Untangling the association between the burden of chronic back problems, current utilization of chiropractic care, and availability of chiropractors at the health region level: an ecological study protocol

Jhalok Ronjan Talukdar, PhD[1-3]
Dan Wang, PhD[1-4]
Sheilah Hogg-Johnson, PhD[1,2,4,5]
Jessica J. Wong, DC, PhD[1,3,4,6,7]
Silvano A. Mior, DC, PhD[1-5]
Pierre Côté, DC, PhD[1,3-5]

Background: *Chronic back problems (cBP) are the leading cause of disability in Canada, with chiropractors as second most-consulted professionals for cBP care. However, little is known about chiropractor supply, demand, and gaps between them. We will determine the prevalence of cBP, chiropractic utilization, the chiropractic availability across Canadian health regions; compute a demand-supply measure; and investigate characteristics associated with the demand-supply.*

Démêler l'association entre le fardeau des problèmes chroniques de dos, l'utilisation actuelle des soins chiropratiques et la disponibilité des chiropraticiens dans les régions de santé: Un protocole d'étude écologique
Contexte: Les problèmes chroniques de dos (PCD) constituent la principale cause d'incapacité au Canada, les chiropraticiens étant les deuxièmes professionnels les plus consultés pour le traitement des PCD. Cependant, peu de choses sont connues sur l'offre et la demande en chiropraticiens, ainsi que sur les lacunes

1   Institute for Disability and Rehabilitation Research, Ontario Tech University
2   Department of Research and Innovation, Canadian Memorial Chiropractic College
3   Faculty of Health Sciences, Ontario Tech University
4   Institute of Health Policy, Management and Evaluation, University of Toronto
5   Dalla Lana School of Public Health, University of Toronto
6   School of Physical Therapy, Faculty of Health Sciences, Western University
7   Department of Epidemiology and Biostatistics, Schulich School of Medicine & Dentistry, Western University

Corresponding author:
Pierre Côté, DC, PhD, Institute for Disability and Rehabilitation Research, Faculty of Health Sciences, Ontario Tech University.
2000 Simcoe Street North,
Oshawa, Ontario L1H 7K4
Email: Pierre.Cote@ontariotechu.ca

Methods: *We designed an ecological study with 102 Canadian health regions as the unit of analysis. We will estimate derived and observed demand using the Canadian Community Health Survey data (2015/2016, 2021/2022), and supply using Canadian Chiropractic Association membership data (2021/2022). We will use spatial analyses to map the prevalence of cBP (derived demand), chiropractic utilization for cBP (observed demand), and chiropractor availability (supply) across health regions. Poisson regression models will assess the population factors associated with supply and demand-supply disparities.*

Conclusion: *The identification of geographical disparities in chiropractic care and the exploration of contextual factors associated with demand-supply dynamics may inform healthcare planning and resource allocation for the management of chronic back problems in Canada.*

entre elles. Nous déterminerons la prévalence de la douleur chronique au bas du dos, l'utilisation de la chiropratique, la disponibilité des chiropraticiens dans les régions de santé canadiennes; nous calculerons une mesure de la demande et de l'offre et nous examinerons les caractéristiques liées à la demande et à l'offre.

Méthodes: Nous avons conçu une étude écologique avec 102 régions de santé canadiennes comme unité d'analyse. Nous estimerons la demande dérivée et observée en utilisant les données de l'Enquête canadienne sur la santé communautaire (2015-2016, 2021-2022), et l'offre en utilisant les données d'adhésion de l'Association chiropratique canadienne (2021-2022). Nous utiliserons des analyses spatiales pour cartographier la prévalence de la douleur chronique au bas du dos (demande dérivée), l'utilisation de la chiropratique pour la douleur chronique au bas du dos (demande observée) et la disponibilité des chiropraticiens (offre) dans les régions de santé. Les modèles de régression de Poisson évalueront les facteurs de population associés aux disparités entre l'offre et la demande.

Conclusion: L'identification des disparités géographiques dans les soins chiropratiques et l'exploration des facteurs contextuels liés aux dynamiques de demande et d'offre peuvent éclairer la planification des soins de santé et l'allocation des ressources pour la gestion des problèmes chroniques de dos au Canada.

Introduction

The Canadian healthcare system is facing significant challenges, particularly in providing adequate primary care and rehabilitation to individuals with chronic conditions such as back pain.[1] In 2015, most Canadians with chronic back problems (86.7%) reported receiving regular healthcare from medical doctors, while chiropractors are the second most common regularly consulted professionals, with 14.5% of those with chronic back problems seeking their care, ahead of physical therapists (10.7%) and nurses (6.6%).[2] However, the utilization of chiropractic services has remained stable over the past two decades.[2,3] This is relevant to today's primary care crisis because the engagement of a range of health care specialties is viewed as one solution to the unsustainable demand on the primary health care system.[4]

We have previously shown that chiropractic utilization by Canadians with chronic back problems varies significantly across provinces, ranging from 25.4% in Saskatchewan to 7.6% in the Territories.[2] Moreover, the utilization of chiropractors is associated with personal and contextual factors. For example, older individuals, women, those with lower socioeconomic status and individuals identifying with racial or ethnic groups other than European American, White, non-Hispanic White, or Caucasian are less likely to consult chiropractors.[2,5]

To date, little is known about regional variation in the demand-supply disparities for chiropractic services among Canadians with chronic back problems. Understanding regional variation is important because health regions within each province serve as geographic areas for planning, delivery, and funding of health services.[6] Therefore, understanding the demand and supply of chiropractic services at this level is crucial for decision-makers to make informed choices about the future of primary care in Canada.

Objectives
To better understand the regional variations in chiropractic supply and demand among Canadians with chronic back problems, we propose to conduct a national ecological analysis at the health region level across Canada. We focus on chiropractic care before (2015/16) and at the end of (2021/22) the COVID-19 pandemic. Specifically, our objectives are to: 1) determine and spatially map the prevalence of chronic back problems (derived demand), chiropractic utilization (observed demand), and availability of chiropractors (supply) across the country's health regions; 2) compute and geospatially map the demand-supply measure to quantify the unrealized demand (gap between derived demand and observed demand) given the regional supply for each health region; and 3) investigate which of the populations' aggregated characteristics are associated with supply and with the demand-supply measure at the health region level. By addressing these objectives, the study seeks to describe geographic disparities in chiropractic care availability and utilization and identify areas of high need or service gaps. Ultimately, these findings can inform healthcare policies and resource planning, potentially enhancing access to chiropractic care for all Canadians and contributing to improved health care delivery across the population.

Methods
This study will be reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[7]

Study design
We designed a national ecological study to examine the demand and supply of chiropractic services at the health region level in Canada. Ecological studies are particularly suited for analyzing population-level relationships between exposures and outcomes, making this design appropriate for understanding the dynamics of chiropractic care across geographic regions. The study will use aggregated data to provide population-level estimates of demand (prevalence of chronic back problems and chiropractic utilization) for two time periods: before the COVID-19 pandemic (2015/16) and at the end of the pandemic (2021/22). The supply data (availability of chiropractors) is available only for the pandemic period (2021/22), but will be used as an estimate for the earlier time period also. This approach will allow for the identification of geographical disparities in chiropractic care and the exploration of contextual factors associated with demand-supply dynamics.

Setting
The Canadian Community Health Survey (CCHS) data is collected from individuals living in private dwellings in over 100 health regions covering all provinces and territories. These regions are geographic areas used for planning, delivering, and funding health services and will be defined using boundary files provided by Statistics Canada.[8]

Data sources
The study will utilize data from two national sources: the Canadian Community Health Survey (CCHS) and the Canadian Chiropractic Association (CCA) membership database. The CCHS provides self-reported information on chronic back problems and chiropractic utilization for 2015/16 and 2021/22. The CCA membership database provides information on the distribution of chiropractors across health regions for 2021/22.

Data access
We will access CCHS datasets through the Open Data Documentation, Extraction Service and Infrastructure

(Odesi) program and the Real Time Remote Access (RTRA) system by Statistics Canada.[9,10] Odesi is a Canadian social science data repository that provides access to more than 5,700 datasets, including Statistics Canada datasets, and is available free of charge at Ontario Tech University.

The CCA will provide postal code information reported by chiropractors that will be linked to the health region boundary files obtained from CCHS.

Participants

Participants in CCHS include Canadians aged 12 and over living in private dwellings. Participation in the survey is voluntary. Exclusions include persons living on reserves and other Aboriginal settlements, full-time members of the Canadian Forces, youth aged 12 to 17 living in foster homes, the institutionalized population, and persons living in specific Quebec health regions. Altogether, these exclusions represent less than 3% of the Canadian population. In CCHS, participants are selected using a multi-stage stratification strategy to provide reliable estimates at the health region level. The study will include data from approximately 130,000 participants per CCHS cycle, covering over 100 health regions.

The CCA membership data include participants who are members of CCA, covering about 85% of licensed chiropractors in Canada.[11]

Population size in health regions: The CCHS data includes a variable indicating what health region each respondent resides in. The region-specific population size, N, will be estimated by applying the population weights to a count of all respondents in that region.

Chronic back problems: In the CCHS, a chronic condition refers to a long-term condition that is expected to last, or has already lasted six months or more and that has been diagnosed by a health professional.[12] We will identify those who answered "yes" to the question: "Do you have back problems, excluding scoliosis, fibromyalgia and arthritis" as having chronic back problems.[13,14] Previous studies used this question to assess chronic back problems in the Canadian population.[2, 15-17]

Utilization of chiropractic services: We will measure the utilization of chiropractic services (yes or no) based on one question in the module of Primary Health Care: "Other than from your family physician/specialist/nurse practitioner/regular health care provider, who do you re-

ceive regular health care from?".[13,14] Discrete response options included: "Another family doctor or general practitioner, specialist doctor, nurse/nurse practitioner, chiropractor, registered dietician, pharmacist, physiotherapist, psychologist/mental health professional, and social worker".[13,14] For our project, we will identify respondents who reported receiving regular health care from a chiropractor as individuals with observed demand of chiropractor.

Conceptual framework

To better understand these variations, we use Andersen's Behavioural Model of Health Services Use for health service utilization. This model was developed to investigate the factors influencing healthcare utilization, evaluate disparities in access to health services, and inform policy-making to ensure equitable access to care.[18-20] The model systematically categorizes factors influencing healthcare use into three components: predisposing factors (e.g., demographic and social characteristics), enabling factors (e.g., income, availability of services), and need factors (e.g., perceived or actual health conditions).[18,21-23] The model is particularly valuable for its flexibility and applicability across diverse populations and settings. Additionally, the model differentiates between potential and actual access, providing deeper insights into the barriers to healthcare and the factors that facilitate the utilization of services.[21] It has been extensively validated in studies addressing various health conditions and healthcare systems, making it a robust model for analyzing disparities in access and utilization.[21]

Covariates

Based on previous research[2, 24, 25], data availability, and Anderson's Behavioural Model of Health Service Use[26,27], we hypothesize the following factors are associated with demand-supply measures. As the study is conducted at the health region level, we will aggregate all covariates at the regional level. The covariates will be grouped as follows as reported in CCHS and PUMF dataset:

i. **Predisposing factors:** Predisposing factors are individual characteristics that influence the likelihood of healthcare utilization, even before a health need arises. These include demographic and social characteristics.[18, 21-23, 28]

Age: Proportion of individuals in different age groups

(i.e., 12 to 17 years, 18 to 34 years, 35 to 49 years, 50 to 64 years, 65 and older)

Sex and Gender: Proportion of male, female and gender diverse (only for gender) in the health region.

Immigration status: Proportion of individuals in each immigration status category (i.e., Landed immigrant / non-permanent resident; Non-immigrant [Canadian born]).

Cultural or racial origin: Proportion of individuals in each cultural or racial group (i.e., White; Non-White).

ii. **Enabling factors:** Enabling factors are the resources or conditions that facilitate or hinder access to healthcare services (e.g., income, living location).[18,21,22,28]

Household Income: Proportion of individuals in different income groups (e.g., No income or less than $20,000; $20,000 to $39,999; $40,000 to $59,999; $60,000 to $79,999; $80,000 to 99,999; $100,000 or more).

Province: Proportion of individuals in different provinces or territories. Provinces will be categorised into 10 provinces and aggregated territories (11 categories overall) as follows:

a) Provinces: Ontario, Quebec, Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta, British Columbia.

b) Territories: Nunavut, Northwest Territories, Yukon Territory.

Geographic area: We will categorize the geographic area as urban, rural or both based on postal codes for each health region.

iii. **Need-related factors:** Need-related factors are the perceived or actual health conditions that drive individuals to seek healthcare services (e.g., Chronic illnesses, perceived general health status, and severity of symptoms).[18, 21, 22, 28]

General Health: Proportion of individuals in each health region reporting their perceived health as "Excellent," "Very Good," "Good," "Fair," or "Poor".

Chronic Conditions: Proportion of individuals reporting common chronic illnesses (e.g., diabetes, anxiety disorder, mood disorder such as depression, bipolar, mania, dysthymia) that are frequently associated with chronic low back pain and healthcare utilization.[29-31]

Outcomes

The primary outcomes for this study are derived demand, observed demand, supply, and the demand-supply measure of chiropractic care. To answer the following objectives of our study, we provide specific definitions for each of these terms.

Objective 1: Determine and spatially map the prevalence of chronic back problems (derived demand), chiropractic utilization (observed demand) and availability of chiropractors (supply) at the health region level.

Derived demand: This refers to the number of Canadians with chronic back problems per 100,000 regional population. The term "derived demand" acknowledges the population's fundamental demand for consumption of health services to maintain good health. This will be calculated as:

$$Derived\ demand,\ D1 = \frac{m_1}{N} \times 100,000,$$

where m_1 is the regional number of individuals with chronic back problems, and N is the regional population size, both obtained as population weighted estimates from CCHS.

Observed Demand: This refers to the number of Canadians with chronic back problems utilizing chiropractic services per 100,000 regional population. This measure will be used to quantify to what extent the regional population's demands were realized (i.e., met the demands of the population). This will be calculated as:

$$Observed\ demand,\ D2 = \frac{m_2}{N} \times 100,000,$$

where m_2 is the regional annual number of individuals with chronic back problems receiving regular care from chiropractors, and N is the regional population size, both obtained as population weighted estimates from CCHS.

Supply: This refers to the number of practicing chiropractors per 100,000 regional population in each of the 102 health regions. We will obtain this information from the CCA membership database. This measure provides information about the availability of chiropractors relative to the regional population size. This will be calculated as:

$$Supply, S = \frac{L}{N} \times 100{,}000,$$

where L is the regional number of practicing chiropractors in the health region identified by mapping postal codes onto health regions, and N is the regional population size obtained as population weighted estimates from CCHS.

Objective 2: In this objective, we aim to compute and geospatially map the demand-supply measure to quantify the unrealized demand. We will compute a measure of demand-supply to quantify the unrealized demand (gap between derived demand and observed demand) given the regional supply for each health region using the following formula:

$$\text{Demand-supply measure} = \frac{\text{Derived demand} - \text{Observed demand}}{\text{Supply}} = \frac{D_1 - D_2}{S}$$

Objective 3: In this objective we aim to investigate which of the populations' aggregated characteristics are associated with supply and with the demand-supply measure at the health region level.

Statistical analysis
We will use descriptive statistics to summarise the distribution of all variables across health regions. We will report the mean, standard deviation (SD), minimum, 25th percentile, median, 75th percentile, and maximum to provide a comprehensive summary of the data distribution across health regions. Geographic variations will be quantified using the coefficient of variation (CV), extremal ratio (maximum/minimum), and interquartile ratio (interquartile range/median).

We will create choropleth maps using ArcGIS Pro to visualise the derived demand, observed demand, chiropractor supply, and the demand-supply measure across health regions. Choropleth maps are thematic maps that use differences in shading or colouring to represent the magnitude of a variable across geographic areas.[32] These maps will help identify regions with high unrealized demand or potential service gaps.

Poisson regression models with log link functions will be used to assess the association between ecological predictors (covariates) and chiropractor supply, focusing on univariable models to evaluate the individual association of each covariate. The covariate for Province/Territories will be represented by 10 indicator variables (11 categor-

ies, so 10 indicators) with Prince Edward Island serving as the reference category since PEI contains only one Health Region.

The remaining covariates will be represented by the % of the population in the health region that falls within each category of a variable – e.g., % of the population female and % of the population male. Poisson regression models are suitable for count data, with the logarithm of the health region population size (e.g., log(N)) included as an offset. With a sample size of around 100 health regions, there are insufficient observations to build multivariable models including all covariates simultaneously and so we will model one covariate at a time to investigate associations between the covariate and outcome.

Poisson regression models with log link functions will also be used to assess the association between ecological predictors (covariates) and the demand-supply outcome with the outcome defined by m1 – m2 (number of people with chronic back problems not receiving regular care from a chiropractor) and offset variable logarithm of L (number of chiropractors). We will use the same approach to operationalize covariates as described for chiropractor supply and the analysis will focus on univariable models to assess the individual association of each covariate with the demand-supply measure.

Results from Poisson regression models will be presented as exponentiated regression coefficients with 95% confidence intervals, indicating the association of each factor with the outcomes.

Sensitivity analyses will be conducted to evaluate the robustness of results across different categorizations of covariates (e.g., single, multiple, and extreme categories) and model specifications (e.g., one, two, or three covariate categories). For categorical variables, sensitivity analyses will also assess the impact of using different definitions of extreme categories (e.g., logical extremes vs. regions with the highest and lowest proportions).

Strengths and limitations of the study
Our proposed study has the following strengths:

Comprehensive national scope: The study covers 102 health regions across Canada, providing a robust and detailed analysis of chiropractic care demand, supply, and disparities at a national level.

Theoretical framework: The use of Andersen's Behav-

ioural Model of Health Services Use provides a validated and systematic approach to understanding factors influencing chiropractic care utilisation.

Knowledge translation (KT) strategy: The study actively engages partners, including the national and provincial associations, ensuring that findings are relevant, actionable, and widely disseminated.

Our proposed study has limitations such as:

Self-reported data: The Canadian Community Health Survey (CCHS) relies on self-reported data, which may be subject to misclassification bias. This could affect the validity of the derived demand and observed demand measures.

Data availability for supply: Chiropractor supply data is only available for the 2021/22 period, limiting the ability to assess changes in supply over time or its relationship with demand during earlier periods.

Incomplete data on chiropractor availability: We only have about 85% of chiropractors in Canada. [11] Therefore, we will likely underestimate the supply and overestimate the gap between supply and demand.

Population exclusions: The CCHS excludes certain population groups, including persons living on reserves and other Aboriginal settlements, full-time members of the Canadian Forces, youth aged 12 to 17 living in foster homes, the institutionalized population, and persons living in specific Quebec health regions. These exclusions account for less than 3% of the Canadian population but may limit the generalizability of our findings to these groups.

Ethics
Ethical approval was obtained from the Research Ethics Boards (REB) at Ontario Tech University (File no 17688) and at Canadian Memorial Chiropractic College (Project # 232018). All data will be de-identified to ensure participant confidentiality. The CCHS data will be accessed through secure platforms, and de-identified chiropractor data will be provided by the CCA.

Knowledge Translation (KT)
We will use an integrated KT approach.[33] This approach is characterized by the active and continuous engagement of knowledge users as research partners throughout the research process. These partners were involved from the outset, including in the identification of the research questions, study design, and development of study objectives. Our approach focusses on the active engagement of knowledge users throughout the study. Specifically, we will collaborate with the Canadian Chiropractic Association (CCA), six provincial chiropractic associations (i.e., Ontario, Alberta, British Columbia, Quebec, Saskatchewan, and New Brunswick), and one Canadian chiropractic education institution (i.e., Canadian Memorial Chiropractic College). These partners will comprise our project's Advisory Committee, who will be consulted and updated about the project on a quarterly basis and engaged during critical decision points throughout the project.

We will work collaboratively with our Advisory Committee at each stage to co-develop knowledge products. At the completion of each objective, we will prepare evidence briefs which will serve as a medium to communicate our study results. The evidence briefs will be used to develop key messages, infographics and other communication tools with input from the Advisory Committee. We will also disseminate findings to the scientific community through peer-reviewed publications and presentations. At the end of the project, we will organize a conference for key national partners to engage in Human Resource Strategic Planning for the chiropractic profession. This conference will provide a platform for knowledge exchange, strategic planning of policy priorities, and address the workforce needs for chiropractic in Canada. Finally, we will disseminate our findings to the general public through lay language summaries, infographics, and webinars. Our free and accessible webinars will be organized by the Institute for Disability and Rehabilitation Research and made available to the chiropractic community at large.

Abbreviations
CCA: Canadian Chiropractic Association
CCHS: Canadian Community Health Survey
HR: Health region
Odesi: Open Data Documentation, Extraction Service and Infrastructure
RTRA: Real Time Remote Access
YLD: Year lived with disability

References

1. Canadian Pain Task Force. Chronic pain in Canada: Laying a foundation for action. 2019.
2. Wong JJ, Wang D, Hogg-Johnson S, et al. Prevalence and characteristics of healthcare utilization with different providers among Canadians with chronic back problems: A population-based study. Brain Spine. 2024;4:102812. doi: 10.1016/j.bas.2024.102812
3. Mior S, Wang D, Wong JJ, et al. Assessing the change in prevalence and characteristics of canadians utilizing chiropractic services across two time periods 2001-2010 and 2015-2018: a population-based repeated cross-sectional study. Chiropr Man Therap. 2024;32(1):30. doi: 10.1186/s12998-024-00552-1
4. Taglione MS, Brown JB. Primary care engagement in health system change: a scoping review of common barriers and effective strategies. BMC Primary Care. 2023;24(1):157. doi: 10.1186/s12875-023-02117-2
5. Gliedt JA, Spector AL, Schneider MJ, et al. Disparities in chiropractic utilization by race, ethnicity and socioeconomic status: a scoping review of the literature. J Integr Med. 2023;21(2):159-167. doi: 10.1016/j.joim.2023.02.002
6. Statistics Canada. Health regions 2025 [Available from: https://www150.statcan.gc.ca/n1/pub/82-402-x/2023001/hr-rs-eng.htm accessed February 22 2025.
7. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med 2007;147(8):573-577. doi: 10.7326/0003-4819-147-8-200710160-00010
8. Statistics Canada. Health Regions: Boundaries and Correspondence with Census Geography 2024 [cited 2024 December 12].
9. Open Data Documentation, Extraction Service and Infrastructure [Odesi] 2024 [cited 2024 December 12].
10. Statistics Canada. Real Time Remote Access 2024 [cited 2024 December 12].
11. Southerst D, Bakaa N, Côté P, et al. Diversity of the chiropractic profession in Canada: a cross-sectional survey of Canadian Chiropractic Association members. Chiropr Man Therap. 2022;30(1):52. doi: 10.1186/s12998-022-00463-z
12. Statistics Canada. Canadian Community Health Survey - Annual Component (CCHS) 2019 [cited 2024 December 17].
13. Statistics Canada. Canadian Community Health Survey - Annual component(CCHS) - 2021 2021 [cited 2024 December 17].
14. Statistics Canada. Canadian Community Health Survey (CCHS) - 2015 2016 [cited 2024 December 17].
15. Lu M, Wong JJ, Côté P, et al. Association between physiotherapy utilization and medical healthcare utilization and costs in adults with back pain from Ontario, Canada: a population-based cohort study. Pain. 2023;164(11):2572-2580. doi: 10.1097/j.pain.0000000000002957

16. Wong JJ, Côté P, Tricco AC, et al. Effect of back problems on healthcare utilization and costs in Ontario, Canada: a population-based matched cohort study. Pain. 2021;162(10):2521-2531. doi: 10.1097/j.pain.0000000000002239

17. Wong JJ, Côté P, Tricco AC, et al. Joint effects of back pain and mental health conditions on healthcare utilization and costs in Ontario, Canada: a population-based cohort study. Pain. 2022;163(10):1892-1904. doi: 10.1097/j.pain.0000000000002587

18. Andersen RM. Revisiting the behavioral model and access to medical care: does it matter? J Health Soc Behav. 1995;36(1):1-10.

19. Chen C, Gu D. Andersen Model. In: Gu D, Dupre ME, eds. Encyclopedia of Gerontology and Population Aging. Cham: Springer International Publishing 2020:1-15.

20. Andersen R, Newman JF. Societal and individual determinants of medical care utilization in the United States. Milbank Mem Fund Q Health Soc. 1973;51(1):95-124.

21. Alkhawaldeh A, M AL, Rayan A, et al. Application and Use of Andersen's Behavioral Model as Theoretical Framework: A Systematic Literature Review from 2012-2021. Iran J Public Health. 2023;52(7):1346-1354. doi: 10.18502/ijph.v52i7.13236

22. Gliedt JA, Spector AL, Schneider MJ, et al. A Description of Theoretical Models for Health Service Utilization: A Scoping Review of the Literature. Inquiry. 2023;60:469580231176855. doi: 10.1177/00469580231176855

23. Andersen R. A behavioral model of families' use of health services. 1968

24. Whedon JM, Song Y. Geographic variations in availability and use of chiropractic under medicare. J Manipulative Physiol Ther. 2012;35(2):101-109. doi: 10.1016/j.jmpt.2011.12.004

25. Whedon JM, Song Y. Racial disparities in the use of chiropractic care under Medicare. Altern Ther Health Med. 2012;18(6):20-26.

26. Andersen R. A behavioral model of families' use of health services. Center for Health Administration Studies, University of Chicago 1968.

27. Andersen RM, Rice TH, Kominski GF. Changing the US health care system: Key issues in health services policy and management: John Wiley & Sons 2011.

28. Radhamony R, Cross WM, Townsin L, et al. Culturally and Linguistically Diverse Community Access and Utilisation of the Mental Health Service: An Explanation Using Andersen's Behavioural Model. Issues in Mental Health Nursing. 2024;45(7):758-765. doi: 10.1080/01612840.2024.2359602

29. Slater M, Perruccio AV, Badley EM. Musculoskeletal comorbidities in cardiovascular disease, diabetes and respiratory disease: the impact on activity limitations; a representative population-based study. BMC Public Health 2011;11(1):77. doi: 10.1186/1471-2458-11-77

30. de Luca KE, Parkinson L, Haldeman S, et al. The Relationship Between Spinal Pain and Comorbidity: A Cross-sectional Analysis of 579 Community-Dwelling, Older Australian Women. J Manipulative Physiol Ther. 2017;40(7):459-466. doi: 10.1016/j.jmpt.2017.06.004

31. Green BN, Johnson CD, Haldeman S, et al. A scoping review of biopsychosocial risk factors and co-morbidities for common spinal disorders. PLoS One 2018;13(6):e0197987. doi: 10.1371/journal.pone.0197987

32. Esri. Create and use a choropleth map 2025 [cited 2025 March 6].

33. Graham ID, Kothari A, McCutcheon C, et al. Moving knowledge into action for more effective practice, programmes and policy: protocol for a research programme on integrated knowledge translation. Implementation Science 2018;13(1):22. doi: 10.1186/s13012-017-0700-y