies to refine the identification of opioid involvement in overdose fatalities, concluding that superior categorisation enhances epidemiological precision and guides resource allocation. Campo et al. (2020) utilised machine-learning techniques on web search data to produce spatiotemporal maps of overdose mortality, illustrating that digital surveillance technologies might enhance the early identification of overdose clusters and potentially alleviate pressure on healthcare systems through timely intervention. Marks et al. (2021a) performed a narrative review of methodological strategies for forecasting opioid-related epidemics, emphasising the necessity for interdisciplinary modelling frameworks to facilitate proactive healthcare and public health planning. Likewise, Sumetsky et al. (2021) employed predictive epidemiological models in two U.S. states to forecast future overdose mortality trends and determined that anticipatory modelling is essential for synchronising healthcare capacity with burgeoning demand. Lim et al. (2022) employed national-level systems modelling to predict the progression of the U.S. opioid crisis, illustrating the intricate interplay between policy actions and market dynamics that influence long-term healthcare utilisation and cost trajectories.

A significant volume of research has assessed the economic impact of opioid consumption and analysed healthcare-associated expenses. Florence et al. (2021) assessed the national economic impact of opioid use disorder and fatal overdose by cost-of-illness methods, determining that healthcare expenditures constitute a significant portion of total societal costs. Murphy (2020) evaluated the economic impact of opioid use disorder through valuation and aversion-based methodologies, emphasising that traditional cost assessments may underestimate the actual economic strain on healthcare systems and society. Beaulieu et al. (2021) performed a systematic assessment of economic evaluations in opioid modelling, revealing that although many models evaluate cost-effectiveness, there exists considerable variety in methodologies and assumptions, which restricts comparability and thorough system-level inference. Baracas et al. (2022) employed modelling techniques to evaluate the clinical impact, expenses, and cost-effectiveness of hospital-based strategies for tackling the opioid epidemic, concluding that hospital-initiated interventions can be cost-effective but necessitate ongoing investment and system integration. Onuoha et al. (2021) conducted a review of economic assessments concerning pharmacologic interventions for opioid use disorder and concluded that medication-assisted treatments are predominantly cost-effective, advocating for increased access as a means to diminish long-term healthcare expenditures. Patton et al. (2022) conducted a critical analysis of the role of economic evaluation in shaping opioid policy responses, highlighting methodological and data-related issues that hinder the integration of cost-effectiveness evidence into comprehensive healthcare planning.

Further research highlights the issues posed by institutions, reporting mechanisms, and public health systems that influence healthcare system expenditures. Fliss et al. (2021) examined overdose death reporting mechanisms and determined that delays and inconsistencies obstruct prompt public health and healthcare system responses, thereby escalating subsequent treatment and emergency care expenses. Judd et al. (2023) conducted an extensive analysis of the variables contributing to the opioid pandemic and its adverse effects, synthesising evidence that associates opioid usage with increased healthcare utilisation, chronic illness comorbidities, and prolonged treatment requirements. Adejumo (2024) analysed the social determinants of the opioid crisis, highlighting how socioeconomic and structural issues aggravate opioid usage and increase healthcare demand, and advocating for policy solutions that target upstream social drivers. Barman and Mukesh (2025), in a narrative review of opioid toxicity, underscored the expanding clinical issues posed by strong synthetic opioids and stressed the necessity for adaptable healthcare system measures to address escalating clinical complexity and cost pressures. The White House (2025) commented on the exorbitant national expenses of the illicit opioid epidemic, highlighting the increasing financial strain on healthcare institutions and the necessity for coordinated, systemic remedies.

The current literature together indicates that the opioid crisis incurs significant and escalating expenses for the U.S. healthcare system, influenced by changing drug markets, social vulnerability, and intricate feedback mechanisms. Nevertheless, previous research is predominantly fragmented, concentrating on particular therapies, chosen cost

categories, or discrete modelling frameworks, without comprehensively incorporating epidemic progression, healthcare use trajectories, and overarching cost ramifications. This work enhances the literature by offering a theory-driven, comprehensive synthesis of how the dynamics of the opioid epidemic result in persistent healthcare system expenditures. This study enhances the understanding of healthcare system exposure to the opioid crisis by integrating epidemiological dynamics, social factors, and economic burden evidence, thereby providing a holistic framework for long-term healthcare planning and policy responses.

3. Research Methodology

This study employed a quantitative, cross-sectional explanatory research approach to empirically evaluate the financial impact of the opioid crisis on the U.S. healthcare system. The design is suitable for analysing correlations between opioid-related health events and healthcare system cost outcomes utilising structured secondary and primary survey data, while also aligning with previous economic and systems modelling studies in the opioid literature (Florence et al., 2021; Lim et al., 2022; Barocas et al., 2022). The explanatory design for a systematic assessment of how opioid-related utilisation patterns, treatment pathways, and overdose dynamics convert into direct healthcare costs and system-wide financial constraints. This methodology aligns with prior empirical and modelling studies that examine opioid-related healthcare burdens through structured analytical frameworks to elucidate epidemiological and economic correlations (Beaulieu et al., 2021; Patton et al., 2022).

3.1. Population of the Study

The study population consists of healthcare system units and personnel directly engaged in opioid-related care and cost management inside prominent U.S. acute care and treatment facilities. The target population comprises hospital administrators, emergency department managers, clinical leaders in addiction medicine, billing and health information management officers, and public health surveillance officers employed in U.S. hospitals and treatment centres that document opioid-related incidents. The total finite population for this study is defined as $N = 12,480$ eligible healthcare system units and designated professionals, based on consolidated national hospital utilisation statistics and opioid-related encounter reporting from large acute-care facilities and treatment centres across selected U.S. hospitals and affiliated opioid treatment programs. This population frame encompasses institutions and appointed cost and utilisation officers accountable for opioid-related care reporting and cost monitoring, in alignment with system-level analyses employed in previous opioid cost and utilisation studies (Florence et al., 2021; Judd et al., 2023).

3.2. Sample Size Determination

The sample size was determined using a finite population correction formula to ensure representativeness and statistical efficiency. The Yamane (1967) sample size determination formula was applied as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the total population, and e is the level of precision (set at 5%). Substituting the study values:

$$n = \frac{12,480}{1 + 12,480 (0.05)^2}$$

$$n = \frac{12,480}{1 + 31.20}$$

$$n = \frac{12,480}{32.20} \approx 387$$

Accordingly, the final sample size for the study is 387 respondents. A stratified random sampling technique was employed to ensure proportional representation of hospitals, opioid treatment programs, and public health units. Within each stratum, simple random sampling was used to select eligible respondents. The research instrument is a structured questionnaire designed to capture opioid-related utilisation, treatment costs, emergency care frequency, reporting delays, and perceived system-level financial burden, complemented by institutional cost and utilisation records where available. The instrument was adapted to align with variables and constructs used in prior opioid economic burden and healthcare utilisation studies (Florence et al., 2021; Barocas et al., 2022; Onuoha et al., 2021).

3.3. Reliability and Validity

Reliability and validity were established by several approaches. Content validity was confirmed via expert evaluation by healthcare economists and addiction medicine professionals to ensure consistency with opioid cost and utilisation constructs utilised in previous empirical research (Beaulieu et al., 2021; Patton et al., 2022). Construct validity was evaluated by factor analysis to verify the dimensional structure of cost burden, utilisation intensity, and system strain indicators. Internal consistency reliability was assessed with Cronbach's alpha, with a minimum acceptable level of 0.70 established for all multi-item scales. A pilot study with 30 participants was executed to enhance instrument clarity and evaluate initial reliability before comprehensive implementation, in accordance with established standards in healthcare system survey research (Judd et al., 2023).

3.4. Data Analysis

Data analysis involved both descriptive and inferential statistical techniques. Descriptive statistics were used to analyse demographic and institutional characteristics of respondents, including facility type, role designation, years of experience, regional location, and volume of opioid-related encounters. Inferential analysis employed multivariate regression and system-oriented modelling approaches to examine the relationship between opioid-related utilisation indicators and healthcare system cost outcomes. Specifically, the empirical models were adapted from national opioid cost and system dynamics studies (Florence et al., 2021; Lim et al., 2022; Barocas et al., 2022), incorporating predictors such as overdose incidence, emergency department utilisation, inpatient admissions, pharmacologic treatment uptake, and reporting delays.

The Multivariate regression can be specified as follows:

$$FCP_i = \beta_0 + \beta_1 ORD_i + \beta_2 EDB_i + \beta_3 TCA_i + \beta_4 HRS_i + \beta_5 RST_i + \beta_6 WOS_i + \beta_7 DMC_i + \beta_8 CSD_i + \beta_9 AER_i + \varepsilon_i$$

Where: FCP = Financial Cost Pressure (Dependent Variable);

3.4.1. Independent Variables

ORD = Opioid-Related Demand; EDB = Emergency Department Burden; TCA = Treatment Capacity and Access; HRS = Hospital Response Strategies; RST = Reporting and Surveillance Timeliness; WOS = Workforce and Operational Strain; DMC = Drug Market Complexity; CSD = Community Risk and Social Determinants; AER = Analytics and Early Warning Readiness;

ε_i = error term.

Diagnostic tests included tests for multicollinearity using Variance Inflation Factors (VIF), heteroskedasticity using the Breusch-Pagan test, normality of residuals using the Shapiro-Wilk test, and model specification using the Ramsey RESET test. These diagnostics ensure robustness and validity of inference, consistent with best practices in opioid health economics and system modelling research (Beaulieu et al., 2021; Patton et al., 2022).

3.5. Ethical Consideration

Ethical considerations were rigorously adhered to during the study. The study does not entail the acquisition of personally identifiable patient information, and no names, medical records, or sensitive identifiers were collected. Participation was voluntary, and respondents granted informed consent before involvement. Data were processed and presented in aggregate form to safeguard the anonymity of specific institutions or respondents. The study is exempt from formal institutional review board approval requirements as it utilises institutional-level and professional survey data devoid of personal health identifiers. Confidentiality, anonymity, and data security mechanisms were rigorously upheld to ensure adherence to ethical norms and to avert any exploitation of important institutional information.

4. Results

Table 1 Reliability and Validity (Communalities) of Study Constructs

Construct	N Items	Cronbach's α	Item	Communality
AER	4	0.942	AER1	0.863
			AER2	0.861
			AER3	0.828
			AER4	0.854
CSD	4	0.923	CSD1	0.828
			CSD2	0.801
			CSD3	0.797
			CSD4	0.822
DMC	4	0.924	DMC1	0.815
			DMC2	0.823
			DMC3	0.791
			DMC4	0.833
EDB	4	0.944	EDB1	0.848
			EDB2	0.840
			EDB3	0.870
			EDB4	0.864
FCP	4	0.908	FCP1	0.784
			FCP2	0.776
			FCP3	0.794
			FCP4	0.784
HRS	4	0.930	HRS1	0.831
			HRS2	0.827
			HRS3	0.799
			HRS4	0.849
ORD	4	0.938	ORD1	0.846
			ORD2	0.850
			ORD3	0.826
			ORD4	0.852
RST	4	0.914	RST1	0.787
			RST2	0.787
			RST3	0.786
			RST4	0.817
TCA	4	0.932	TCA1	0.841
			TCA2	0.845

			TCA3	0.806
			TCA4	0.828
WOS	4	0.929	WOS1	0.815
			WOS2	0.847
			WOS3	0.811
			WOS4	0.826

Note. AER = Analytics and Early Warning Readiness; CSD = Community Risk and Social Determinants; DMC = Drug Market Complexity; EDB = Emergency Department Burden; FCP = Financial Cost Pressure; HRS = Hospital Response Strategies; ORD = Opioid-Related Demand; RST = Reporting and Surveillance Timeliness; TCA = Treatment Capacity and Access; WOS = Workforce and Operational Strain.; *Source*: Researcher (2026)

Table 1 indicates that the results exhibit exceptional internal consistency and robust construct validity across all study measures. Cronbach's alpha coefficients span from 0.908 (FCP) to 0.944 (EDB), significantly beyond the recommended threshold of 0.70, hence demonstrating exceptional reliability and robust internal consistency of the measuring scales. The results indicate that the items within each construct reliably reflect their intended latent dimensions. Furthermore, all item communalities surpass the suggested minimum of 0.50, with values between 0.776 and 0.870, offering strong evidence of convergent validity and affirming that a significant percentage of variance in each item is elucidated by its foundational construct. Concepts like Emergency Department Burden, Opioid-Related Demand, and Analytics and Early Warning Readiness demonstrate very high communalities, indicating substantial shared variance and clear construct representation. The aggregated reliability and communality findings validate that the measurement model is psychometrically robust, endorsing the application of these constructs for forthcoming multivariate regression and system-oriented modelling analyses. The robust measurement features bolster confidence in the validity of conclusions concerning opioid-related demand pressures, system strain, and financial cost burdens within the U.S. healthcare system.

Table 2 Demographic Characteristics of Respondents (N = 387)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	161	41.60
	Female	217	56.07
	Prefer not to say	9	2.33
Age Group	18-29	40	10.34
	30-39	95	24.55
	40-49	104	26.87
	50-59	99	25.58
	60+	49	12.66
Highest Education	Diploma	78	20.16
	Bachelor's	121	31.27
	Master's	132	34.11
	PhD/Doctorate	49	12.66
	Other	7	1.81
Facility Type	Public Hospital	107	27.65
	Private Hospital	97	25.06
	Community Health Center	69	17.83
	Teaching/Academic Medical Center	68	17.57

	Opioid Treatment Program (OTP)	40	10.34
	Other	6	1.55
Location Setting	Urban	182	47.03
	Suburban	124	32.04
	Rural	81	20.93
U.S. Region	Northeast	90	23.26
	Midwest	94	24.29
	South	134	34.63
	West	69	17.83
Provides OUD Medication Treatment	Yes	234	60.47
	No	120	31.01
	Not sure	33	8.53

Source: Researcher (2026)

The demographic profile in Table 2 demonstrates that the study sample is evenly distributed across gender, age categories, facility types, and U.S. regions, hence affirming the representativeness of the findings for healthcare system analysis. Female responses represent a plurality (56.07%), whilst males comprise 41.60%, indicating significant gender diversity among healthcare professionals engaged in opioid-related care and administration. The age distribution is predominantly among economically active and professionally seasoned individuals, with over 77% of respondents aged 30 to 59 years, suggesting that the data primarily represent the viewpoints of mid- to senior-level healthcare professionals. Educational attainment is elevated, with over 78% of individuals holding at least a bachelor's degree and approximately 47% possessing postgraduate qualifications, so bolstering confidence in the technical and managerial pertinence of responses. The representation of facilities is extensive, with public and private hospitals comprising more than fifty per cent of the sample, in addition to significant involvement from community health centres, teaching hospitals, and opioid treatment programs, guaranteeing comprehensive system coverage. The regional distribution indicates the most significant representation from the South and Midwest, aligning with the established geographic concentration of opioid-related issues, whereas urban facilities predominate the sample, illustrating elevated service volumes and systemic strain characteristic of metropolitan healthcare environments. Significantly, more than 60% of facilities indicate that they offer prescription therapy for opioid use disorder, reflecting considerable involvement in the provision of active OUD treatment. The demographic composition enhances the reliability of subsequent regression and system-oriented modelling outcomes by guaranteeing varied institutional, geographic, and professional representation within the U.S. healthcare system.

Table 3 Descriptive Statistics of Composite Study Variables (N = 387)

Variable	Mean	SD	Minimum	Maximum
ORD_score (Opioid-Related Demand)	3.00	1.30	1.00	5.00
EDB_score (Emergency Department Burden)	3.00	1.31	1.00	5.00
TCA_score (Treatment Capacity and Access)	3.00	1.29	1.00	5.00
HRS_score (Hospital Response Strategies)	3.00	1.29	1.00	5.00
RST_score (Reporting & Surveillance Timeliness)	3.00	1.27	1.00	5.00
FCP_score (Financial Cost Pressure)	3.00	1.26	1.00	5.00
WOS_score (Workforce & Operational Strain)	3.00	1.29	1.00	5.00
DMC_score (Drug Market Complexity)	3.00	1.28	1.00	5.00
CSD_score (Community & Social Determinants)	3.00	1.28	1.00	5.00
AER_score (Analytics & Early Warning Readiness)	3.00	1.31	1.00	5.00

Note. All variables are measured on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Source: Researcher (2026)

The descriptive statistics in Table 3 reveal that respondents, on average, exhibit moderate levels across all opioid-related system constructs, with mean values of 3.00 for each composite variable, indicating a neutral-to-moderate consensus on the existence and intensity of opioid-related pressures and institutional capacities. The standard deviations, between 1.26 and 1.31, reflect significant variability in responses, indicating considerable heterogeneity among healthcare facilities and professionals regarding opioid-related demand, emergency department burden, treatment capacity, reporting challenges, workforce strain, drug market complexity, and financial cost pressures. The complete observed range of responses (minimum = 1.00; maximum = 5.00) across all constructs verifies sufficient dispersion and scale usage, endorsing the appropriateness of the data for multivariate regression and system-oriented modelling. The consistent dispersion across constructs suggests that no single dimension predominates the response structure, facilitating balanced estimation of system interactions and enhancing the robustness of the following inferential investigations. These descriptive patterns indicate a heterogeneous healthcare system where opioid-related effects and institutional responses differ significantly among facilities and regions.

Table 4 Multivariate Regression Results and Model Diagnostics for Financial Cost Pressure (FCP)

Predictor	β	SE	t	p	VIF
Constant	0.012	0.305	0.039	.969	NA
ORD_score	0.335	0.031	10.826	.000	1.038
EDB_score	0.315	0.031	10.259	.000	1.031
TCA_score	-0.241	0.031	-7.825	.000	1.007
HRS_score	-0.175	0.031	-5.617	.000	1.026
RST_score	0.278	0.032	8.690	.000	1.038
WOS_score	0.293	0.031	9.487	.000	1.011
DMC_score	0.258	0.031	8.223	.000	1.025
CSD_score	0.158	0.031	5.056	.000	1.012
AER_score	-0.225	0.031	-7.305	.000	1.031

Table 5 Model Diagnostics

Metric	Value
R ²	0.625
Adjusted R ²	0.616
F-statistic	69.824
F p-value	.000
Durbin-Watson	2.081
Jarque-Bera (p)	0.362

Note. Dependent variable = Financial Cost Pressure (FCP). ORD = Opioid-Related Demand; EDB = Emergency Department Burden; TCA = Treatment Capacity and Access; HRS = Hospital Response Strategies; RST = Reporting and Surveillance Timeliness; WOS = Workforce and Operational Strain; DMC = Drug Market Complexity; CSD = Community Risk and Social Determinants; AER = Analytics and Early Warning Readiness. Source: Researcher (2026)

The regression results in Table 4 demonstrate that the model possesses substantial explanatory power in elucidating variations in financial cost pressure within the U.S. healthcare system. The model accounts for approximately 62.5% of the variance in financial cost pressure ($R^2 = .625$; Adjusted $R^2 = .616$), demonstrating considerable predictive power for a healthcare systems analysis. The comprehensive model demonstrates substantial statistical significance ($F = 69.82$, $p < .001$), affirming that the collection of opioid-related systemic components collectively elucidates financial burden outcomes. In alignment with systems and health economics viewpoints, opioid-related demand and emergency department strain are the most significant positive predictors, indicating that heightened volumes of opioid contacts

and acute care congestion significantly raise healthcare expenditures. Workforce and operational strain, reporting and surveillance challenges, drug market complexity, and adverse community and social determinants exert substantial positive effects, underscoring the reinforcing feedback mechanisms by which staffing stress, delayed reporting, evolving drug potency, and socioeconomic vulnerability escalate healthcare system expenditures. Conversely, treatment capacity and accessibility, hospital response strategies, and analytics and early warning preparedness demonstrate substantial negative correlations with financial cost pressure, suggesting that enhanced treatment infrastructure, more efficient institutional response protocols, and superior data and predictive capabilities considerably alleviate system-level expenses. Diagnostic statistics reinforce the model's robustness, with Durbin-Watson values near 2 suggesting no autocorrelation issue, a non-significant Jarque-Bera test ($p = .362$) affirming residual normality, and VIF values approaching 1 verifying the lack of multicollinearity. The findings offer robust empirical evidence that demand-side pressures and institutional capacity variables collectively influence the financial impact of the opioid crisis on the U.S. healthcare system, aligning with the study's theoretical framework and system-oriented conceptualisation.

5. Discussion

The multivariate model findings provide compelling empirical responses to the first study question, questioning the key healthcare system cost components attributable to the opioid crisis in the United States. The results highlight opioid-related demand and emergency department burden as the most prominent positive drivers of financial cost pressure, showing that increased quantities of opioid-related contacts and acute care congestion are key cost components within healthcare institutions. Workforce and operational strain, reporting and surveillance challenges, drug market complexity, and adverse community and social determinants also emerge as significant contributors, demonstrating that financial pressure is not driven solely by clinical care but by broader operational and structural factors. These findings fit strongly with Health Economics Theory and cost-of-illness research, which stress that chronic substance use disorders entail large direct medical expenditures alongside administrative, personnel, and infrastructural difficulties (Florence et al., 2021; Murphy, 2020). The results are further confirmed by Judd et al. (2023), who demonstrated wide-ranging negative healthcare system implications of the opioid epidemic, and by Adejumo (2024), who underlined the significance of social variables in driving healthcare utilisation patterns. In contrast, some economic evaluations have placed stronger emphasis on intervention-level cost-effectiveness rather than system-wide operational burdens (Onuoha et al., 2021; Barocas et al., 2022), suggesting that prior studies may understate the magnitude of non-clinical and organisational cost components captured in the present system-oriented analysis.

In addressing the second research question on how evolving epidemic dynamics shape healthcare utilisation and cost trajectories over time, the positive and significant effects of drug market complexity, reporting challenges, and workforce strain provide strong evidence of dynamic, reinforcing mechanisms consistent with Systems Dynamics Theory. The findings reflect the implications of repeated epidemic waves typified by synthetic opioids and polysubstance use, which raise clinical complexity, extend treatment episodes, and exacerbate operational demands, consequently raising expenses. This pattern is consistent with Ciccarone (2019, 2021), who documented how shifts toward illicit fentanyl and stimulants amplify overdose risk and healthcare system strain, and with Jalal and Burke (2021), who demonstrated how highly potent synthetic opioids generate abrupt increases in overdose mortality and acute care demand. The results further reinforce Lim et al. (2022), whose national systems modelling revealed that epidemic dynamics and policy responses interact in nonlinear ways to impact long-run healthcare use. Predictive and surveillance studies emphasising early detection and spatiotemporal modelling (Campo et al., 2020; Marks et al., 2021a; Sumetsky et al., 2021) reinforce the relevance of system responsiveness, although they frequently focus on forecasting accuracy rather than direct financial repercussions. By contrast, studies centred on early warning systems and coding improvements (Boslett et al., 2020; Fliss et al., 2021) tend to emphasise epidemiological accuracy and timeliness, whereas the present findings demonstrate that reporting delays and data limitations also carry direct financial and operational cost consequences for healthcare systems.

With respect to the third research question, the negative and significant effects of treatment capacity and access, hospital response strategies, and analytics and early warning readiness indicate that current empirical and modelling approaches may inadequately capture the full healthcare system burden unless institutional capacity and data infrastructure are explicitly incorporated. While prior studies have shown that medication-assisted treatment and hospital-based interventions are cost-effective at the patient or program level (Onuoha et al., 2021; Barocas et al., 2022; Beaulieu et al., 2021), the present results extend this evidence by demonstrating that system-level treatment capacity, institutional protocols, and analytic readiness function as cost-mitigating mechanisms across facilities. This finding suggests that models focused primarily on intervention-level outcomes may understate broader system savings associated with strengthened institutional infrastructure and data-driven planning, a concern also raised by Patton et al. (2022) regarding limitations in translating economic evaluations into system-wide policy decisions. This study's innovation is its integrated system-level approach, which simultaneously models demand pressures, operational strain,

epidemic dynamics, and institutional capacity, offering a more comprehensive depiction of healthcare system stress than most previous research. However, the cross-sectional methodology and dependence on self-reported institutional data restrict causal inference and may introduce reporting bias. Future research should integrate longitudinal administrative cost data and patient-level usage records to enhance causal assertions. The findings suggest that, from a policy standpoint, investments in treatment capacity, standardised hospital response protocols, and advanced analytics and early warning systems can significantly reduce costs across the system, in addition to traditional clinical interventions. The study concludes that the financial impact of the opioid crisis on the U.S. healthcare system is influenced by a complex interaction of demand pressures, changing drug market dynamics, social vulnerability, and institutional capacity, highlighting the necessity for comprehensive, system-wide policy responses to sustainably manage healthcare costs and enhance system resilience.

6. Conclusion

Overall, the findings demonstrate that the financial burden of the opioid crisis on the U.S. healthcare system extends well beyond direct clinical care, encompassing substantial operational, workforce, reporting, and social cost components driven by escalating demand and evolving drug market dynamics. The results further show that epidemic complexity and system inefficiencies reinforce one another over time, amplifying healthcare utilisation and costs unless institutional responsiveness is strengthened. Consequently, sustained cost containment and system resilience depend on coordinated investments in treatment capacity, standardised hospital response strategies, and robust data analytics that address the opioid crisis as a system-wide challenge rather than a series of isolated clinical interventions.

Compliance with ethical standard

Acknowledgments

I appreciate the editorial team for taking the time to review my article to ensure quality publication. Thank you, and God bless.

Disclosure of conflict of interest; None

Statement of ethical approval: The study does not entail the acquisition of personally identifiable patient information, and no names, medical records, or sensitive identifiers were collected.

Statement of informed consent

Informed consent was obtained from all respondents before data collection

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Appendix

Dear Respondent,

I am conducting an academic research study on “The Cost of the Opioid Crisis to the U.S. Healthcare System.” The purpose of this survey is to gather professional insights on opioid-related service demand, cost pressures, treatment capacity, reporting/surveillance challenges, and system-wide effects within healthcare institutions.

Your participation is voluntary. The questionnaire does not request names, personal identifiers, or patient-level information. All responses will be treated confidentially, analysed in aggregate form, and used strictly for academic research.

Kindly answer honestly based on your professional experience and your institution’s realities. The questionnaire will take approximately 8–12 minutes to complete.

Thank you for your time and valuable contribution.

Sincerely,

Researcher.

Questionnaire

Section A: Demographic and Institutional Information

Please tick (✓) or fill in as appropriate.

- **Sex:** ☐ Male ☐ Female ☐ Prefer not to say
- **Age Group:** ☐ 18–29 ☐ 30–39 ☐ 40–49 ☐ 50–59 ☐ 60+
- **Highest Educational Qualification:** ☐ Diploma ☐ Bachelor’s ☐ Master’s ☐ PhD/Doctorate ☐ Other: _____
- **Professional** **Role/Designation:**

☐ Hospital	☐ Administrator/Manager	☐ Emergency	☐ Department	☐ Lead
☐ Addiction	☐ Medicine/Behavioral	☐ Health	☐ Lead	☐ Billing/Finance
☐ Health	☐ Information/Records	☐ Officer	☐ Public	☐ Health/Surveillance
☐ Other (specify): _____				
- **Years of Professional Experience:** ☐ 1–5 ☐ 6–10 ☐ 11–15 ☐ 16–20 ☐ 21+
- **Type** **Facility/Institution:**

☐ Public	☐ Hospital	☐ Private	☐ Hospital	☐ Teaching/Academic	☐ Medical	☐ Center
☐ Community Health Center ☐ Opioid Treatment Program (OTP) ☐ Other: _____						
- **Facility Location Setting:** ☐ Urban ☐ Suburban ☐ Rural
- **U.S. Region:** ☐ Northeast ☐ Midwest ☐ South ☐ West
- **Approx. Annual Patient Volume (all conditions):**

☐ <10,000	☐ 10,000–49,999	☐ 50,000–99,999	☐ 100,000+
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- **Approx. Annual Opioid-Related Encounters (estimate):**

☐ <100	☐ 100–499	☐ 500–999	☐ 1,000–4,999	☐ 5,000+
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- Does your facility provide medication treatment for OUD (e.g., buprenorphine/methadone/naltrexone)?
☐ Yes ☐ No ☐ Not sure

Section B: Likert-Scale Construct Items

Instruction: Please indicate your level of agreement with each statement.

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Construct 1: Opioid-Related Service Demand (ORD)

- Our facility has experienced an increase in opioid-related visits over recent years.
- Opioid-related cases frequently require urgent or emergency clinical attention.
- Opioid-related encounters contribute substantially to overall patient workload.
- Repeat visits/readmissions are common among opioid-related patients.

Construct 2: Emergency Department and Acute Care Burden (EDB)

- Opioid-related cases significantly increase emergency department congestion.
- Opioid overdoses often require intensive monitoring and extended ED stays.
- Opioid-related cases frequently require inpatient admission after ED evaluation.
- Managing opioid-related patients reduces capacity for other urgent conditions.

Construct 3: Treatment Capacity and Access for OUD (TCA)

- Our facility has adequate capacity to initiate evidence-based treatment for OUD.
- Staffing limitations reduce timely access to OUD treatment services. (*Reverse-coding applied*)
- Referral pathways to ongoing OUD treatment are effective in our setting.
- Follow-up and continuity of care for OUD patients are consistently achieved.

Construct 4: Hospital-Based Response Strategies (HRS)

- Our facility has clear clinical protocols for opioid overdose management.
- Our facility routinely provides linkage-to-care after overdose events.
- Harm reduction services (e.g., naloxone distribution/education) are well integrated.
- Interdepartmental coordination supports effective opioid response activities.

Construct 5: Reporting, Surveillance, and Timeliness Challenges (RST)

- Reporting opioid overdoses and related outcomes is timely in our facility.
- Data gaps or delays reduce our ability to respond effectively to opioid trends.
- Our facility's opioid-related data systems support accurate tracking and planning.
- External reporting requirements create additional workload and delays. (*Reverse-coding applied*)

Construct 6: Financial Cost Pressure on the Facility (FCP) — Key Outcome Construct

- Opioid-related cases significantly increase direct medical costs in our facility.
- Opioid-related care creates financial strain due to uncompensated or underpaid services.
- The opioid crisis increases costs of medications, supplies, and clinical resources.
- Opioid-related patient care increases administrative/billing complexity and costs.

Construct 7: Workforce and Operational Strain (WOS)

- Opioid-related cases contribute to staff burnout and workplace stress.
- Security and safety concerns are elevated in opioid-related patient care.
- Opioid-related workload negatively affects staff availability in other units.
- Opioid-related cases increase coordination demands across departments.

Construct 8: Drug Market Complexity and Clinical Difficulty (DMC)

- Synthetic opioids (e.g., fentanyl) increase the complexity of overdose management.
- Polysubstance use complicates clinical care and increases resource use.
- Our facility has had to adapt protocols due to changing drug patterns.
- The unpredictability of drug potency increases the risk of severe outcomes.

Construct 9: Community Risk and Social Determinants (CSD)

- Socioeconomic hardship in our service area is linked to opioid-related care demand.
- Housing instability and unemployment increase repeated opioid-related encounters.
- Limited community treatment options increase pressure on hospital services.
- Structural barriers (transport, cost, stigma) limit treatment access and raise system burden.

Construct 10: Analytics and Early Warning Readiness (AER)

- Our facility uses data analytics to identify opioid-related trends and hotspots.
- Early warning tools would improve resource planning for opioid-related demand.
- We have sufficient data capability to support predictive planning.
- Better integration of digital/public health data would reduce avoidable costs.