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Towards a comprehensive COVID-19 non-pharmaceutical interventions' index for the province of Québec

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Abstract

Objectives The primary objective of this project was to develop a comprehensive COVID-19 non-pharmaceutical interventions' index for the province of Québec (QCnPI-Index). The resulting database systematically categorizes, multiple non-pharmaceutical interventions implemented in the 17 administrative regions (AR) of the province of Québec to mitigate the spread of COVID-19 in the form of an index.

Data description Data represent interventions and groups of interventions implemented during the COVID-19 period in Québec. They are a compilation of policies, guidelines, and governmental interventions related to COVID-19, considering temporal and geographical dimensions. Data were collected for all 17 AR of Québec using dates as unit of analysis, from March 2020 to April 2022. They were first collected and then coded by an interdisciplinary research team to form the foundation of the QCnPI-Index.

Contribution This quantitative instrument offers the necessary granularity for nuanced spatial and temporal studies within the province of Québec, using AR, for instance, as unit of analysis. With this database, pre-, during-, and post-COVID periods can thus be better analyzed. Additionally, the innovative methodologies employed for data collection, coding, and weighting offer valuable insights that may have broader applications in public health, epidemiology, and other research domains. The QCnPI-Index could be instrumental for public health, epidemiology, and transportation researchers investigating the multifaceted impacts of non-pharmaceutical interventions on various societal domains, such as road safety, alcohol and cannabis consumption, and/or mental health, in the province of Québec.

Keywords Non-pharmaceutical interventions, Policies, COVID-19, Index, Québec, Time-variation, COVID-19 mitigation strategies, Multi domain impact analysis

Introduction

In January 2020, the World Health Organization (WHO) declared COVID-19 a global health emergency [4]. To limit and ease its spread, national and regional jurisdictions introduced multiple and even contradictory NPIs at different speeds [9]. Some of these NPIs reduced mobility through: closures of educational institutions [7], non-essential businesses [11] and prison facilities [14], curfews [3, 12], cancelations and suspensions of public

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events [1], and promotion of teleworking [1]. In short, the COVID-19 pandemic forced governments to act rapidly, yet NPIs were highly heterogeneous in terms of implementation time, duration, content and strength.

In Canada, and provincial NPIs have also differed from each other; that is, there has been substantial geographic heterogeneity in NPIs' design across these jurisdictions [5]. Further, time of NPI implementation also varied significantly across these settings. For instance, between January 1, 2020, and April 20, 2020, more than 2500 NPIs were identified across Canada, and based on the Oxford Stringency Index (OSI) of NPIs, the provinces of British Columbia and Newfoundland and Labrador obtained the highest values on the OSI score.

This research note presents a database that systematically organizes a group of NIP implemented at the regional level in the province of Québec from March 2020 to July 2022 to help scholars to assess multiple effects of these interventions within this province.

Objective

The primary objective of this database is to advance a comprehensive COVID-19 non-pharmaceutical interventions' index (QCnPI-Index) for the province of Québec. This work systematically categorizes, in the form of an index, multiple non-pharmaceutical interventions implemented within the province of Québec to mitigate the spread of COVID-19. Multiple sources were used to build this database. First, the Canadian COVID-19 Intervention Timeline Tool [1], developed by the Canadian Institute for Health Information, was used to construct a set of dimensions where COVID non-pharmaceutical interventions could be organized. This tool incorporates data compiled by the Government of Canada and, has a high level of data reliability and validity [2]. While this instrument categorizes interventions by jurisdiction, including both federal and provincial levels, it does not systematically collect data at more specific jurisdictional levels, such as administrative regions (AR) within provinces. Therefore, other data sources, such as information disseminated through media outlets—namely, press releases available on the Government of Québec's official website, timeline of *Institut national de santé publique du Québec* (INPSQ) [3], newspapers, and online news platforms were carefully examined to capture regional and temporal variations within the province. These supplementary data enhance the Canadian COVID-19 Intervention Timeline Tool by providing more detailed contextual and temporal information. Researchers interested in evaluating the various consequences of non-pharmaceutical interventions during the pandemic may utilize this database, depending on their theoretical and methodological approaches. It can be used to assess these interventions across multiple areas of interest, including but not limited to traffic crashes, alcohol or cannabis consumption and sales, and mental health outcomes, such as depression and anxiety.

Data description

Data collection

This database focuses on four pivotal categories—(i) Travel, (ii) Physical distancing, (iii) Closure/Opening, and (iv) Public Information—applied across Québec's 17 AR. The Travel encompasses interventions aimed at regulating the movement of individuals between geographic locations. The Physical distancing involves interventions intended to enforce physical distancing and minimize interpersonal interactions. The Closure/Opening includes a variety of interventions aimed at suspending or resuming operations in different sectors of activity. The Public Information includes, among other details, information related to the phases and alert level changes in Québec, characterized by different colors (red, orange, yellow, and green). This category was used to identify the specific regions where interventions were implemented and, in some cases, to help determine when interventions might have started or ended. Since the first three categories (travel, physical distancing, and closure/opening) are related to public spaces and have the potential to impact mobility, mental health and even alcohol and cannabis consumption, we used them to construct the QCnPI-Index. These categories collectively included 58 interventions. This classification was essential to ascertain the duration of each implemented intervention, which was not always clear in the timeline.

This database does not cover all interventions, such as mandatory face mask-wearing, which may affect certain categories. Additionally, interventions in specific administrative region sectors are sometimes considered region-wide if they significantly impact a sizable area or population.

Data treatment

The collected data underwent meticulous organization to various facets of the interventions. In Table 1 we depict the interventions associated with each category. Travel includes the following interventions: travel restrictions, self-isolation protocols, and checkpoints. Similarly, Physical distancing was broken down into curfew, social gathering limitations, and telework protocols. Closure/Opening was segmented into Daycare, Education, Non-essential Services, and Recreation.

Table 1 Weights for Categories, Subcategories, Interventions, Sub-interventions, and Micro-sub-interventions

Categories	Weights	Sub-categories	Weights	Interventions	Weights	Sub-interventions	Weights	Micro-sub-interventions	Weights
Travel	0.25	Self-isolation	0.3	Mandatory 14-day self-isolation (International)	0.3	–	–	–	–
				Mandatory 14-day (US)	0.7	–	–	–	–
		Checkpoint	0.1	US border checkpoint: checking restrictions according to COVID-19 policies	0.2	–	–	–	–
				Checkpoint from one region to another region	0.4	–	–	–	–
				Additional police checkpoints	0.4	–	–	–	–
		Travel Restriction	0.6	Travel advisory warning (within province)	0.05	–	–	–	–
				Only essential travel to specific regions	0.2	–	–	–	–
				Travel advisory warning (within regions)	0.05	–	–	–	–
				Residents of Ontario are prohibited from entering or staying in Québec	0.2	–	–	–	–
				Travel to and from prohibited regions	0.2	–	–	–	–
				Travel prohibited from red and orange zones to yellow zones	0.2	–	–	–	–
				Travel from discouraged	0.05	–	–	–	–
				Travel advisory warning (within regions, cities, districts)	0.05	–	–	–	–

Table 1 (continued)

Categories	Weights	Sub-categories	Weights	Interventions	Weights	Sub-interventions	Weights	Micro-sub-interventions	Weights
Distancing	0.40	Curfew	0.6	Curfew: 20h00 to 5h00 and time extension	0.7	–	–	–	–
				Curfew: 21h30 or 22h00 to 5h00	0.3	–	–	–	–
		Work from home	0.1	Mixed work encouragement	0.2	–	–	–	–
				Recommended/ encouraged work from home	0.3	–	–	–	–
				Mandatory work from home	0.5	–	–	–	–
		Gathering	0.3	Indoor/Private	0.5	350 and more	0.03	–	–
						100–250	0.07	–	–
						11–50	0.1	–	–
						6–10	0.15	–	–
						No one	0.65	–	–
				Outdoor/Private	0.2	350 and more	0.03	–	–
						100–250	0.07	–	–
						11–50	0.1	–	–
						6–10	0.15	–	–
						No one	0.65	–	–
				Indoor/Outdoor/ Private	0.3	350 and more	0.03	–	–
						100–250	0.07	–	–
						11–50	0.1	–	–
						6–10	0.15	–	–
						No one	0.65	–	–

Table 1 (continued)

Categories	Weights	Sub-categories	Weights	Interventions	Weights	Sub-interventions	Weights	Micro-sub-interventions	Weights
Closures/Openings	0.35	Day Care	0.1	Mixed condition	0.5	–	–	–	–
				Open with limited	0.4	–	–	–	–
				Expand: Extension of restrictions	0.1	–	–	–	–
		Education	0.25	Elementary	0.2	–	–	–	–
				Secondary	0.2	–	–	–	–
				Post-Secondary	0.5	–	–	–	–
				Mixed condition: Simultaneity of restrictions between different educational groups	0.1	–	–	–	–
		Non-Essential	0.15	Outdoor activities	0.3	–	–	–	–
				Place of worship	0.1	–	–	–	–
				Non-priority business	0.6	Completely Closed	0.6	–	–
						Partial Closed	0.3	–	–
						Shopping center Permitted: Allowing only them to work	0.1	–	–
		Recreation	0.5	Restaurants	0.5	Completely Closed	0.5	–	–
						Delivery only/ Take out	0.3	–	–
						Allowing restaurants to operate in shopping centers	0.2	–	–
				Bar	0.5	Hours Restriction	0.25	Midnight/1 a.m	0.75
								Midnight/2 a.m	0.25
						Completely Closed	0.75	–	–

Data coding

First, categories were divided by subcategories, and subcategories were divided by interventions. Some interventions were further divided into sub-interventions. Only one sub-intervention was divided into micro-sub interventions. All micro-sub interventions, sub-interventions, interventions, subcategories, and categories are identified in Table 1.

Both theoretical and mathematical approaches were deployed to construct the QCnPI-Index as well as its sub-indexes. With both approaches, Sub-interventions within interventions, interventions within subcategories, and subcategories within categories were assigned weights, with the highest value being 1. For instance, according to the Eq. 1, travel includes three sub-categories self-isolation, checkpoint, and travel restriction with the devoted values 0.3, 0.1, and 0.6 that the total of them equal 1.

$$\text{Travel} = \text{Self} - \text{isolation} + \text{Checkpoint} + \text{Travel Restriction} \quad (1)$$

Table 2 Lowest and highest values per category and for the QCnPI-Index per administrative regions, Québec (March 2020-April 2022)

Administrative region's number	Administrative regions	Travel		Distancing		Closuring/Opening		QCnPI-Index	
		Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest
1	Bas-Saint-Laurent	0.09	0.60	0.0063	0.6650	0.0656	0.7765	0.0225	0.5447
2	Saguenay–Lac-Saint-Jean	0.09	0.71	0.0063	0.6650	0.0656	0.7765	0.0225	0.5810
3	Capitale-Nationale	0.03	0.59	0.0063	0.6650	0.0656	0.7765	0.0225	0.5422
4	Mauricie	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5529
5	Estrie	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5529
6	Montréal	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5617
7	Outaouais	0.03	0.59	0.0063	0.6650	0.0656	0.7765	0.0225	0.5422
8	Abitibi-Témiscamingue	0.09	0.71	0.0063	0.6650	0.0656	0.7765	0.0225	0.5810
9	Côte-Nord	0.09	0.71	0.0063	0.6650	0.0656	0.7765	0.0225	0.5810
10	Nord-du-Québec	0.02	0.63	0.0063	0.6150	0.0656	0.7765	0.0050	0.4425
11	Gaspésie–Îles-de-la-Madeleine	0.09	0.69	0.0063	0.6650	0.0656	0.7765	0.0225	0.6210
12	Chaudière-Appalaches	0.03	0.59	0.0063	0.6668	0.0656	0.7765	0.0225	0.5517
13	Laval	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5617
14	Lanaudière	0.03	0.59	0.0063	0.6668	0.0656	0.7765	0.0225	0.5429
15	Laurentides	0.03	0.67	0.0063	0.6668	0.0656	0.7765	0.0225	0.5792
16	Montérégie	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5617
17	Centre-du-Québec	0.03	0.63	0.0063	0.6668	0.0656	0.7765	0.0225	0.5617

The absence of sub-interventions or interventions on specific dates were coded as 0. In theoretical approach, to determine the distribution of weights for categories, a consensus approach involving four researchers (JINM, AM, VNMG, CCMP) was applied.

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was utilized to determine the weights of each category, mathematically (Najafi Moghaddam [6]) [4, 5]. In this method, m categories were evaluated by n sub-categories, and n sub-categories

Table 3 Correlations between the averages theoretical and mathematical QCnPI-Indexes per administrative regions, Québec (March 2020-April 2022)

Administrative region's number	Administrative regions	QCnPI-Index		Correlation
		Theoretical	Mathematical	
1	Bas-Saint-Laurent	0.2209	0.2437	0.9899
2	Saguenay–Lac-Saint-Jean	0.2425	0.2761	0.9906
3	Capitale-Nationale	0.2409	0.2521	0.9931
4	Mauricie	0.2352	0.255	0.9890
5	Estrie	0.2309	0.2505	0.9899
6	Montréal	0.2509	0.2646	0.9936
7	Outaouais	0.2326	0.2447	0.9904
8	Abitibi-Témiscamingue	0.2309	0.2667	0.9902
9	Côte-Nord	0.2311	0.2664	0.9906
10	Nord-du-Québec	0.1861	0.2153	0.9905
11	Gaspésie–Îles-de-la-Madeleine	0.2491	0.2907	0.9895
12	Chaudière-Appalaches	0.2417	0.2528	0.9931
13	Laval	0.2428	0.2568	0.9928
14	Lanaudière	0.224	0.2397	0.9872
15	Laurentides	0.2389	0.2598	0.9906
16	Montérégie	0.2402	0.2583	0.9912
17	Centre-du-Québec	0.2296	0.2507	0.9905

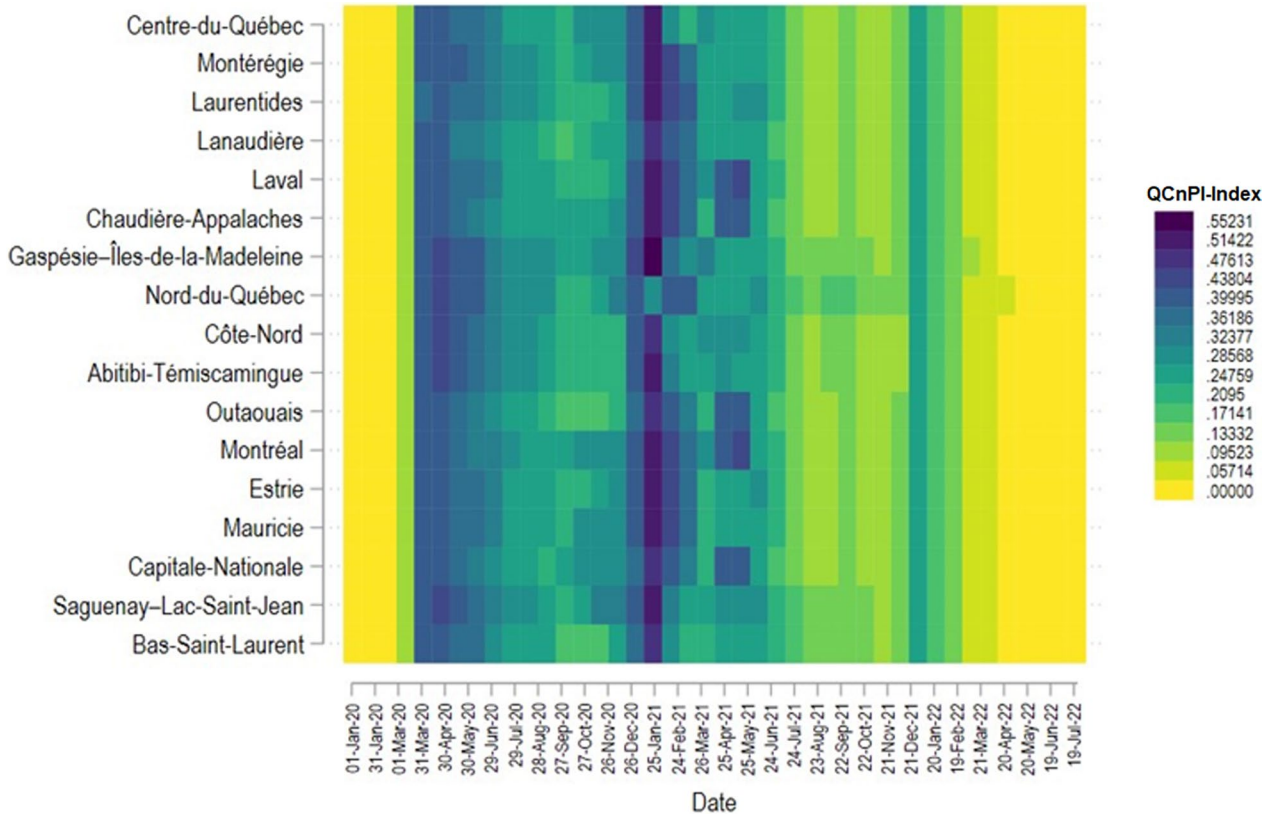

Fig. 1 Heat map of the QCnPI Index across Québec's 17 administrative regions (January 2020–July 2022). The presentation of results in the figure is based on the order of the regions' numbers, which have been previously provided in Tables 2 and 3

were evaluated by x interventions, and each category and sub-categories were assigned a score based on the values of its sub-categories and interventions, respectively. The values referenced in this method are those we determined earlier for interventions, sub-interventions, and sub-categories. This approach provides higher rankings to categories, which exhibit the highest similarity to the ideal solution.

In the context of the QCnPI index, a higher score signifies a greater level of implementation of non-pharmaceutical interventions by the government within a specific administrative region during a given time period. This means that more interventions were simultaneously in effect, reflecting a more comprehensive approach to mitigating the spread of COVID-19. Conversely, lower scores indicate a lower level of intervention implementation, with fewer measures in place during the same period, suggesting a less comprehensive approach.

Indices comparison

To assess differences between theoretical and mathematical approaches simple correlations analysis were applied [13], where a value of 0.9 or higher, or value of -0.9 or lower, is considered a high correlation where both indices measure the same phenomenon almost equally.

Data access

Data are publicable available at https://doi.org/https://doi.org/10.7910/DVN/XMUQMR [8].

Results

A total of 58 distinct interventions were documented, comprising 33 interventions, 23 sub-interventions, and 2 micro-sub-interventions. Table 2 identifies the lowest and highest values within each category, as well as the QCnPI-Index values for the 17 AR. Notably, a high level of homogeneity was observed across all AR in Distancing and Closuring and opening, with consistent highest and lowest values. In contrast, Travel exhibited more heterogeneity in terms of both its highest and lowest values when assessed across different AR. Furthermore, the highest QCnPI-Index values displayed relatively greater heterogeneity across AR, indicating variations in peak performance over time.

Table 3 presents the correlations between the averages of the QCnPI-Index obtained with both theoretical and

mathematical approaches. According to the correlation matrix, both approaches provided similar results (all r ≈ 0.99) for each administrative region, indicating that both indexes can be used interchangeably. However, upon comparative analysis between the theoretical and TOPSIS methodologies in Table 3, it was observed that values for Closure/Opening showed a high degree of similarity between the two approaches. Nevertheless, notable differences were observed between the two approaches (theoretical and mathematical) for Travel and Physical distancing, warranting statistical correlation analyses. The correlation coefficients ranged between -1 and 1, indicating the strength and directionality of the relationship between theoretical and mathematical weights [6]. For instance, Montréal not only has the highest correlation value 0.9936 among all AR but also indicates a strong and direct relationship between the two study approaches.

Figure 1 and supporting information, Appendix (Figs, S-1 to S-3) depict heat maps illustrating the temporal distribution of the QCnPI-Index and its three respective categories across various AR, spanning from January 2020 to July 2022. In Fig. 1, we observe that the highest values within all AR occurred between December 2020 and February 2021. Intriguingly, the initial two months of the pandemic also exhibited elevated scores, gradually declining until December 2020. Notably, there was a more substantial decline in the QCnPI-Index from April 2021 to December 2021, relative to the decrease observed from April 2020 to December 2020. Figure S-1 displays values for Travel. The highest values in this category are concentrated between April 2021 and June 2021, after which these interventions began disappearing rapidly. Figure S-2 provides insights into the distribution for Distancing. Comparatively to Fig. 1, we observe an overlap during the period of December 2020 to February 2021. However, the periods before and after exhibited notably lower values. Figure S-3 displays the results for Closure/Opening. Here, the highest values manifest during the early stages of the pandemic, especially within the first three months. Subsequently, the intensity of these interventions gradually diminished from July 2020, with a relatively strong increase in December 2021 and January 2022.

Discussion

The QCnPI-Index, along with its corresponding dataset documenting the durations of 58 Non-Pharmaceutical Interventions (NPIs) categorized into Travel, Physical Distancing, and Closure/Opening measures, elucidates the disparate temporal patterns of these interventions across Québec. When considered collectively, these interventions appear to have exerted varying levels of stringency over time. Notably, during the period from December 2020 to January 2021, the index reached its peak value in each administrative region (AR), subsequently displaying a more consistent decline starting from February 2022.

This dataset holds significant value for researchers aiming to analyze the multifaceted impacts of the QCnPI-Index throughout the pandemic. For instance, there exists a potential correlation between the index and reductions in traffic flow, which in turn could be linked to declines in traffic collisions [2]. It could be thus expected that across regions in Québec, *ceteris paribus*, considerable reductions of collisions within the pandemic were observed between December 2020 and January 2021. Researchers investigating variations in alcohol consumption over time during the pandemic could also utilize certain components of the index exclusively. Building upon the findings of Sherk and colleagues [10] regarding alcohol availability and consumption, one could posit that there may be a decrease in alcohol consumption during the first three months of the pandemic (March to May 2020). This hypothesis stems from the fact that the Closure/Opening category, which encompasses closures of restaurants and bars, reached its peak score during this period, as illustrated in Figure S-3.

Limitations

a) The exclusion of certain interventions: The study did not include all possible interventions, such as the mandatory wearing of face masks and this exclusion of specific interventions has the potential to impact various categories within our database.
b) A partial implementation of interventions: Some interventions have only been applied in specific sectors of AR. However, these interventions have been considered as being implemented across the entire administrative region if the area of application was significant in terms of geographical size, population, or other relevant factors.
c) Risks associated with data organization: For instance, due to the complexity of the interventions and sub-interventions, there is a risk of oversimplification. This may result in the omission of nuanced variations in the impact of specific interventions on different demographic groups or geographical areas, potentially leading to misinterpretations of the data.
d) Time to implement: it was assumed that when an AR introduced a given intervention, the implementation was immediate. Thus, when researchers apply statistical analysis to assess different impacts of the index, or some of its components, on specific outcomes, they could adjust with lags depending on what inter-

ventions are examining. For instance, while curfew had an immediate implementation closures of non-priority business may have taken days to be enforced as state resources to monitor this intervention may not have been sufficient.

e) Mechanisms behind changes in NPIs: while important differences across the components were observed over time as depicted in Figures S-1 to S-3, other studies are necessary to identify what led the public health community and other political, social and economic actors in Québec to opt for certain measures at times during the COVID-19 period of this province. To what extent for instance disease trends as well as vaccination rates were used to inform NPIs, including its duration.

Strengths

Despite the mentioned limitations, there are notable strengths to this database and index:

a) The database is a comprehensive and meticulous compilation of non-pharmaceutical interventions related to COVID-19 in Québec, providing a valuable resource for research in public health, epidemiology, and other related fields.
b) Innovative Index: The development of the QCnPI-Index offers a novel approach to quantifying and categorizing non-pharmaceutical interventions, facilitating multifaceted analyses of their impact.
c) Interdisciplinary Research Team: The collaboration of an interdisciplinary team in the data collection and coding process enhances the reliability and validity of the database.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13104-024-06947-w.

Supplementary file 1.

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Not Applicable

Author contributions
JINM designed and supervised the construction of the study. AM, CCMP, VNMG, BB, TGB, MSC, MCO, CP, CG, EM, JT, WV, improved the design of the study. AM and CCMP collected and organized first round of data. AM, CCMP and VNMG coded the second round of data. AM, CCMP, VNMG and JINM develop the theoretical distribution of the values of the index. VNMG carried out the statistical analysis and designed the figures. AM wrote the first draft of the study. JINM wrote the last draft of the study. AM, CCMP, VNMG, BB, TGB, MSC, MCO, CP, CG, EM, JT, WV, made corrections and edits, and approved the manuscript.

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Availability of data and materials
Data are available at https://doi.org/https://doi.org/10.7910/DVN/XMUQMR, Harvard Dataverse.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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