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A Narrative Review of Literature Examining Studies Researching the Impact of Law on Health and Economic Outcomes

Dawn A. Pepin, JD, MPH,

Rebekah St. Clair Sims, PhD,

Jaya Khushalani, PhD,

Lauren Tonti, JD MPH,

Megan A. Kelly, JD, MPH,

Suhang Song, PhD,

Aziza Arifkhanova, PhD,

Rachel Hulkower, JD, MSPH,

Brian H. Calhoun, PhD,

Richard W. Puddy, PhD,

Jennifer W. Kaminski, PhD

Centers for Disease Control and Prevention, Atlanta, GA, Office of Policy, Performance, and Evaluation (Dawn Pepin - Public Health Analyst, Rebekah St. Clair Sims - Public Health Advisor, Jaya Khushalani – Health Economist, Megan Kelly – Health Policy Scientist, Aziza Arifkhanova – Health Economist, Richard Puddy – Director, Jennifer Kaminski – Lead Health Scientist) and the Office of Public Health Law Services, National Center for State, Tribal, Local, and Territorial Public Health Infrastructure and Workforce (Rachel Hulkower – Public Health Analyst).

The Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN (Lauren Tonti – Fellow, Suhang Song – Fellow, Brian Calhoun – Fellow)

Abstract

Context: Public health policy can play an important role in improving public health outcomes. Accordingly, there has been an increasing emphasis by policy makers on identifying and implementing evidence-informed public health policy interventions.

Program or Policy: Growth and refinement of the field of research assessing the impact of legal interventions on health outcomes, known as legal epidemiology, prompted this review of studies on the relationship between laws and health or economic outcomes.

Implementation: Authors systematically searched 8 major literature databases for all English-language journal articles that assessed the effect of a law on health and economic outcomes

Corresponding Author: Dawn A. Pepin, JD, MPH, Office of Policy, Performance, and Evaluation, Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, H21-11, 1600 Clifton Rd., NE, Atlanta, Georgia 30333 (dpepin@cdc.gov).

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published between January 1, 2009, and September 18, 2019. This search generated 12,570 unique articles 177 of which met inclusion criteria. The team conducting the systematic review was a multidisciplinary team that included health economists and public health policy researchers, as well as public health lawyers with expertise in legal epidemiological research methods. The authors identified and assessed the types of methods used to measure the laws' health impact.

Evaluation: In this review the authors examine how legal epidemiological research methods have been described in the literature as well as trends among the studies. Overall, three major themes emerged from this study: (1) limited variability in the sources of the health data across the studies, (2) limited differences in the methodological approaches used to connect law to health outcomes, and (3) lack of transparency surrounding the source and quality of the legal data relied upon.

Discussion: Through highlighting public health law research methodologies, this systematic review may inform researchers, practitioners, and lawmakers on how to better examine and understand the impacts of legal interventions on health and economic outcomes. Findings may serve as a source of suggested practices in conducting legal epidemiological outcomes research and identifying conceptual and method-related gaps in the literature.

Keywords

public health; legal epidemiology; economic; health services

Introduction

Public health policy[a] is one essential lever utilized to improve public health outcomes.[1–3] Overtime, there has been increasing emphasis by lawmakers and other policy makers on the identification and implementation of evidence-informed public health policy interventions shown to improve health outcomes.[4,5,6] The field of policy analysis broadly seeks to identify which policy interventions are the most effective. However, the unique complexities of law[b] led to the development of a field specific to assessing the impact of legal interventions on health outcomes, known as legal epidemiology. Legal epidemiology is "the study of law as a factor in the cause, distribution, and prevention of disease and injury."[7]

Legal epidemiological studies can serve an important role in the development of evidence-based public health policy.[7] However, to develop credible evidence of a law's impact on health and economic outcomes, the quality—of both (1) the legal data and extraction methods and (2) the outcomes data and research methods—matter. Combining these approaches to produce quality evidence increases study reliability and, as a result, can better inform policy makers seeking to draw upon this body of evidence to identify what works (i.e., evidence-informed interventions).[7] These studies, when conducted using established and replicable methods, can serve various purposes, including supporting the identification of the necessary core components of a successful legal intervention, shedding light on how laws affect health and economic outcomes in different communities in different ways, or in highlighting how laws can have unintended consequences.[8,9]

[a]CDC defines policy as "a law, regulation, procedure, administrative action, incentive, or voluntary practice of governments and other institutions."
[b]Defined herein as constitutions, statues and ordinances, regulations, and caselaw.

There are recommended standards for legal epidemiological research, including scientific legal mapping (i.e., the development of data about law following a systematic approach),[10] however, it is not currently known to what extent these standards are being utilized and reported on in health and economic studies. With this review, the authors sought to (1) identify how scientific legal mapping is described and used in health and economic outcomes studies, and (2) understand and analyze the methods used in research studying the connection between laws and health or economic outcomes in research. A previous review looked specifically at CDC authored articles[11]; however, no recent review has studied the larger body of literature to identify trends and patterns. To address this gap, the authors conducted this review investigating trends in those studies examining the relationship between laws and health or economic outcomes, in order to describe the quality of such research.

Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[12] However, given the considerable scope of the research question, each paper was reviewed by only one reviewer during screening and selection.

Study identification and selection

The authors searched Medline (OVID), PsycInfo (OVID), CINAHL (Ebsco), EconLit (Ebsco), Scopus, Public Health Database (ProQuest), Sociological Abstract (ProQuest), and ERIC (ProQuest) for all English-language journal articles that assessed the effect of a law on health or economic outcomes published between January 1, 2009, and September 18, 2019 (full search strings for each database are shown in the Supplemental Digital Content Table A[13]). This date range was chosen to capture the time period during which legal epidemiological methods and terminology were first being utilized in the field[3,11,14,15]. Authors uploaded all references to Covidence systematic review software (https://covidence.org), which removed duplicate entries. Authors conducted title, abstract, and full-text screening using Covidence software. The team conducting the review was a multidisciplinary team that included health economists and public health policy researchers (methods team – AA, BC, JK, RS, SS) and public health lawyers with expertise in legal epidemiological research methods (legal team – DP, LT, MK, RH). Rather than duplicating review for inclusion, every author (AA, BC, JK, SS, DP, LT, MK, RH) screened a subset of the articles during the title, abstract, and then full text review stages. RS joined the methods team during data extraction. There was no duplication of review of the studies for inclusion.

The authors excluded studies both during the title and abstract screening, as well as during the full-text screening when exclusion criteria was not identified in the title and abstract screening alone. Authors excluded studies not specific to the United States, non-empirical studies, qualitative analysis studies, commentaries, review articles, grey literature, conference proceedings, dissertation theses, case studies, and book chapters. Further, only studies with a health outcome (defined here as mortality, morbidity or disease diagnosis, injury, self-reported physical or mental health status, and utilization of a drug or health service) or economic outcome (e.g., cost of care or reimbursement for medical services)

were included. Due to the scope of this review, studies linking laws to mediating factors alone such as health-related behaviors (e.g., smoking or diet) or upstream factors such as social determinants of health[16] (e.g., homelessness or insurance coverage) when not linked directly to health outcomes, were excluded. Studies on laws related to immigration, prisons, and the military were also excluded given their unique contexts and implications for morbidity and mortality. Finally, authors limited this review to multi-site studies, that is, studies that examined impacts of laws across multiple jurisdictions or at the federal level. Examining the impact of a law on an outcome across multiple different sites includes varying contexts in which a law was implemented, thereby potentially offering a more robust and thorough study of the law's impact across different populations, and demographics.

Data extraction

Both a legal team member and a methods team member reviewed and analyzed the extent to which each study included the different elements and extracted data from all included full texts. As an additional quality check, two researchers (SD and JM) who were not part of the screening and extraction teams reviewed 20% of all the extracted studies, selected at random, for accuracy and consistency. Discrepancies at any stage of study selection or data extraction were resolved by consensus.

Both the methods team and legal team members worked together to identify key elements that demonstrate research rigor and relevance and developed a comprehensive checklist that was guided by multiple sources. The compiled Legal Epidemiological Outcomes Research Checklist can be found in the Supplemental Digital Content Table B.[13] The checklist has two parts: legal research elements (scientific legal mapping) and methods elements (study design and analytics). The scientific legal mapping components were informed by the CDC's Legal Epidemiology Competency Model[17] and modeled largely on Presley's Standards of Policy Surveillance Derived from Likert-Scale Questions with Corresponding Scores, which covers methods associated with legal epidemiological research including scientific legal mapping.[15] The study design and analytic components of the checklist were adapted from three commonly used checklists[18–20] for observational and quasi-experimental studies (Joanna Briggs Institute Checklist for Quasi-Experimental Studies, the Strengthening the Reporting of Observational Studies in Epidemiology [STROBE] checklist for cohort, case-control, and cross-sectional studies [combined], and the Johns Hopkins Nursing Evidence-Based Practice Research Evidence Appraisal Tool).

Regarding study design and methods, elements were included to determine whether: the article explicitly identified the knowledge gap the study was filling; there was a control group; the control and treatment groups were matched; there were measurements of the outcome before and after an intervention; the methods used were valid and reliable; all statistical methods were described; sensitivity analyses or robustness checks were conducted; and there was a discussion of limitations and cautious interpretation of findings.

For additional context about the studies, the authors extracted: year of publication, type of law (e.g., state, local, or federal law), the type of health or economic outcomes studied (e.g., morbidity, mortality, cost, etc.) and the rationale for inclusion of that specific outcome, type of health or economic dataset used (e.g., claims/prescription data, survey data, patient/

disease registry), and details about the study design (level of analysis, whether study was panel, cross-sectional, or pooled cross-sectional, statistical analytic method used, whether and how researchers controlled for confounding effects, and method used).

Data analysis

The authors used only descriptive statistics to determine trends across all extracted legal and methodological study components described above to determine how each study was conducted both overall across all years and over time. All quantitative analyses were conducted using Stata 15 (StataCorp LLC).

Results

Literature searches identified 12,570 unique citations. Of these, 930 were potentially relevant based on title and abstract screening (see Figure 1 for PRIMA flow diagram). Detailed review of full texts ultimately yielded 177 studies that met the inclusion criteria, reporting on a total of 1,002 statistical relationships (Figure 1). Table 1 shows the included studies and selected variables coded for analysis. The number of studies that met the inclusion criteria generally increased over time, from 11 studies published in 2009 to 32 studies published in 2019. Overall, nearly all studies (95%) examined the impact of state-level laws, with just 5% of studies looking at federal law, local laws, or a combination of jurisdictional levels (not shown). The rationale for the study was most often established by citing scientific literature, however, in 5% of coded relationships across all studies proposed causal pathway in the form of a logic model or conceptual model (not shown).

Legal components

Table 2 displays the frequencies for the legal extraction elements. In 92% of studies, the source of the legal data was identified, meaning that 8% of the studies did not provide a citation to or describe the source of their legal data. Among those studies that identified the source of the legal data, more than half relied upon external sources, primarily websites (40%), articles (10%), or a combination of external sources, such as data from both a website and an article (combination of secondary sources: 11%). These external sources refer to websites summarizing the status of the law or articles describing the law rather than those reporting the written language of the law.

Among the studies that identified the source of the legal mapping study, 14% indicated that the legal mapping, analysis, and coding of the laws to generate the legal data were conducted by researchers as part of their study (Table 2). The largest percentage of studies (53%) cited an external entity as the source that generated the legal mapping study. Of the studies, 26% were also categorized as having a “mixed” source, meaning that the study authors obtained legal data from an external source and conducted some original analyses (e.g., additional years of data generated and added to the legal dataset; effective dates for laws in existing dataset were identified; or new coding questions were included; and additional data were added to the dataset).

The authors used discussion of or reference to a search string as one proxy for application of scientific legal mapping research methods. While 6% of the studies overall referred to

using a search string, among the 14% of studies where an original legal mapping study was conducted as part of the study, a quarter (25%) referred to a search string.

While only 19% of the total studies had a legal member on the team, 54% of those who conducted their own scientific legal mapping had a legal member on the team. There were no clear patterns over time regarding the source of legal data used in studies relating law to health or economic outcomes.

Research design and methods components

Table 3 shows the methodological characteristics of the included studies and their patterns. Studies often presented results on multiple outcomes, therefore each outcome was coded as a separate finding. Percentages in this section represent percent of the 1002 statistical relationships coded. Of the outcomes studied, mortality/fatality (34%) and utilization of services (32%) were most common, with cost/charges and self-reported health status being the least common (6% and 4%, respectively). Studies commonly used reporting systems as their health or economic outcomes data source (e.g., CDC Wonder, FBI Crime Reports) (44%). Half of the analyses were conducted at the state level. The majority of studies examined outcomes over time (80%), with panel-based studies being the most popular across studies overall (53%). Regression-based methods were the primary research method used (75%), especially regression methods that did not use Difference in Difference (DiD) approaches (51% across all studies). Nearly 44% incorporated fixed and/or random effect modeling.

Of the methods classified as “Other” (13%), only 3% of relationships studied were descriptive or qualitative in nature, 30% used structural equation models, 31% used Analysis of Variance/Covariance (ANOVA/ANCOVA), 11% used chi-square tests, and 10% used t-tests (or other parametric) or non-parametric tests.

Additional methodological characteristics include the use of a control or comparison group, method used for matching, and whether researchers conducted sensitivity or robustness checks. Regarding the control or comparison groups, nearly all (94%) used a control or comparison group, most commonly matching control and treatment groups via multiple control variables (52%). For sensitivity or robustness checks, these were conducted for fewer than half of all relationships studied (46%). Ultimately, across all relationships studied, 63% were found to have a significant effect between the legal intervention and the health or economic outcome(s) of interest in the expected direction based on the logic model or a priori hypotheses specified. Another 1% of relationships coded found a significant effect in the opposite direction as expected.

Integrating legal and design methods checklists

The review checklist was derived from multiple existing checklists outlining important components of research studies. Largely because the combined checklist did not go through a validation process, the authors did not quantify a quality score. However, in examining whether each study included the legal and methods components from the checklists, the authors found that many studies did not include (or did not describe) various checklists components in their study (notably for legal components). The authors did find multiple

studies that included most of the items on both the legal and methods checklists: Bian (2009), Gertner (2018), Hasin (2017), and McGinty (2016). These studies may provide insights to those conducting research on the impact of law on health and economic outcomes, as well as insights to the body of research itself as it continues to grow. Future researchers may seek to build upon or validate the Legal Epidemiological Outcomes Research Checklist (Supplemental Digital Content Table B[13]).

Implications for Policy or Practice

- Legal epidemiological studies linking law to health or economic outcomes can play an important role in the development of evidence-based policy.
- To develop credible evidence of a law's impact on health and economic outcomes, the quality of both the legal data and extraction methods, as well as the outcomes data and research methods matter. Findings regarding variability and transparency show considerable differences across existing studies, which may ultimately have implications on the quality of the evidence base and replicability of studies.
- In the era of data modernization, artificial intelligence, and big data, access to new data sources may be possible and may be helpful in facilitating the use of a wider range of methods, expanding how outcomes and influencing factors are considered, measured, and defined.
- Health and economic researchers as well as policy makers may want to consider using legal data from scientific legal mapping research studies that have clearly described their legal methods to further refine the concept of quality legal analysis.
- Renewed consideration of transparency, replicability, and choosing data and methods that fit the research question may benefit researchers, reviewers, and policy makers seeking to link legal and data methods productively.

Discussion

Acknowledging that the parameters of this review were narrow, the patterns that emerged from this study may still have implications for future researchers, reviewers, and policy makers as they both develop and consume research. This is particularly true both given the increase in the number of studies over time (Table 1) along with the establishment of the field of legal epidemiology. The identification of where gaps exist may be valuable as the field continues to expand.

Three major themes emerged from this study: (1) limited variability in the sources of the health data across the studies, (2) limited differences in the methodological approaches used to connect law to health outcomes, and (3) lack of transparency surrounding the source and quality of the legal data relied upon.

First, existing research largely relied on similar data sources. Thus, studies conducted may be subject to similar data limitations and scope of how outcomes are defined and measured.

This may be especially true given that some data sources, such as electronic health records and claims data, are not primarily generated for research purposes.[21,22] However, data sources may lack the geographical granularity required for assessing the impact of laws. The lack of granularity in many datasets may also explain why most studies use similar data sources.

Second, there was little variability in methodological approaches (Table 3). The approach taken may be dependent on the data and software available, ultimately limiting the selection of study methods. The background and training of the researchers may also explain some of the lack of variability in methods. Ultimately, the limited use of sensitivity analyses or robustness checks may reflect the lack of researchers approaching the relationship between law and outcomes in multiple ways.

Third, legal mapping methods were generally not well-described. Although 92% of studies provided a source for the legal data, most did not discuss scientific legal mapping methods used (e.g., search string referenced in 6% of studies) or provide a discussion of the validity of the legal data relied on. The most common legal sources (websites and articles) can vary greatly in terms of quality of methods used to generate the legal data provided,[15] the lack of thorough and rigorous description of the legal methods used in a study made it difficult to assess the quality of secondary sources of legal data.

This study has a few notable limitations. These findings may not generalize beyond the included review parameters. Additionally, very few studies included information about the legal component, thus it was difficult to evaluate how closely the legal data aligned with the checklist. Examination of the details of external legal sources were not within the scope of this review. Also, as mentioned above, the checklists were used to demonstrate important study components but were not quantified with a quality score. Finally, measuring the language variations of a law as written does not equate to measuring the implementation or enforcement of the law in practice.

These results have several possible implications. In the era of data modernization, artificial intelligence, and big data, access to new data sources may be possible and may be helpful in facilitating the use of a wider range of methods, expanding how outcomes and influencing factors are considered, measured, and defined. Currently, the lack of methodological variability and advanced methods for modelling and controlling for confounders, may affect how the researchers understand phenomena and what decisions are made about enacting policies that influence health. The impact of a legal intervention on a health outcome may be more thoroughly understood if studied utilizing wider variety of methodological approaches. Different approaches may enable assessment of phenomena from a different viewpoint. While there is no single approach best suited for all research questions, methods like multilevel analysis and ARIMA methods may provide more accurate estimates of a law's impact.[23,24] These methods may also better align with the logic and conceptual models used. Sensitivity analyses can also help improve the rigor of a study, especially when examining the impact of complex laws on health or economic outcomes, by testing for robustness of findings.[25] Multiple mediating and moderating factors may affect this relationship. Where feasible, allowing the research question to guide the appropriate methods and sources,[26]

instead of choosing research questions based on availability of data and the training of the researchers, may be a productive approach.

Second, similar to health data, a robust transparent description of the legal data sources' strengths and weaknesses may help others to determine the validity of the study outcomes.[14] Without accurate data about the laws, any analysis conducted may not result in accurate information about the impact of the law on health and economic outcomes, and decisions made based on that information may not result in the intended outcomes.[14] Health and economic researchers and decision-makers may want to consider using legal data from scientific legal mapping research studies that have clearly described the legal methods to further refine the concept of quality legal analysis. Additionally, to identify those studies relying on research using methods to create a strong foundation for outcomes research, reviewers for journals may consider requesting additional information about important elements of legal epidemiological research be documented and journals can seek reviewers with experience in scientific legal mapping. Finally, policy decision-makers may also want to consider if studies have documented the source and methods utilized to collect the legal data as well as the health data, to ensure evidence-based policy making.

It may be helpful to use the elements in the Legal Epidemiological Outcomes Research Checklist (Supplemental Digital Content Table B[13]), which is grounded in CDC's Legal Epidemiology Competency Model and Presley's *Standards of Policy Surveillance*[17] when evaluating whether to use or rely upon an available legal source. Documenting those elements as the reason an author determined an existing legal source was reliable could provide clarity and transparency for reviewers and readers. Future research could also seek to continue to build upon and validate the Legal Epidemiological Outcomes Research Checklist (Supplemental Digital Content Table B[13]), utilizing the elements derived from the sources above as a starting point, and determine whether it could represent quantifiable quality scores and potentially serve as a standard for publication of legal epidemiological outcomes research.[23,24]

The findings regarding variability and transparency show considerable differences across existing studies, which may ultimately have implications on the quality of the evidence base and replicability of studies. To produce high quality studies, researchers may want to consider taking an integrative approach: incorporating scientific legal mapping and legal epidemiological research design, incorporating unique data and methods where applicable, and doing so early in the research process. This approach could enable not only study replicability but also allow for accountability, where the field upholds standards of rigorous and quality work to advance public health.

Conclusion

The results of this review indicate that the field of legal epidemiology is growing. As this growth continues, revisiting the interdisciplinary nature of the studies linking law to health or economic outcomes provides continuing opportunities to learn from advances in the fields in both component parts. The findings from this study underscore that there are multiple avenues that scholars may take to continue to expand knowledge regarding the legal

interventions and health or economic outcomes as well as the integrated approach used to examine the relationship between the legal interventions and health or economic outcomes. Renewed consideration of transparency, replicability, and choosing data and methods that fit the research question may benefit researchers, reviewers, and policy makers seeking to link legal and data methods productively and enact evidence-based health policies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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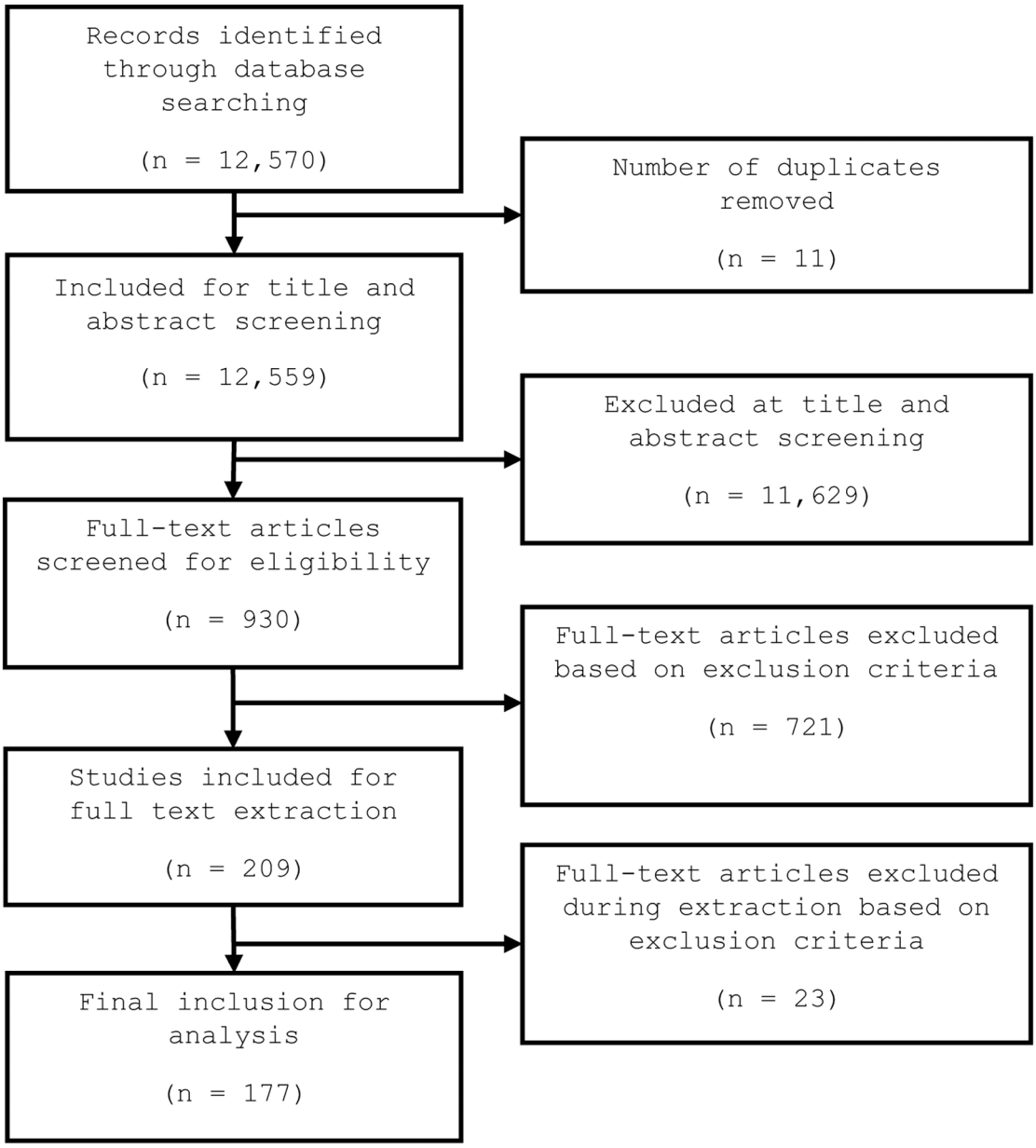

FIGURE 1:
PRISMA Flow Diagram

Table 1:

Studies and Selected Variables

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Abouk	2013	Road & Motor Vehicle Safety	State	Original Legal Mapping	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Agimi	2018	Road Safety and Health/ Healthcare	State	External	No	Utilization of services	Healthcare administrative data	Regression without DiD
Alban	2018	Firearms	State	External	No	Mortality/ fatality	Healthcare administrative data	Regression without DiD
Al-Shammari	2017	Substance Abuse/Mental Health and Health/ Healthcare	Federal	External	No	Utilization of services	Healthcare administrative data	Interrupted Time Series/ ARIMA
Andreyeva	2018	Social and public benefits	State	External	No	Utilization of services; Self-reported health status	Survey data	Regression with DiD
Anestis	2017	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Other
Anestis	2015	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Other
Anestis	2015	Firearms	State	Mix	No	Mortality/ fatality	Other reporting systems	Other
Angelotta	2016	Welfare (elder/ child)	State	External	No	Utilization of services	Other	Regression without DiD
April	2011	Healthcare Services	State	Mix	No	Morbidity/ disease/ injury	Other	Other
Arnold	2018	Other	State	Mix	No	Self-reported health status	Survey data	Regression without DiD
Atkins	2014	Insurance and healthcare costs	State	External	No	Utilization of services	Survey data	Regression with DiD
Aydelotte	2019	Substance Abuse/Mental Health and Road Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Bachhuber	2014	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Bailey	2018	Insurance and healthcare costs	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Barry	2019	Substance Abuse/Mental Health and Insurance/ Healthcare Costs	State	Mix	No	Cost or charges	Claims/ prescription data	Regression with DiD
Batty	2017	Insurance and healthcare costs	State	Mix	No	Utilization of services	Healthcare administrative data	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Bauermeister	2014	Other	State	Mix	No	Self-reported health status	Survey data	Regression without DiD
Bell	2015	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Berman	2014	Mental Health & Substance Use	Local	Mix	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Bernat	2013	Tobacco	State	Mix	No	Mortality/ fatality	Other reporting systems	Interrupted Time Series/ ARIMA
Bian	2009	Insurance and healthcare costs	State	Original Legal Mapping	No	Utilization of services	Other	Regression with DiD
Bilaver	2013	Substance Abuse/Mental Health and Insurance/ Healthcare Costs	State	Mix	No	Cost or charges; Utilization of services	Survey data	Regression without DiD
Binswager	2014	Tobacco	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Bitler	2016	Insurance and healthcare costs	State	External	No	Utilization of services; Morbidity/ disease/ injury	Survey data; Patient/disease registry	Regression without DiD; Regression with DiD
Blanchard	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Healthcare administrative data	Regression without DiD
Bokhari	2011	Other	State	Mix	No	Utilization of services; Morbidity/ disease/ injury	Claims/ prescription data; Survey data	Regression without DiD
Bradford	2016	Healthcare Services	State	External	No	Utilization of services; Morbidity/ disease/ injury	Other reporting systems	Multilvel analysis; Other
Bradford	2016	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Claims/ prescription data	Regression with DiD
Bradford	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Claims/ prescription data	Regression without DiD
Bradford	2017	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Claims/ prescription data	Regression with DiD
Brighthaupt	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	Original Legal Mapping	No	Mortality/ fatality	Other reporting systems	Other

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Brooks	2010	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Other; Regression without DiD; Multilvel analysis
Browne	2018	Insurance and healthcare costs	State	External	No	Utilization of services; Cost or charges; Morbidity/ disease/ injury	Claims/ prescription data	Regression without DiD; Other
Busch	2014	Substance Abuse/Mental Health and Insurance/ Healthcare Costs	Federal	Other	No	Utilization of services; Cost or charges	Claims/ prescription data	Regression with DiD; Regression without DiD
Busch	2019	Healthcare Services	State	Original Legal Mapping	No	Utilization of services; Morbidity/ disease/ injury	Claims/ prescription data	Regression with DiD
Casp	2019	Insurance and healthcare costs	State	External	No	Cost or charges; Utilization of services; Mortality/ fatality; Morbidity/ disease/ injury	Claims/ prescription data	Other
Chin	2019	Insurance and healthcare costs	State	None or unclear	No	Cost or charges	Claims/ prescription data	Regression without DiD
Ciaccio	2016	Tobacco	State and Local	External	No	Utilization of services	Healthcare administrative data	Regression without DiD
Cil	2017	Mental Health & Substance Use	State	None or unclear	No	Morbidity/ disease/ injury	Other reporting systems	Regression without DiD
Cloud	2019	Social and public benefits	State	Mix	No	Morbidity/ disease/ injury	Other reporting systems	Multilvel analysis
Collins	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Utilization of services	Other reporting systems	Other
Cylus	2015	Social and public benefits	State	Mix	No	Morbidity/ disease/ injury	Survey data	Multilvel analysis
Daly	2013	Welfare (elder/ child)	State	Original Legal Mapping	Yes	Morbidity/ disease/ injury	Other	Other
Dao	2012	Road & Motor Vehicle Safety	State	External	Yes	Utilization of services	Healthcare administrative data	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Dao	2012	Road & Motor Vehicle Safety	State	External	Yes	Mortality/ fatality; Morbidity/ disease/ injury; Cost or charges; Utilization of services	Healthcare administrative data	Regression without DiD
Dasgupta	2018	Welfare (elder/ child)	State	External	No	Mortality/ fatality; Morbidity/ disease/ injury; Cost or charges; Utilization of services	Other reporting systems	Regression with DiD
D'Aunno	2014	Healthcare Services	State	Mix	No	Utilization of services	Survey Data	Regression without DiD
Davis	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Other reporting systems	Regression without DiD
Dee	2009	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Dierker	2009	Substance Abuse/Mental Health and Insurance/ Healthcare Costs	State	External	No	Utilization of services; Morbidity/ disease/ injury	Survey data	Regression without DiD
Diez	2017	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Dong	2017	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Dove	2010	Tobacco	State	External	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Dusetzina	2017	Insurance and healthcare costs	State	External	No	Cost or charges; Utilization of services	Claims/ prescription data	Regression with DiD
Dutra	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	Original Legal Mapping	Yes	Morbidity/ disease/ injury	Survey data	Regression without DiD
Edwards	2012	Healthcare Services	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Edwards	2014	Healthcare Services	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Edwards	2016	Healthcare Services	State	Original Legal Mapping	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Ehrenkranz	2009	Healthcare Services	State	Mix	Yes	Utilization of services	Survey data	Regression without DiD
Ehsani	2013	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality; Morbidity/	Other reporting systems	Interrupted Time Series/ ARIMA

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
						disease/ injury		
Eichelberger	2012	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality; Morbidity/ disease/ injury	Other reporting systems	Other
Farmer	2009	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Fell	2011	Road & Motor Vehicle Safety	State	Mix	No	Mortality/ fatality	Other reporting systems	Interrupted Time Series/ ARIMA
Fell	2016	Mental Health & Substance Use	State	Mix	Yes	Mortality/ fatality	Other reporting systems	Other
Fell	2009	Mental Health & Substance Use	State	Mix	No	Mortality/ fatality	Other reporting systems	Other
Fell	2014	Mental Health & Substance Use	State	Mix	No	Mortality/ fatality	Other reporting systems	Other
Ferdinand	2015	Road & Motor Vehicle Safety	State	Mix	No	Utilization of services	Healthcare administrative data	Regression with DiD
Ferdinand	2019	Road & Motor Vehicle Safety	State	Mix	No	Utilization of services	Healthcare administrative data	Regression with DiD
Fertig	2009	Mental Health & Substance Use	State	External	No	Morbidity/ disease/ injury	Other reporting systems	Regression with DiD
Fleegler	2013	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Flexon	2011	Welfare (elder/ child)	Federal	External	No	Mortality/ fatality	Other reporting systems	Interrupted Time Series/ ARIMA
Folz	2017	Tobacco	State	External	No	Morbidity/ disease/ injury; Mortality/ fatality	Other reporting systems	Regression without DiD
Fulton	2015	Other	State	External	No	Morbidity/ disease/ injury	Survey data	Regression with DiD
Gertner	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	Original Legal Mapping	No	Utilization of services	Claims/ prescription data	Regression without DiD
Ghiani	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Gibson	2015	Healthcare Services	State	None or unclear	No	Utilization of services	Claims/ prescription data	Regression with DiD
Goldman	2014	Insurance and healthcare costs	State	Other	No	Morbidity/ disease/ injury; Utilization of services	Survey data; Claims/ prescription data	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Goyal	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Hamilton	2018	Firearms	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Hardesty	2018	Healthcare Services	State	External	No	Utilization of services; Cost or charges	Electronic health records	Other; Regression without DiD
Harvey	2019	Healthcare Services	State	External	No	Utilization of services	Claims/ prescription data	Regression without DiD
Hasin	2017	Substance Abuse/Mental Health and Health/ Healthcare	State	Original Legal Mapping	No	Utilization of services	Survey data	Regression with DiD
Hatoun	2017	Tobacco	State	External	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Hennessy	2014	Food and nutrition	State	external	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Jehan	2018	Firearms	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Jones	2017	Road & Motor Vehicle Safety	State	External	No	Utilization of services; Mortality/ fatality	Other reporting systems	Regression with DiD
Kagawa	2018	Firearms	State	None or unclear	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Kaufman	2016	Substance Abuse/Mental Health and Road Safety	State	Mix	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Kaufman	2018	Firearms	State	Mix	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Kaushal	2018	Other	State	External	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Kennedy	2014	Environmental Health	State	Original Legal Mapping	No	Morbidity/ disease/ injury	Other reporting systems	Regression without DiD
Kennedy	2016	Environmental Health	State	Original Legal Mapping	No	Morbidity/ disease/ injury	Other reporting systems	Regression without DiD
Kim, J.	2016	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Other reporting systems	Multilvel analysis
Kim, S.	2016	Insurance and healthcare costs	State	External	No	Utilization of services	Patient/disease registry	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Kivisto	2017	Firearms	State	Mix	No	Mortality/ fatality	Other	Regression without DiD
Kivisto	2018	Firearms	State	Original Legal Mapping	No	Mortality/ fatality	Other reporting systems	Other
Knepper	2015	Healthcare Services	State	External	No	Cost or charges	Other	Regression without DiD
Komro	2019	Social and public benefits	State	Original Legal Mapping	No	Morbidity/ disease/ injury	Other reporting systems	Regression without DiD
Komro	2016	Social and public benefits	State	Original Legal Mapping	No	Mortality/ fatality; Morbidity/ disease/ injury	Other reporting systems	Regression with DiD
Kreiger	2013	Other	State	External	No	Mortality/ fatality	Other reporting systems	Multilvel analysis; Regression without DiD
Kweon	2009	Road & Motor Vehicle Safety	State	None or unclear	No	Mortality/ fatality	Other reporting systems	Other; Interrupted Time Series/ ARIMA
Ladd	2019	Healthcare Services	State	External	No	Utilization of services	Claims/ prescription data	Regression without DiD
Langer	2012	Food and nutrition	State	Original Legal Mapping	No	Morbidity/ disease/ injury	Other	Regression without DiD
Lee	2015	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Interrupted Time Series/ ARIMA
Lenhart	2019	Social and public benefits	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Liao	2019	Healthcare Services	State	External	No	Utilization of services	Survey data	Regression without DiD
Lin	2015	Tobacco	State	None or unclear	No	Morbidity/ disease/ injury; Utilization of services	Survey data	Regression without DiD
Lin	2016	Healthcare Services	State	Mix	No	Utilization of services	Survey data	Multilvel analysis
Lindley	2019	Healthcare Services	State	Original Legal Mapping	Yes	Utilization of services	Other reporting systems	Multilvel analysis
Liu	2017	Healthcare Services	State	Mix	No	Morbidity/ disease/ injury	Survey data	Regression with DiD
Loomis	2012	Tobacco	Local	External	No	Utilization of services	Healthcare administrative data	Regression without DiD; Other
Lovenheim	2011	Mental Health & Substance Use	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Madhavan	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Mahmoudi	2017	Healthcare Services	State	External	No	Utilization of services	Healthcare administrative data	Regression with DiD
Mannix	2012	Road & Motor Vehicle Safety	State	None or unclear	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Markowitz	2017	Healthcare Services	State	Mix	No	Morbidity/ disease/ injury	Other reporting systems	Regression with DiD
Markowitz	2015	Road & Motor Vehicle Safety	State	Mix	No	Morbidity/ disease/ injury	Other reporting systems	Regression with DiD
Masten	2014	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Morbidity/ disease/ injury	Other reporting systems	Interrupted Time Series/ ARIMA
McCartt	2010	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
McClellan	2018	Mental Health & Substance Use	State	Original Legal Mapping	Yes	Mortality/ fatality; Utilization of services	Other reporting systems; Survey data	Regression with DiD
McGinty	2015	Insurance and healthcare costs	Federal	None or unclear	No	Utilization of services; Cost or charges	Claims/ prescription data	Interrupted Time Series/ ARIMA
McGinty	2016	Substance Abuse/Mental Health and Road Safety	State	Original Legal Mapping	No	Mortality/ fatality	Other reporting systems	Multilvel analysis
Meara	2016	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Morbidity/ disease/ injury; Utilization of services	Healthcare administrative data	Regression without DiD
Medoff	2015	Sexual & Reproductive Health	State	External	No	Cost or charges	Other	Regression without DiD
Medoff	2016	Sexual & Reproductive Health	State	External	No	Self-reported health status	Other	Regression without DiD
Medoff	2014	Sexual & Reproductive Health	State	External	No	Self-reported health status	Other	Regression without DiD
Meehan	2013	Road & Motor Vehicle Safety	State	external	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Meinhofer	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	external	No	Utilization of services	Healthcare administrative data	Regression with DiD
Meyer	2019	Mental Health & Substance Use	State	None or unclear	No	Self-reported health status	Survey data	Regression without DiD
Miles-Richardson	2012	Non-infectious disease	State	External	Yes	Utilization of services	Survey data	Other

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Mulia	2019	Substance Abuse/Mental Health and Insurance/ Healthcare Costs	State	Mix	No	Utilization of services	Healthcare administrative data	Regression without DiD
Naumann	2012	Road & Motor Vehicle Safety	State	External	No	Cost or charges	Other reporting systems	Other
Notrica	2018	Substance Abuse/Mental Health and Road Safety	State	Mix	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Owusu-Edusei	2010	Insurance and healthcare costs	State	Mix	No	Utilization of services	Claims/ prescription data	Interrupted Time Series/ ARIMA
Pakyz	2013	Healthcare Services	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Palakshappa	2016	Food and nutrition	State	Mix	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Park	2019	Healthcare Services	State	Original Legal Mapping	No	Utilization of services	Other reporting systems	Regression with DiD
Patel	2019	Firearms	State	External	No	Utilization of services	Healthcare administrative data	Regression without DiD
Phillips	2017	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Mortality/ fatality	Other reporting systems	Other
Popovici	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Mortality/ fatality; Utilization of services	Other reporting systems; Healthcare administrative data	Regression with DiD
Pressley, Benedicto	2009	Road & Motor Vehicle Safety	State	External	No	Cost or charges; Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Pressley, Trieu	2009	Road & Motor Vehicle Safety	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Other
Rahman	2016	Insurance and healthcare costs	State	External	No	Cost or charges	Claims/ prescription data	Regression with DiD
Raifman	2018	Other	State	Mix	No	Self-reported health status	Survey data	Regression with DiD
Raji	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Utilization of services	Claims/ prescription data	Regression without DiD
Roberts	2019	Substance Abuse/Mental Health and Injury and	State	Mix	No	Morbidity/ disease/ injury;	Other reporting systems	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
		Maternal and Child Health				Utilization of services		
Romano	2011	Road & Motor Vehicle Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Safavi	2014	Firearms	State	Mix	No	Mortality/ fatality; Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Sandoval	2012	Food and nutrition	State	Original Legal Mapping	Yes	Self-reported health status	Survey data	Regression without DiD
Santaella-Tenorio	2017	Substance Abuse/Mental Health and Road Safety	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Saulsberry	2019	Healthcare Services	State	External	No	Utilization of services	Claims/ prescription data	Regression with DiD
Scherer	2015	Mental Health & Substance Use	State	Mix	No	Mortality/ fatality	Other reporting systems	Other
Segura	2019	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Morbidity/ disease/ injury	Survey data	Regression without DiD
Shaw	2018	Healthcare Services	State	Original Legal Mapping	No	Utilization of services	Other	Regression without DiD
Shraim	2015	Social and public benefits	State	Mix	No	Cost or charges; Morbidity/ disease/ injury	Healthcare administrative data	Regression without DiD
Shrank	2010	Insurance and healthcare costs	State	Mix	No	Utilization of services; Cost or charges	Claims/ prescription data	Regression without DiD
Siegel	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Siegel	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression with DiD
Silver	2014	Road & Motor Vehicle Safety	State	Mix	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Sivaraman	2019	Firearms	State	External	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Smith	2009	Mental Health & Substance Use	State	External	No	Mortality/ fatality	Other reporting systems	Other
Smith-Gagen	2018	Healthcare Services	State	External	No	Morbidity/ disease/ injury	Patient/disease registry	Regression without DiD
Taber	2013	Other	State	External	No	Utilization of services; Morbidity/ disease/ injury	Other	Regression without DiD

First Author	Year	Legal Topic	Type of Law	Classification of Legal Mapping*	Reference to a Search String	Type of Health Outcome	Type of Dataset	Method Used
Taber	2012	Food and nutrition	State	Original Legal Mapping	Yes	Morbidity/ disease/ injury	Other	Regression without DiD
Taber	2013	Food and nutrition	State	Original Legal Mapping	No	Morbidity/ disease/ injury	Other	Regression without DiD
Tak	2019	Healthcare Services	State	Original Legal Mapping	No	Utilization of services	Survey data	Regression without DiD
Tashiro	2016	Firearms	State	External	No	Cost or charges; Morbidity/ disease/ injury; Utilization of services	Healthcare administrative data	Other
Trogdon	2016	Healthcare Services	State	Mix	No	Utilization of services	Survey data	Regression with DiD
Tseng	2018	Firearms	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Other; Regression without DiD
Vander Weg	2012	Tobacco	State and Local	External	No	Utilization of services	Healthcare administrative data	Multilvel analysis
Weiss	2010	Road & Motor Vehicle Safety	State	External	No	Morbidity/ disease/ injury	Healthcare administrative data	Other
Wen	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	None or unclear	No	Cost or charges; Utilization of services	Claims/ prescription data	Regression with DiD
Williams	2017	Substance Abuse/Mental Health and Health/ Healthcare	State	External	No	Morbidity/ disease/ injury	Survey data	Multilvel analysis
Xie	2015	Insurance and healthcare costs	State and Federal	None or unclear	No	Utilization of services	Patient/disease registry	Regression with DiD
Xu	2018	Substance Abuse/Mental Health and Health/ Healthcare	State	Mix	No	Utilization of services	Claims/ prescription data	Regression without DiD
Zeoli	2010	Firearms	State	Mix	No	Mortality/ fatality	Other reporting systems	Regression without DiD
Zimmerman	2013	Healthcare Services	State	None or unclear	No	Utilization of services	Survey data	Multilvel analysis

*Categories:

- Original Legal Mapping - Legal mapping was part of the study
- External - Legal elements were gathered from another source
- Mix - An outside source was used but there was additional analysis by the researchers

DiD: difference in difference

Arima: autoregressive integrated moving average modeling

Table 2:

Legal Components Present

Variable*	**# Studies* (Percent)**
Domain Expert	33 (19%)
Reference to a legal member among original legal mapping studies (original and mix)/ (original only)	*27 (39%)/13 (54%)*
Source of Legal Data NOT Identified	14 (8%)
Source of Legal Data Identified	163 (92%)
Source: Article	*17 (10%)*
Source: Website	*70 (40%)*
Source: Caselaw	*1 (1%)*
Source: Legal Database	*7 (4%)*
Source: State Legal Database	*5 (3%)*
Source: Original (internal study)	*2 (1%)*
Source: Combination of Primary Sources	*7 (4%)*
Source: Combination of Secondary Sources	*20 (11%)*
Source: Other	*3 (2%)*
Source: Primary and Secondary	*31 (18%)*
Classification of Legal Mapping	165 (91%)
Legal Mapping Source Identified**	*24 (14%)*
Original Legal Mapping	*93 (53%)*
External	*46 (26%)*
Mix	*2 (1%)*
Other	12 (7%)
No source Identified	
Reference to a Search String Provided	10 (6%)
Reference to a search string among original legal mapping studies (original and mix) / (original only)	*8 (11%)/6 (25%)*

*Relationship level (weighted by number of relationships per study)

**There were two studies that did not have any reference to how or where the legal data was collected but did discuss legal mapping

Table 3:

Methods Variable Descriptives

Variable	# Studies* (Percent)
Type Health or Economic Outcome	
Mortality/Fatality	*61 (34%)*
Morbidity/Disease/Injury	*40 (23%)*
Self-reported Health Status	*8 (4%)*
Utilization of Services	*57 (32%)*
Cost or Charges	*11 (6%)*
Type of Dataset	
Claims/Prescription Data	*23 (13%)*
Healthcare Administrative Data	*27 (15%)*
Survey Data	*32 (18%)*
Patient/Disease Registry	*3 (2%)*
Electronic Health Records	*1 (1%)*
Other Reporting Systems	*77 (44%)*
Other	*14 (8%)*
Level of Analysis	
Individual/Claim/Discharge/Encounter	*68 (38%)*
State	*89 (50%)*
County/Other Local	*9 (5%)*
Hospital/Physician/Clinic/Organization	*6 (4%)*
Other	*5 (3%)*
Type of Study	
Single Measure/Cross-Sectional	*35 (20%)*
Panel	*94 (53%)*
Pooled Cross-Sectional	*48 (27%)*
Methods Controlling for Confounding	
No Method	*66 (37%)*
Control Variables	*93 (52%)*
Synthetic Cohort	*3 (2%)*
Propensity Score Matching	*5 (3%)*
Not Applicable	*10 (6%)*
Control Group Used in Study	
Yes	*167 (94%)*
No	*10 (6%)*
Study Method	
Regression with DiD	*43 (24%)*
Regression without DiD	*91 (51%)*
Multilevel Analysis	*11 (6%)*
Interrupted Time Series/ARIMA	*9 (5%)*

Variable	# Studies* (Percent)
Other	*23 (13%)*
Fixed/Random Effects used	
Yes	*78 (44%)*
No	*99 (56%)*
Significant Legal Effect on Health or Economic Outcome	
Yes	*109 (63%)*
No	*62 (36%)*
Yes, but in Opposite Direction	*2 (1%)*
Limitations Provided	
Yes	*161 (91%)*
No	*16 (9%)*

*Relationship level (weighted)

DiD: Difference in Difference

Arima: Autoregressive integrated moving average modeling