Supplementary Materials

eTable1: Definition of conditions based on CEDIS codes

Condition	CEDIS codes
Cardiovascular[a]	001-050
ENT[b]	051-200
Gastrointestinal/genitourinary[c]	251-300, 301-350
General and minor	851-900
Injury/Trauma[d]	02, 52, 56, 102, 105, 153, 155, 201-207, 255, 264-265, 310, 407, 452, 502-503, 510, 552-553, 556-557, 656-657, 701-705, 717, 801-850
Mental health	351-400
Neurologic[e]	401-450
OBGYN[f]	451-500
Ophthalmology[g]	501-550
Orthopedic[h]	551-600
Respiratory	651-700
Sexual assault	454
Skin-related	701-750
Substance misuse	751-800

[a]Excludes 002 – cardiac arrest traumatic.
[b]Excludes: 052 – foreign body in ear; 056 – ear injury; 102 – facial trauma; 105 – neck trauma; 153 – foreign body nose; 155 – nasal trauma.
[c]Excludes: 255 – foreign body in rectum; 264 – anal/rectal trauma; 265 – oral/esophageal foreign body; 310 – genital trauma.
[d]Injury: injury-specific CEDIS codes across different categories were grouped together to create a new category of "Injury/trauma". It includes environmental conditions (CEDIS: 201-207), trauma conditions (801-850), and others (Head injury, neck and facial trauma etc.) To prevent double counting, codes captured in the Injury/trauma category were excluded from all other categories.
[e]Excludes: 407 – head injury.
[f]Excludes: 454 – sexual assault; 452 – foreign body vagina.
[g]Excludes: 502 – chemical exposure eye; 503 – foreign body eye; 510 – eye trauma.
[h]Excludes: 552 – traumatic back/spine injury; 553 – amputation; 556 – upper extremity injury.

eTable 2. Total visits by age group: Absolute and relative difference of emergency department visits (95% confidence interval) with and without pandemic effect in model in April 2020, December 2020, and cumulative for the entire period between February 2020 and May 2021.

	April 2020		December 2020		Cumulative (Feb 2020 - May 2021)	
	Absolute	Relative (%)	Absolute	Relative (%)	Absolute	Relative (%)
<10	-9,800 (-10,700 to -8,900)	-68 (-71 to -64)	-8,200 (-8,900 to -7,400)	-52 (-55 to -48)	-93,600 (-101,900 to -85,200)	-42 (-44 to -40)
10-19	-7,500 (-8,200 to -6,800)	-65 (-69 to -61)	-3,500 (-4,000 to -2,900)	-32 (-36 to -28)	-48,600 (-55,500 to -41,900)	-27 (-30 to -25)
20-29	-7,500 (-8,700 to -6,300)	-43 (-49 to -37)	-2,700 (-3,700 to -1,800)	-15 (-20 to -10)	-38,200 (-49,600 to -27,300)	-13 (-17 to -10)
30-39	-6,400 (-7,600 to -5,200)	-37 (-44 to -30)	-1,600 (-2,500 to -660)	-10 (-15 to -4)	-24,300 (-34,700 to -13,900)	-9 (-12 to -5)
40-49	-5,200 (-6,400 to -4,000)	-35 (-42 to -28)	-1,400 (-2,200 to -680)	-10 (-14 to -5)	-21,900 (-31,000 to -12,600)	-9 (-13 to -5)
50-59	-5,500 (-6,800 to -4,200)	-33 (-40 to -25)	-1,700 (-2,600 to -920)	-11 (-16 to -6)	-24,800 (-35,100 to -15,100)	-9 (-13 to -6)
60-69	-5,200 (-6,300 to -3,800)	-33 (-40 to -26)	-1,100 (-1,800 to -290)	-7 (-11 to -2)	-19,800 (-29,500 to -10,500)	-8 (-11 to -5)
70-79	-5,000 (-6,000 to -3,900)	-36 (-43 to -28)	-1,400 (-2,000 to -700)	-10 (-15 to -6)	-24,400 (-33,200 to -16,200)	-11 (-14 to -7)
80-89	-3,500 (-4,200 to -2,800)	-35 (-42 to -28)	-1,600 (-2,100 to -1,100)	-16 (-21 to -11)	-20,900 (-27,200 to -14,900)	-13 (-17 to -10)
90+	-1,400 (-1,700 to -1,200)	-43 (-49 to -37)	-510 (-680 to -320)	-15 (-20 to -11)	-8,400 (-10,600 to -6,500)	-16 (-19 to -12)

Appendix 1, as submitted by the authors. Appendix to: Yao J, Irvine MA, Klaver B, et al. Changes in emergency department use in British Columbia, Canada during the first 3 years of the COVID-19 pandemic. *CMAJ* 2023. doi: 10.1503/cmaj.221516.

eTable 3. Total visits by CTAS levels: Absolute and relative difference of emergency department visits (95% confidence interval) with and without pandemic effect in model in April 2020, December 2020, and cumulative for the entire period between February 2020 and May 2021.

	April 2020		December 2020		Cumulative (Feb 2020 - May 2021)	
	Absolute	Relative (%)	Absolute	Relative (%)	Absolute	Relative (%)
Non-urgent	-1,900 (-2,200 to -1,700)	-47 (-52 to -41)	-840 (-1,000 to -660)	-22 (-26 to -17)	-11,900 (-14,300 to -9,900)	-19 (-21 to -16)
Less urgent	-19,100 (-21,500 to -16,600)	-47 (-52 to -42)	-8,700 (-10,500 to -7,000)	-22 (-26 to -18)	-112,400 (-132,400 to -92,700)	-18 (-20 to -15)
Urgent	-27,400 (-31,400 to -23,200)	-42 (-46 to -36)	-11,700 (-14,300 to -8,900)	-18 (-22 to -14)	-154,200 (-186,300 to -121,100)	-15 (-18 to -12)
Emergent	-8,200 (-9,500 to -6,800)	-36 (-41 to -30)	-3,400 (-4,400 to -2,400)	-15 (-19 to -11)	-49,200 (-60,600 to -38,500)	-13 (-16 to -11)
Resuscitation	-150 (-230 to -70)	-20 (-29 to -9)	40 (20 to 70)	5 (2 to 9)	290 (-40 to 630)	2 (0 to 5)

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eTable 4. Total visits by health region: Absolute and relative difference of emergency department visits (95% confidence interval) with and without pandemic effect in model in April 2020, December 2020, and cumulative for the entire period between February 2020 and May 2021.

	April 2020		December 2020		Cumulative (Feb 2020 - May 2021)	
	Absolute	Relative (%)	Absolute	Relative (%)	Absolute	Relative (%)
Fraser	-26,900 (-30,500 to -23,000)	-43 (-48 to -38)	-13,300 (-16,000 to -10,700)	-21 (-25 to -17)	-172,500 (-201,600 to -143,500)	-17 (-20 to -15)
Interior	-5,700 (-6,500 to -4,900)	-43 (-48 to -37)	-2,200 (-2,800 to -1,600)	-17 (-21 to -13)	-29,500 (-35,500 to -23,200)	-14 (-17 to -11)
Northern	-1,800 (-2,000 to -1,500)	-43 (-48 to -38)	-1,100 (-1,200 to -900)	-26 (-29 to -22)	-13,400 (-15,600 to -11,400)	-20 (-23 to -18)
Vancouver Coastal	-14,100 (-15,500 to -12,700)	-47 (-51 to -42)	-7,000 (-8,200 to -5,800)	-24 (-27 to -20)	-94,400 (-108,400 to -80,800)	-20 (-22 to -17)
Vancouver Island	-8,600 (-9,900 to -7,100)	-35 (-40 to -29)	-2,200 (-3,200 to -1,100)	-9 (-13 to -5)	-24,600 (-37,200 to -12,800)	-6 (-9 to -4)

Appendix 1, as submitted by the authors. Appendix to: Yao J, Irvine MA, Klaver B, et al. Changes in emergency department use in British Columbia, Canada during the first 3 years of the COVID-19 pandemic. *CMAJ* 2023. doi: 10.1503/cmaj.221516.

eTable 5. Respiratory visits by age groups: Absolute and relative difference of emergency department visits (95% confidence interval) with and without pandemic effect in model in April 2020, December 2020, and cumulative for the entire period between February 2020 and May 2021.

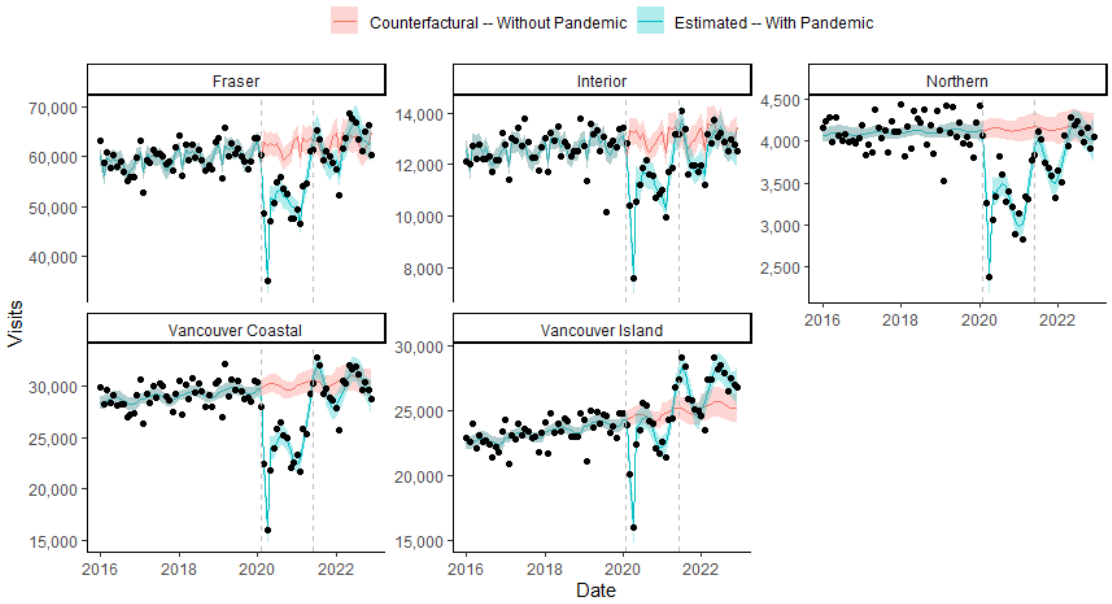
Appendix 1, as submitted by the authors. Appendix to: Yao J, Irvine MA, Klaver B, et al. Changes in emergency department use in British Columbia, Canada during the first 3 years of the COVID-19 pandemic. *CMAJ* 2023. doi: 10.1503/cmaj.221516.

	April 2020		December 2020		Cumulative (Feb 2020 - May 2021)	
	Absolute	Relative (%)	Absolute	Relative (%)	Absolute	Relative (%)
<10	-1,800 (-2,100 to -1,500)	-82 (-87 to -76)	-2,700 (-3,100 to -2,400)	-79 (-82 to -75)	-24,000 (-27,200 to -20,900)	-65 (-68 to -61)
10-19	-370 (-460 to -280)	-64 (-74 to -52)	-380 (-460 to -310)	-57 (-64 to -50)	-4,000 (-4,800 to -3,200)	-44 (-49 to -38)
20-29	-310 (-450 to -150)	-39 (-53 to -20)	-390 (-500 to -280)	-42 (-50 to -33)	-3,200 (-4,500 to -2,000)	-25 (-32 to -16)
30-39	-220 (-380 to -30)	-27 (-45 to -2)	-400 (-510 to -290)	-42 (-50 to -32)	-3,000 (-4,300 to -1,800)	-23 (-30 to -15)
40-49	-140 (-310 to 50)	-18 (-38 to 5)	-280 (-380 to -180)	-32 (-41 to -23)	-2,300 (-3,400 to -1,200)	-19 (-27 to -11)
50-59	-270 (-470 to -30)	-27 (-44 to -5)	-270 (-390 to -160)	-25 (-34 to -16)	-2,600 (-4,100 to -1,300)	-17 (-25 to -8)
60-69	-360 (-590 to -120)	-29 (-47 to -8)	-340 (-480 to -190)	-25 (-34 to -16)	-3,800 (-5,500 to -2,200)	-19 (-27 to -12)
70-79	-420 (-630 to -140)	-32 (-49 to -12)	-320 (-460 to -170)	-23 (-31 to -14)	-3,900 (-5,700 to -2,200)	-19 (-26 to -12)
80-89	-400 (-590 to -190)	-37 (-53 to -17)	-290 (-420 to -170)	-26 (-35 to -17)	-3,700 (-5,200 to -2,100)	-22 (-29 to -15)
90+	-180 (-250 to -100)	-45 (-59 to -26)	-130 (-180 to -70)	-28 (-37 to -18)	-1,500 (-2,200 to -970)	-24 (-31 to -16)

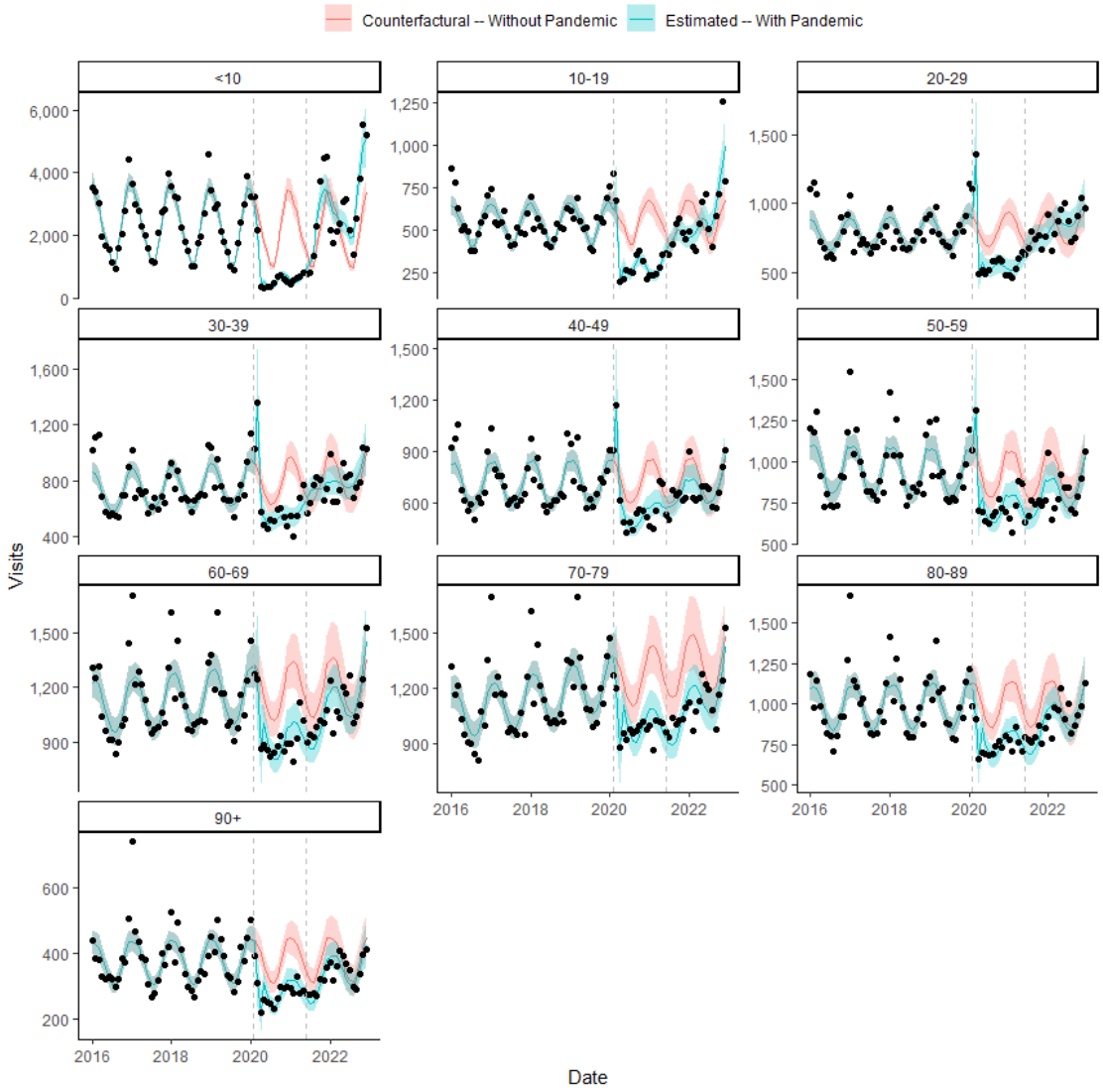
Appendix 1, as submitted by the authors. Appendix to: Yao J, Irvine MA, Klaver B, et al. Changes in emergency department use in British Columbia, Canada during the first 3 years of the COVID-19 pandemic. *CMAJ* 2023. doi: 10.1503/cmaj.221516.

eTable 6. Data Sources integrated within the BC COVID-19 Cohort (BCC19C). The dataset used and presented for this study is highlighted in orange. The dataset highlighted in gray was also used in the exploratory and validation analysis, but results were not presented in this article due to a number of limitations.

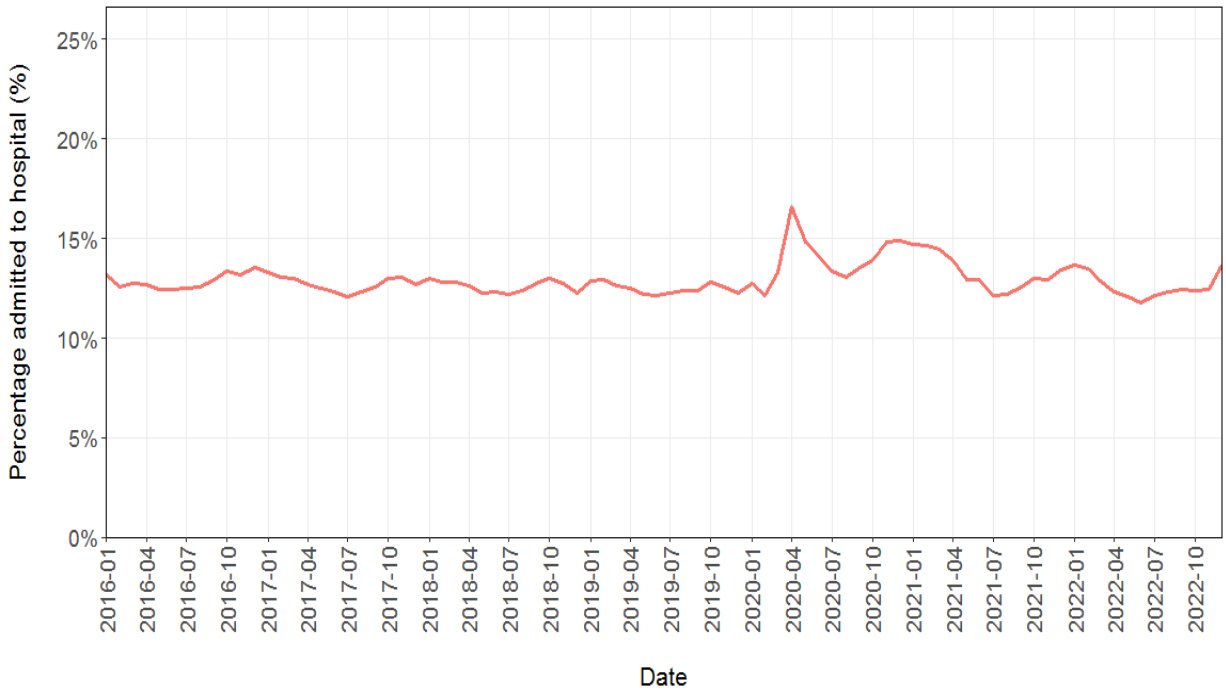
British Columbia Centre for Disease Control (BCCDC), Provincial Heath Services Authority (PHSA) and Regional Health Authority data sources:	**Data Date Ranges:**
Integrated COVID-19 laboratory dataset (SARS-CoV2 tests from private/public labs) [S1]	Jan,2020-onward
COVID-19 surveillance case data (information collected on all probable/confirmed cases as part of public health follow up) [S2]	Jan,2020-onward
Provincial COVID-19 Monitoring Solution (critical and non-critical care hospital census data) [S3]	Jan,2020-onward
Provincial Immunizations Registry (COVID-19 vaccination data) [S4]	Dec,2020-onward
Provincial Laboratory Information Solution (laboratory tests from private/public labs) [S5]	Jan,2020-onward
Public Health Reporting Data warehouse (Influenza laboratory tests) [S6]	Jan,2008-onward
Emergency department visits (hospital-based and community-based ambulatory care)	Mar,2020-onward
Ministry of Health (MoH) Administrative Data Sources:	**Data Date Ranges:**
Client Roster (CR) (registry of enrollment in the universal public health insurance plan including residential history) [S7]	2008/9-onward
Discharge Abstracts Database (DAD) (hospital discharge records) [S8]	2008/9-onward
Medical Services Plan (MSP) (physician diagnostic and billing data for services provided through universal public health insurance plan) [S9]	2008/9-onward
PharmaNet (Pharma) (prescription drugs dispensed from community pharmacies, includes medications covered by public and private insurance plans) [S10]	2008/9-onward
BC Vital Statistics (VS) (deaths registry)[S11]	2008/9-onward
National Ambulatory Care Reporting System (NACRS) (hospital-based and community-based ambulatory care) [S12]	2011/12–onward
Chronic Disease Registry [S13]	2008/9-2018/19
811 Calls (respiratory calls only) [S14]	2014-onward
Health System Matrix [S15]	2018/19-onward
Population Grouper Methodology [S16]	2008/9-onward



eFigure 1. Number of estimated visits by health regions. Blue and red line (area) shows that estimates (95% confidence interval) with and without the effect of the pandemic, respectively. Black points represent observed monthly emergency department visits. The vertical dash line indicates important events: (1) report of the first COVID-19 case in BC (Jan 28, 2020); (2) total emergency department visits return to baseline level (May, 2021)



eFigure 2. Number of estimated visits for respiratory conditions by age groups. Blue and red line (area) shows that estimates (95% confidence interval) with and without the effect of the pandemic, respectively. Black points represent observed monthly emergency department visits. The vertical dash line indicates important events: (1) report of the first COVID-19 case in BC (Jan 28, 2020); (2) total emergency department visit return to baseline level (May, 2021)



eFigure 3. Percentage of ED visits admitted to hospital by month in BC.

Statistical methods

Model settings

Due to length of study period and changes in population demographics, a linear annual trend was incorporated after adjustment for seasonality and pandemic effects. Greater flexibility was provided for the month-of-year terms allowing general seasonal patterns to be modeled with appropriate correlation between the end and start of each year. The pandemic effect was also modeled with greater flexibility allowing for smooth interpolation month on month after adjustment for annual and seasonal trends. In addition, two categorical predictors for March 2020 and April 2020 were included to account for the out of trend changes in behaviour at the initial two months following the declaration of the public health emergency. We found that the incorporation of these predictors provided a better fit over just including the pandemic effect, which was not flexible enough to capture the drop in visits during the two months. Specifically, cyclic cubic splines were used to estimate seasonality, linear terms were used for annual trends, and a further thin plate spline was used to estimate the effect of the pandemic in terms of days since the first COVID-19 case in BC on January 28, 2020. The interaction between seasonality, annual trend, March 2020, April 2020, and pandemic effect was applied to visiting reason, age group, acuity, and health authority.

Model evaluation

Auto-correlation, partial auto-correlation, and residuals of the deviance plots were used to visually assess model diagnostics and fitting. To assess model fit to pre-pandemic trends the root mean-squared error (RMSE) was calculated on the overall number visits and the number of visits by visit reason between April 2016 and January 2020 in the table below.

	RMSE
Overall Model	1354
All conditions	4928
Gastrointestinal/Genitourinary	924
Injury	614
Cardiovascular	661
Orthopedics	473
General and minor	773
Respiratory	669
Neurologic	273
Skin	261
ENT	213
Mental health	189
Ophthalmology	113
Substance misuse	145
OBGYN	76
Sexual assault	10

Derivation of the 95% confidence intervals

The difference in outcomes between baseline and counterfactual scenarios were estimated through the employment of generalized additive models (GAMs) in this study, which are extensions of generalized linear models incorporating general basis functions representing splines. We adopted the Delta method in order to estimate the variance and 95% confidence intervals within and between these scenarios.

Given an outcome Y with a set of predictors X a simple linear regression model is of the form,

$$Y = \beta X + \epsilon.$$

Where ϵ is a normally distributed i.i.d. random variate. Generalizing to multiple predictors in matrix notation this can be described as,

$$\mathbf{Y} = \mathbf{X\beta} + \boldsymbol{\epsilon}. \qquad (1)$$

Where X in Equation (1) is the design matrix. Given that the estimator for the response is $X\hat{\beta}$, the variance of the response estimator is,

$$\begin{aligned}\widehat{\mathrm{Var}}(\hat{Y}) &= X(X^{\intercal}X)^{-1}X^{\intercal}\mathrm{Var}(Y)X(X^{\intercal}X)^{-1}X^{\intercal},\\ &= \hat{\sigma}^2X(X^{\intercal}X)^{-1}X^{\intercal}.\end{aligned}$$

Where $\hat{\sigma}^2$ is the estimated variance for ϵ. A generalized linear model is an extension of a linear model that includes a link function g to define the expected value of the response according to the following relationship,

$$\mathbb{E}(Y|X) = g^{-1}(X\beta)$$

The results for the variance estimator of the coefficients follows as above, however in order estimate the variance of the response estimator we need to apply the delta method for a non-linear function f applied to a random variable Z,

$$\mathrm{Var}\big(f(Z)\big) = (\nabla f)^{\intercal}Var(Z)(\nabla f).$$

For a Poisson or negative binomial model f is the exponential function and it follows that,

$$\begin{aligned}(\nabla f)_{ij} &= \frac{\partial}{\partial\beta_i}\exp\left(\sum_k \beta_k\, x_{kj}\right),\\ &= x_{ij}\exp\big(\hat{y}_j\big).\end{aligned}$$

GAMs in addition to linear terms fit general spline terms based on a series of basis functions ϕ_i. As each term in the design matrix is transformed by these basis functions, it is straightforward to extend the above estimate of the variance for $\hat{Y}$ to a GAM with the final estimate,

$$\widehat{\mathrm{Var}}\big(\hat{Y}\big) = \hat{\sigma}^2\tilde{X}(\nabla f)^{\intercal}\big(\tilde{X}^{\intercal}\tilde{X}\big)^{-1}\tilde{X}^{\intercal}(\nabla f). \qquad (2)$$

Where $\tilde{X}$ is the transformed design matrix. To calculate the variance of the difference in outcome between a baseline and counterfactual scenario we have to calculate both the variance of the outcome for each scenario and the covariance induced by the dependence on the model coefficients. The variance of the difference for two random variables that are not independent (X_1 and X_2) are,

$$\mathrm{Var}(X_1 - X_2) = \mathrm{Var}(X_1) + \mathrm{Var}(X_2) - 2\mathrm{Cov}(X_1, X_2).$$

The difference in outcome between scenarios can be calculated directly from Equation (2) using the constant vector $u = (1, -1)^{\intercal}$ as the following quadratic form,

$$u^{\intercal}\widehat{\mathrm{Var}}\big(\hat{Y}\big)u. \qquad (3)$$

Supplementary References:

S1. British Columbia Centre for Disease Control [creator]. Integrated COVID-19 laboratory dataset (SARS-CoV2 tests from private/public labs). Public Health Reporting Data Warehouse, British Columbia Centre for Disease Control [publisher] (2020). 2021.

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