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## Extending the Benefits of Healthy Ageing Across the Life Course: An Environmental Scan of Canadian Data to Inform Data Harmonisation Across the Life Course

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### Abstract

Life course research requires data that capture exposures, critical periods, and key transitions from early life through to old age; however, in Canada a cohort extending across all life stages does not exist. An environmental scan was conducted using Maelstrom and the Atlas of Longitudinal Datasets to map the landscape of pre-existing Canadian data sources and to identify where they align, and where they do not, across life stages and domains of healthy aging. The identification of cohorts that span across different life stages provides an opportunity to create a harmonised data set that allows researchers to address life course related research questions. A total of 14 studies met the inclusion criteria for this review, none of which followed the same participants across the full life course. Studies included a breadth of measures not just focusing on disease but included measures of intrinsic capacity, functional ability and the environment. This scan maps the potential for harmonisation; however, continued work is needed to overcome methodological challenges, determine comparability of measures, and establish necessary data infrastructure.

### Keywords

Canada, longitudinal data, harmonization, life course

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## Introduction

In 2024, the Canadian population was approximately 41,288,600 people. The median age of Canadians was 40.3 years, which has increased by 2.7 years since 2002. Of the total population, 19% or 7,820,121 people were aged 65 years or older. The percentage of people aged 65 years and older compared to children aged 0-14 years is growing, as only 15% of the population falls within the younger age group [1]. This demographic phenomenon places tremendous pressure on health and social services, which are critical to meet the needs of our ageing population.

Ageing is a complex process influenced by biological, social and environmental factors and requires one to consider processes that span from cell to society, not only focusing on chronic diseases. It is therefore important to consider a person's capacities and abilities and how these may optimise both health and well-being. Healthy ageing is relevant to everyone, not only those free of disease. Healthy ageing uses a person-centred approach that is comprised of three components, intrinsic capacity, functional ability and the environment [2]. A person's intrinsic capacity includes physical and mental capabilities that a person can draw on. Important domains include locomotor capacity (e.g., physical movement), sensory capacity (e.g., vision/hearing), vitality (e.g., energy and equilibrium), cognition (e.g., dementia) and psychological capacity (e.g., depression). Functional ability combines an individual's intrinsic capacity, the environment they live in and how people interact with their environment. Functional ability includes the ability to: meet basic needs, learn, grow and make decisions, be mobile, build and maintain relationships and contribute to society. Finally, environments broadly encompass where people live and conduct their lives, including environmental exposures like pollution, the built environment, relationships, attitudes, or services, systems and policies.

Given the ageing population of Canada, there is growing importance to address the complex needs of this group recognising that there is great heterogeneity across older people. Provincial and Territorial governments will need additional funding over the next 10 years to adequately care for the ageing population [3]. Since people are living longer, it signifies the importance of not only investing in older people but also investing in each life stage to act early and based on evidence, optimising health trajectories and targeting sensitive periods across the life course, leading to optimal development and healthy ageing. A life course approach to health considers various biological, social and behavioural factors at distinct life stages, and how these may influence current and future health [4].

To answer questions incorporating a life course approach, studies with longitudinal data are needed. For instance, birth cohorts, which include participants from birth to later life, provide the opportunity to assess health and well-being over time, determining how various factors may accumulate to improve health or lead to declines. Data spanning all life stages, including critical periods (e.g., childhood development) and key transitions (e.g., completing school, retirement), are important, but longitudinal follow-up of the same individuals is what enables life course trajectories to be constructed. Due to the complexity, cost, and time required for data

collection, many studies focus on specific life stages or age groups rather than following individuals across the entire life course [5]. Harmonising existing data sources that include individuals from different life stages offers one way to address this limitation. Although this approach does not necessarily capture data from the same individuals over time, it allows for the connection of all life stages, which is essential for life course research. When harmonising data across life stages, careful consideration must be given to how variables are defined and measured to ensure that a consistent and comparable dataset can be generated.

The overarching objective of this environmental scan was to map the landscape of Canadian data sources that could potentially be harmonised to capture data across the life course. This is a scoping exercise intended to establish what data exist and where they align and was not a formal feasibility assessment of harmonisation. To meet this objective, studies were mapped to life stages, and WHO's conceptualisation of Healthy Ageing to understand availability of measures of intrinsic capacity, functional ability and the environment across the life course.

## Methods

### Study Design

An environmental scan was conducted to identify Canadian data sources across all life stages that potentially include measures of intrinsic capacity, functional ability and the environment. An environmental scan is a methodological approach used to examine a range of practices, policies, programs, and data sources in order to describe the current landscape and inform decision-making [6]. Although no established guidelines for environmental scans exist [7], we consulted five phases of the RADAR-ES framework [6], and have adapted reporting items from PRISMA where applicable.

### Search Strategy

A search was first conducted on Maelstrom (<https://www.maelstrom-research.org/>), which is an international database used to facilitate collaborative epidemiological research through rigorous data documentation, harmonisation, integration, and co-analysis, globally, and catalogues study metadata for over 393 studies. A second search was conducted on the Atlas of Longitudinal Datasets (<https://atlaslongitudinaldatasets.ac.uk/>), which is a list of longitudinal datasets from across the world. Since both are curated catalogues rather than bibliographic databases, keyword search strategies could not be applied. For each, Canadian studies were identified using the country filter. The remaining eligibility criteria were applied at the screening stage. The catalogues were scanned in 2023 and rechecked in January 2025. As both are curated registries of longitudinal studies, hand-searching and citation checking were not undertaken.

### Eligibility Criteria

Eligible studies needed to have the following criteria: 1) a general population sample, including gender specific cohorts;

2) were not a COVID-19-specific cohort or study; 3) had ongoing data collection; and 4) utilised a longitudinal, cohort or repeat cross-sectional design. Studies that did not have a clear data access policy for a broader research community were excluded. These eligibility criteria were deemed important if future data harmonisation were to take place.

## Screening and Data Extraction

Records were screened by a single reviewer. Information from eligible studies were extracted including study name, location, sample size, location in Canada, start year, study design, availability of data support documentation, availability of data, number of waves of data collection and if studies were linked to administrative data. Extraction was performed by a single reviewer using a standardised extraction form. Where linkage to administrative data could not be verified from study documentation or study websites, this was recorded as “Unsure” rather than inferred; these entries therefore reflect the absence of publicly available information.

## Mapping and Selection of Exemplar Measures

Studies were mapped to life stages and domains of intrinsic capacity, functional ability, and the environment as proposed by the Framework of Healthy Ageing, using data support documentation. To explore comparability of data in included studies, measures of intrinsic capacity, functional ability and the environment were selected. Selected measures are only an exemplar, acting as an exploratory exercise and does not mean they are the only measure of each domain, or the only measure available within studies. For some domains, two measures were selected, if a single measure for all life stages was not suitable. Selection of relevant measures was made using the Baseline report on Healthy Ageing [2], and other relevant frameworks (e.g., Nurturing Care Framework [8], Integrated Management of Childhood Illness [9] and the Adolescent Well-being Framework [10]). Candidate measures were identified from these frameworks by the research team, and expert consultation on the basis of relevance to the sub-domain, applicability across the greatest number of life stages, and availability in at least one included study.

## Results

### Overview of Existing Data

A total of 262 Canadian studies were identified from both Maelstrom and the Atlas of Longitudinal Datasets. After removing duplicates, 238 studies remained. After restricting studies to the general population sample and those that used a cohort or repeat cross-sectional design, 68 studies were eligible. Studies were excluded if they were a COVID-19-specific study ( $n=17$ ), did not have ongoing data collection ( $n=17$ ), did not have data support documentation or a data dictionary publicly available ( $n=9$ ), did not have possible access to data or access was restricted ( $n=8$ ), and did not collect individual-level data ( $n=2$ ). A final 14 studies were identified to be eligible for inclusion in a possible life course data harmonisation study. Figure 1 outlines the process of identification of relevant studies.

Among the 14 included studies, 10 used a cohort design, and the remaining four used a repeat cross-sectional design. One study was classified as a clinical trial on Maelstrom, however, the intervention was embedded within an observational cohort design. A total of 9,424,056 participants are included across the eligible studies, with three studies having no limit on participant number as they used a repeat cross-sectional design, thus do not have a fixed sample size. There were six studies that included participants across Canada, not limited to a single province or territory. A complete description of the studies included can be found in Table 1.

## Mapping Data to Life Stages

The studies included were mapped to life stages (Table 2). Life stages include Childhood (0–9 years); Adolescents (10–19 years); Young adults (20–29 years); Adults (30–44 years); Middle aged adults (45–59); Older adults (60–84 years); Oldest adults (85+ years). No study followed participants from birth across the life course, spanning all life stages. The Manitoba Multigenerational Cohort included participants of all life stages, linking participants across generations within a family. Three studies the Canadian Healthy Infant Longitudinal Development (CHILD) study, Canadian Health Survey on Children and Youth (CHSCY) and Healthy Life Trajectories Initiative (HeLTI) included data on children, however, participants have not yet been followed into subsequent life stages. The remaining studies recruited participants from other life stages. For example, the Canadian Community Health Survey (CCHS) included participants from all life stages except for childhood. Most of the other studies recruited participants at various adulthood life stages, with only six studies including adults in the oldest adult age range.

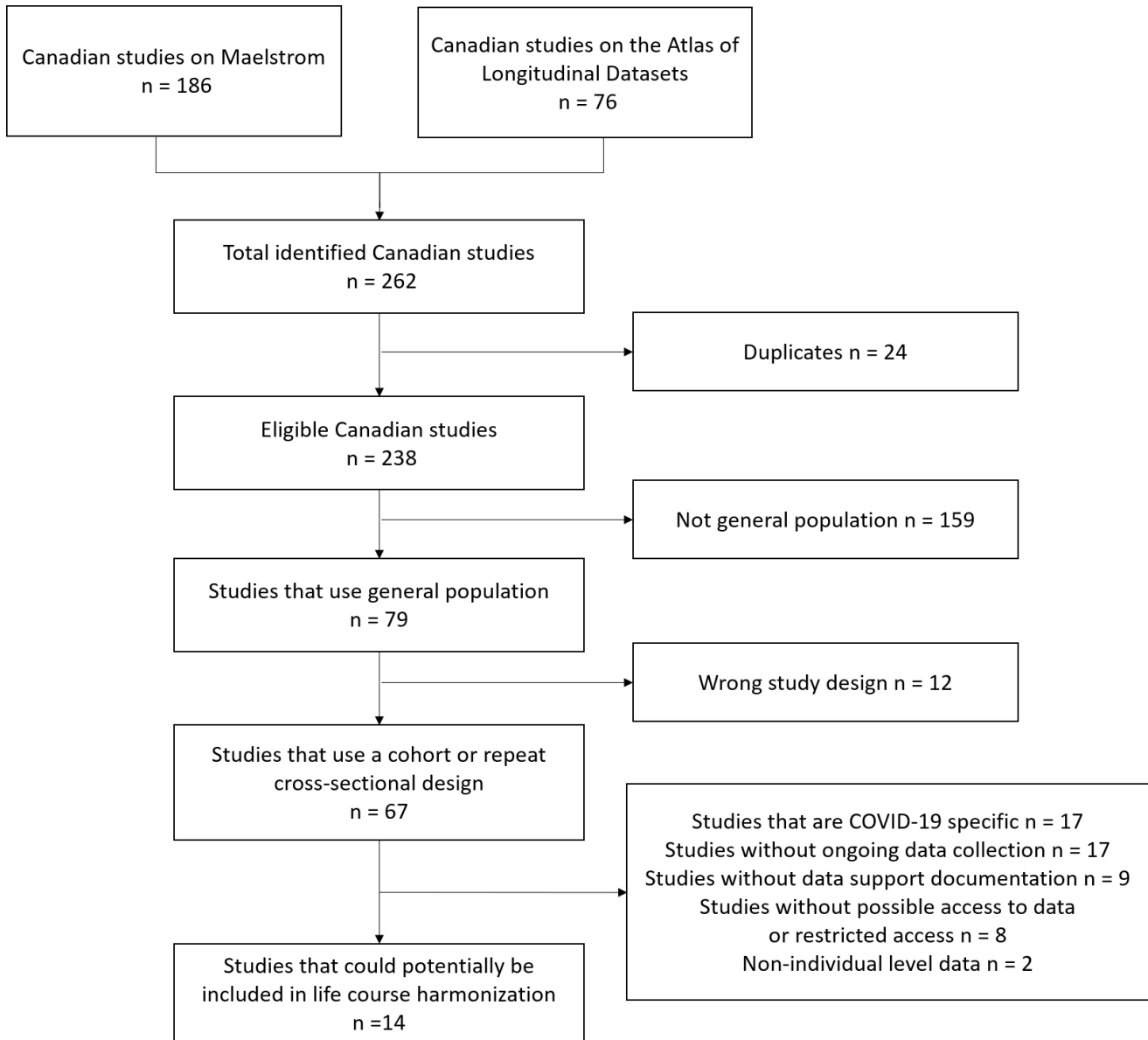
## Mapping Data to Domains of Intrinsic Capacity, Functional Ability, and Environment

Almost all studies included at least one measure of intrinsic capacity, functional ability and the environment (Table 2). However, the Labour Force Survey only included measures of functional ability. Tables 3–5 map eligible studies to specific measures of intrinsic capacity, functional ability and the environment as a preliminary assessment of comparability of measures across studies which could inform potential harmonisation.

*Intrinsic capacity.* For each selected measure of vitality, psychological capacity, sensory and locomotion, at least one study had data for each life stage (Table 3). Executive functioning was selected as the sub-domain of cognition; however, it was difficult to select a measure that was relevant and applicable to all life stages. The selected measure (verbal fluency) was not measured in many studies, aside from the Canadian Longitudinal Study on Aging (CLSA). Beyond this measure and sub-domain, many studies did assess other aspects of cognition using different measures.

*Functional ability.* It was difficult to identify one single measure of each domain of functional ability that was relevant to each life stage. For be mobile, learn, grow, make decisions and meeting basic needs, two measures were selected. For

Figure 1: Flow diagram of eligible studies



the sub-domain, Contribution to society, the selected measure (Participating in volunteering) was available for almost all life stages except for Children (Table 4).

*Environment.* Selected measures for the environment at both community- and individual-levels were available in some data sources for most life stages, except for childhood where no studies evaluated the selected individual-level measure (Table 5).

## Discussion

Several studies exist in Canada that aim to understand health and well-being at specific life stages, however, there is no current study that is life course in nature. No included study followed the same individuals across the life course. Two studies recruited participants in early life, the CHILD Study, which recruited pregnant women, and HeLTI Canada, which recruits preconception, but follow-up of offspring for both

currently does not extend beyond childhood. This does not indicate that Canada lacks studies recruiting in early life, rather no such study extends into subsequent life stages. This gap is partly a function of time, as studies recruiting in early life are still following participants through childhood, and the life stages they cover will extend as those participants age. Whether Canada eventually has life course-spanning cohort data will therefore depend on sustained follow-up, maintained documentation, and pre-specified access in the studies that already exist. Novel approaches, such as data harmonisation, can be used to create harmonised life course cohorts and be used to address questions aimed at understanding risk factors, trajectories, or transitions associated with health and well-being. When harmonised data combine individuals at different life stages rather than following the same individuals over time, they support research questions focused on population-level patterns across the life course, such as how exposures and health outcomes vary by life stage, identify sensitive periods, and examine cohort-specific differences that inform

Table 1: Characteristics of Included Studies (n = 14)

| Study name                                                     | Location                                                                                                                                                                                   | Sample size          | Start year | End year | Study design                                 | Number of Waves of data collection     | Linked to administrative data |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------|----------|----------------------------------------------|----------------------------------------|-------------------------------|
| Alberta's Tomorrow Project (ATP)                               | Alberta                                                                                                                                                                                    | 52,810               | 2000       | Ongoing  | Cohort                                       | 4                                      | Unsure                        |
| Atlantic Partnership for Tomorrow's Health (Atlantic Path)     | Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador                                                                                                                | 35,935               | 2009       | Ongoing  | Cohort                                       | 2                                      | Yes                           |
| British Columbia Generations Project (BCGP)                    | British Columbia                                                                                                                                                                           | 29,850               | 2008       | Ongoing  | Cohort                                       | 2                                      | Yes                           |
| Canadian Community Health Survey (CCHS)                        | Canada                                                                                                                                                                                     | 1,177,600            | 2000       | Ongoing  | Repeat cross-sectional                       | 19                                     | Yes                           |
| Canadian Health Survey on Children and Youth (CHSCY)           | Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon     | 39,951               | 2016       | Ongoing  | Repeat cross-sectional                       | 2                                      | Yes                           |
| Canadian Healthy Infant Longitudinal Development (CHILD) Study | Alberta, British Columbia, Manitoba, Ontario                                                                                                                                               | 9,875                | 2008       | Ongoing  | Cohort                                       | 13                                     | Yes                           |
| Canadian Longitudinal Study on Aging (CLSA)                    | Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec and Saskatchewan                                         | 51,338               | 2011       | Ongoing  | Cohort                                       | 4                                      | Yes                           |
| CARTaGENE                                                      | Quebec                                                                                                                                                                                     | 43,046               | 2007       | Ongoing  | Cohort                                       | 2                                      | Unsure                        |
| General Social Survey                                          | Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan                                        | Not fixed            | 1985       | Ongoing  | Repeat cross-sectional                       | 8 <sup>1</sup>                         | Unsure                        |
| Healthy Life Trajectories Initiative (HeLTI Canada)            | Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon     | ~6000                | 2021       | Ongoing  | Clinical trial – embedded in a cohort design | Mothers: up to 12<br>Children: Up to 7 | Yes                           |
| Labour Force Survey (LFS)                                      | Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan, Yukon, Northwest Territories, Nunavut | Not fixed            | 1945       | Ongoing  | Repeat cross-sectional                       | Not clear                              | Unsure                        |
| Manitoba Multigenerational cohort (MMC)                        | Manitoba                                                                                                                                                                                   | 774,265 <sup>2</sup> | 1974       | Ongoing  | Administrative cohort linkage study          | No set waves of data collection        | Yes                           |
| Manitoba Tomorrow Project (MTP)                                | Manitoba                                                                                                                                                                                   | 10,000               | 2019       | Ongoing  | Cohort                                       | 2                                      | Unsure                        |
| Ontario Health Study (OHS)                                     | Ontario                                                                                                                                                                                    | 225,000              | 2009       | Ongoing  | Cohort                                       | 2                                      | Yes                           |

1. Not all modules are collected at all waves.

2. Sample size is for the index sample. Linkages are made across four generations and multiple family relationships.

Table 2: Mapping Eligible Studies to Life Stages and Framework of Healthy Ageing

| Study name                                                     | Mapping to life stages |                                   |                            |                      |                            | Mapping to Framework of Healthy Ageing |                           |                    |                    |             |
|----------------------------------------------------------------|------------------------|-----------------------------------|----------------------------|----------------------|----------------------------|----------------------------------------|---------------------------|--------------------|--------------------|-------------|
|                                                                | Children (0–9 years)   | Adolescents & youth (10–19 years) | Young adults (20–29 Years) | Adults (30–44 years) | Middle aged adults (45-59) | Older adults (60–84 Years)             | Oldest adults (85+ Years) | Intrinsic capacity | Functional ability | Environment |
| Longitudinal cohort design                                     |                        |                                   |                            |                      |                            |                                        |                           |                    |                    |             |
| Alberta's Tomorrow Project (ATP)                               |                        |                                   |                            | X                    | X                          | X                                      |                           | X                  | X                  | X           |
| Atlantic Partnership for Tomorrow's Health (Atlantic Path)     |                        |                                   |                            | X                    | X                          | X                                      |                           | X                  | X                  | X           |
| British Columbia Generations Project (BCGP)                    |                        |                                   |                            | X                    | X                          | X                                      |                           | X                  | X                  | X           |
| Canadian Healthy Infant Longitudinal Development (CHILD) Study | X <sup>1</sup>         | X (10-12) <sup>1</sup>            | X <sup>2</sup>             | X <sup>2</sup>       |                            |                                        |                           | X                  | X                  | X           |
| Canadian Longitudinal Study on Aging (CLSA)                    |                        |                                   |                            |                      | X                          | X                                      | X                         | X                  | X                  | X           |
| CARTaGENE                                                      |                        |                                   |                            | X                    | X                          | X                                      |                           | X                  | X                  | X           |
| Healthy Life Trajectories Initiative (HeLTI Canada)            | X <sup>1</sup> (5+)    |                                   | X <sup>2</sup>             | X <sup>2</sup>       |                            |                                        |                           | X                  | X                  | X           |
| Manitoba Multigenerational cohort (MMC) <sup>3</sup>           | X                      | X                                 | X                          | X                    | X                          | X                                      | X                         | X                  | X                  | X           |
| Manitoba Tomorrow Project (MTP)                                |                        |                                   |                            | X                    | X                          | X (74+)                                |                           | X                  | X                  | X           |
| Ontario Health Study (OHS)                                     |                        | X (18+)                           | X                          | X                    | X                          | X                                      | X                         | X                  | X                  | X           |
| Cross-sectional design                                         |                        |                                   |                            |                      |                            |                                        |                           |                    |                    |             |
| Canadian Community Health Survey (CCHS)                        |                        | X                                 | X                          | X                    | X                          | X                                      | X                         | X                  | X                  | X           |
| Canadian Health Survey on Children and Youth (CHSCY)           | X                      | X                                 |                            |                      |                            |                                        |                           |                    |                    |             |
| General Social Survey (GSS)                                    |                        | X (15+)                           | X                          | X                    | X                          | X                                      | X                         | X                  | X                  | X           |
| Labour Force Survey (LFS)                                      |                        | X (15+)                           | X                          | X                    | X                          | X                                      | X                         |                    | X                  |             |

1. Age of offspring in the study.

2. Age of parents in the study.

3. The Manitoba Multigenerational Cohort is an intergenerational study that links administrative data across generations.



Table 3: Mapping Studies to Example Measures of Sub-Domains of Intrinsic Capacity

| Domain        | Sub-domain               | Measure                                                                        | Children<br>(0-9 years) | Adolescents &<br>Youth<br>(10-19 years) | Young<br>adults<br>(20-29 years) | Adults<br>(30-44 years) | Middle<br>aged adults<br>(45-59 years) | Older<br>adults<br>(60-84 years) | Oldest<br>old<br>(85 + years) |
|---------------|--------------------------|--------------------------------------------------------------------------------|-------------------------|-----------------------------------------|----------------------------------|-------------------------|----------------------------------------|----------------------------------|-------------------------------|
| Vitality      | Body composition         | Self-report<br>BMI/height &<br>weight                                          | CHSCY                   | CCHS                                    | CCHS                             | ATP                     | ATP                                    | ATP                              | CCHS                          |
|               |                          |                                                                                | CHILD                   | CHSCY                                   | CHILD                            | Atlantic Path           | Atlantic Path                          | Atlantic Path                    | CLSA                          |
|               |                          |                                                                                | HeLTI                   | CHILD                                   | HeLTI                            | BCGP (35+)              | BCGP                                   | BCGP                             | MMC                           |
|               |                          |                                                                                | MMC                     | MMC                                     | MMC                              | Cartagene               | CARTaGENE                              | CARTaGENE                        | OHS                           |
|               |                          |                                                                                |                         |                                         |                                  | CCHS                    | CCHS                                   | CCHS                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | HeLTI                   | CLSA                                   | CLSA                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | MMC                     | MMC                                    | MMC                              |                               |
| Psychological | Anxiety                  | Self-report or<br>doctor diagnosis                                             | CHSCY                   | CHSCY                                   | CCHS                             | ATP                     | ATP                                    | ATP                              | CCHS                          |
|               |                          |                                                                                | CHILD                   | CCHS                                    | HeLTI                            | Atlantic Path           | Atlantic Path                          | Atlantic Path                    | CLSA (45+)                    |
|               |                          |                                                                                | MMC                     | MMC                                     | MMC                              | BCGP (35+)              | BCGP                                   | BCGP                             | MMC                           |
|               |                          |                                                                                |                         |                                         |                                  | CARTaGENE               | CARTaGENE                              | CARTaGENE                        | OHS                           |
|               |                          |                                                                                |                         |                                         |                                  | CCHS                    | CCHS                                   | CCHS                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | HeLTI                   | CLSA                                   | CLSA                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | MMC                     | MMC                                    | MMC                              |                               |
| Cognition     | Executive<br>functioning | Verbal fluency test                                                            | Not<br>available        | Not available                           | Not available                    | Not available           | CLSA                                   | CLSA                             | CLSA                          |
|               |                          |                                                                                |                         |                                         |                                  |                         |                                        |                                  |                               |
|               |                          |                                                                                |                         |                                         |                                  |                         |                                        |                                  |                               |
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|               |                          |                                                                                |                         |                                         |                                  |                         |                                        |                                  |                               |
| Locomotion    | Physical activity        | Time spent<br>participating in<br>moderate or<br>vigorous physical<br>activity | CHSCY                   | CCHS                                    | CCHS                             | ATP                     | ATP                                    | ATP                              | CCHS                          |
|               |                          |                                                                                | CHILD                   | CHSCY                                   | CHSCY                            | Atlantic Path           | Atlantic Path                          | Atlantic Path                    | CLSA                          |
|               |                          |                                                                                |                         | OHS (18+)                               | HeLTI                            | BCGP (35+)              | BCGP                                   | BCGP                             | OHS                           |
|               |                          |                                                                                |                         |                                         | OHS                              | CCHS                    | CCHS                                   | CCHS                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | CARTaGENE               | CLSA                                   | CLSA                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | HeLTI                   | CARTaGENE                              | CARTaGENE                        |                               |
|               |                          |                                                                                |                         |                                         |                                  | MTP                     | MTP                                    | MTP                              |                               |
| Sensory       | Vision                   | Vision condition                                                               | CHSCY                   | CCHS                                    | CCHS                             | Atlantic Path           | Atlantic Path                          | Atlantic Path                    | CCHS                          |
|               |                          |                                                                                | MMC                     | CHSCY                                   | OHS                              | BCGP (35+)              | BCGP                                   | BCGP                             | CLSA                          |
|               |                          |                                                                                |                         | OHS                                     | MMC                              | CARTaGENE               | CARTaGENE                              | CARTaGENE                        | MMC                           |
|               |                          |                                                                                |                         | MMC                                     |                                  | CCHS                    | CCHS                                   | CCHS                             | OHS                           |
|               |                          |                                                                                |                         |                                         |                                  | MMC                     | CLSA                                   | CLSA                             |                               |
|               |                          |                                                                                |                         |                                         |                                  | MTP                     | MMC                                    | MMC                              |                               |
|               |                          |                                                                                |                         |                                         |                                  | OHS                     | MTP                                    | MTP                              |                               |

life course-oriented policy and intervention timing. Further, the ability to link these data to administrative records allows for richer and more complex questions to be examined, including trajectories of health care utilisation over time or the long-term consequences of social and economic transitions. Among the included studies, there are data on all life stages and measuring many aspects of health and well-being, however, identifying similar measures within domains posed to be challenging. Many of the included studies can also be linked to administrative data (e.g., medical records, disease registries, immigration data) allowing for longitudinal assessments, exploring variation across the life course. For instance, the Manitoba Multigenerational Cohort is an example where administrative data is linked across generations within a family to explore intergenerational health effects. Additionally, many of the included population-based surveys can be linked to administrative data, allowing rich self-reported survey information to be complemented with routinely collected data such as health care utilisation, medication records, and vital statistics. It is important to leverage pre-existing Canadian data given the breadth of information available and the limitations associated with starting a new longitudinal life course cohort, like the cost or methodological challenges. This

review suggests harmonisation is possible, however, a number of considerations need to be addressed including:

## Methodological Considerations

It was beyond the scope of this paper to explore methodological consistencies across the identified studies. Although harmonisation may be possible, a more nuanced consideration of the methodological complexities involved in harmonisation must be made. The studies identified vary in terms of study design, and although we only included general population samples, the recruitment and sampling strategies across the studies vary. For instance, studies that employed non-probability sampling techniques may result in an underrepresentation of a certain group of the population, like those who may not be inclined to participate in studies (e.g., those who are sick). Whereas, other studies may have employed probability sampling techniques, like using random-digit dialling, meaning every individual within a target population has an equal chance of being recruited into the study. This creates selection bias, which can lead to biased estimates when harmonising data, particularly, if the exposure or outcome of interest is related to the likelihood of being

Table 4: Mapping Studies to Example Measures of Sub-Domains of Functional Ability

| Domain                               | Measure                                 | Children<br>(0-9 years) | Adolescents &<br>Youth<br>(10-19 years)            | Young<br>adults<br>(20-29 years)                   | Adults<br>(30-44 years)                                                                                      | Middle<br>aged adults<br>(45-59 years)                                                       | Older<br>adults<br>(60-84 years)                                                             | Oldest<br>old<br>(85 + years)            |
|--------------------------------------|-----------------------------------------|-------------------------|----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------|
| Be mobile                            | Driving frequency<br>or ability to play | CHSCY                   | CCHS<br>GSS (15+)                                  | CCHS<br>GSS                                        | CCHS<br>GSS                                                                                                  | CCHS<br>CLSA<br>GSS                                                                          | CCHS<br>CLSA<br>GSS                                                                          | CCHS<br>CLSA<br>GSS                      |
| Contribution to<br>society           | Participating in<br>volunteering        | Not available           | CCHS<br>GSS (15+)<br>LFS (15+)<br>OHS (18+)        | CCHS<br>GSS<br>LFS<br>OHS                          | ATP<br>Atlantic Path<br>BCGP (35+)<br>CCHS<br>GSS<br>LFS<br>MTP<br>OHS                                       | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>GSS<br>LFS<br>MTP<br>OHS                     | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>GSS<br>LFS<br>MTP<br>OHS                     | CCHS<br>GSS<br>LFS<br>OHS                |
| Learn, grow, make<br>decisions       | Education or<br>Employment              | CHSCY<br>MMC            | CCHS<br>GSS (15+)<br>MMC<br>LFS (15+)<br>OHS (18+) | CCHS<br>CHILD<br>GSS<br>HeLTI<br>MMC<br>LFS<br>OHS | ATP<br>Atlantic Path<br>BCGP (35+)<br>CCHS<br>CHILD<br>CARTaGENE<br>GSS<br>HeLTI<br>LFS<br>MMC<br>MTP<br>OHS | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>CARTaGENE<br>GSS<br>LFS<br>MMC<br>MTP<br>OHS | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>CARTaGENE<br>GSS<br>LFS<br>MMC<br>MTP<br>OHS | CCHS<br>CLSA<br>GSS<br>LFS<br>MMC<br>OHS |
| Meeting basic<br>needs               | Difficulty eating or<br>food insecurity | CHSCY<br>HeLTI          | CCHS<br>GSS (15+)<br>OHS (18+)                     | CCHS<br>GSS<br>HeLTI<br>OHS                        | ATP<br>Atlantic Path<br>BCGP (35+)<br>CCHS<br>GSS<br>HeLTI<br>MTP<br>OHS                                     | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>GSS<br>MTP<br>OHS                            | ATP<br>Atlantic Path<br>BCGP<br>CCHS<br>CLSA<br>GSS<br>MTP<br>OHS                            | CCHS<br>CLSA<br>GSS<br>OHS               |
| Ability to maintain<br>relationships | Friendships                             | CHSCY<br>CHILD          | CCHS<br>CHSCY                                      | CCHS<br>HeLTI                                      | ATP<br>CCHS<br>HeLTI                                                                                         | ATP<br>CCHS<br>CLSA                                                                          | ATP<br>CCHS<br>CLSA                                                                          | CCHS<br>CLSA                             |

Table 5: Mapping Studies to Example Measures of the Environment

| Domain           | Measure                      | Children<br>(0-9 years) | Adolescents &<br>Youth<br>(10-19 years) | Young<br>adults<br>(20-29 years) | Adults<br>(30-44 years)     | Middle<br>aged adults<br>(45-59 years) | Older<br>adults<br>(60-84 years) | Oldest<br>old<br>(85 + years) |
|------------------|------------------------------|-------------------------|-----------------------------------------|----------------------------------|-----------------------------|----------------------------------------|----------------------------------|-------------------------------|
| Community level  | Neighbourhood<br>crime rate  | CHILD                   | CCHS<br>GSS (15+)                       | CCHS<br>CHILD<br>GSS             | ATP<br>CCHS<br>CHILD<br>GSS | ATP<br>CCHS<br>GSS                     | ATP<br>CCHS<br>GSS               | CCHS<br>GSS                   |
| Individual level | Satisfaction with<br>housing | Not available           | CCHS                                    | CCHS                             | CCHS                        | CCHS<br>CLSA                           | CCHS<br>CLSA                     | CCHS<br>CLSA                  |

sampled. This may result in an underestimation of the true effect. If there is substantial heterogeneity in study design and sampling methods across the identified studies, researchers may consider using meta-analysis techniques rather than pooling data directly or conducting stratified analyses by sampling strategy or study design. In addition, given that some identified studies used a longitudinal design, there is a risk of attrition bias, as participants who remain in the study may differ systematically from those lost to follow-up. If those who do not remain in the study share similar characteristics (e.g., age group, racial background, income level), they then are underrepresented in the study, leading to biased estimates

when pooling data. It is also important for descriptive analyses of attrition over time to be explored, and where possible statistical approaches like multiple imputation or weighting could be used prior to harmonising data to address differential dropout or missingness across studies.

## Relevance of Domains and Comparability of Measures

Measures must consider the whole person assessing both health and well-being. At the time of this review, we found that some domains of the Healthy Ageing framework

may not exactly capture relevant aspects of health at other life stages. As proposed in the recent WHO Life Course framework [11], these domains were extended and modified which were informed from other frameworks including the Nurturing Care Framework, Integrated Management of Childhood Illness and the Adolescent Well-being Framework to capture developmental processes. For example, vitality, which measures metabolic and energy imbalances, was broadened to include thriving, which aligns with health among children and adolescents, and sexual and reproductive capacity was introduced for relevant life stages. These domains now better evaluate health at each life stage and across the life course. Building on these domains, further exploration is needed to determine available and relevant measures at different stages of life. Having this understanding can allow for trajectories of different capacities or abilities to be modelled, using measures that are appropriate at different life stages. For example, executive functioning is an important sub-domain of cognition across the life course. However, it was evident selecting one measure for all life stages was not suitable. Verbal fluency, the exemplar measure selected, was available only in the CLSA among adults aged 45 years and older. This does not indicate that cognition is unmeasured in the other included studies, but rather reflects how cognition is assessed. Verbal fluency, like most validated cognitive measures, requires in-person, trained administration, and among the included studies only those with a face-to-face assessment component were positioned to collect it. Studies relying on self-report or interview-administered questionnaires can capture self-reported cognitive difficulties or diagnoses, but not performance-based cognition. The same constraint operates in childhood, where cognitive assessment requires age-appropriate measures. Harmonisation of cognition across the life course will consequently depend not only on identifying measures of the same underlying construct, but on establishing whether that construct is consistent across life stages. Mapping measures across the life course must recognise that what is typically assessed within cognition shifts with age, with childhood measures focused on learning and development and later life measures on decline and impairment [12]. A life course perspective requires cognition to be captured at all life stages, so that whether these measures align, or reflect similar underlying domains, can be determined. A similar issue arises for the environment in childhood, where only one selected measure for neighbourhood crime was available in the CHILD study. It is possible this is a result as these measures are typically asked of adult respondents about their own circumstances, and their absence for children may reflect the exemplars chosen rather than an absence of environmental measurement. Other environmental measures relevant to childhood are likely to be available within the included studies, and identifying measures that are both relevant and available at each life stage is a necessary step before the extent of any gap can be established. Future work should therefore examine the full range of environmental measures held across studies, and consider how child-level environmental exposures could be derived from data already collected, for example by assigning household-level measures reported by adults to children in the same household, or by linking geocoded residential histories to census, air quality, and built environment data. Harmonisation should extend beyond

choosing a single measure across the life course and instead focus on identifying key constructs relevant to each life stage, followed by selecting valid and reliable measures appropriate to those stages and transforming these measures so they are on the same scale.

## Establishing an Integrated Database and Harmonisation Platform

To further understand harmonisation potential, it will be necessary to establish the appropriate infrastructure. The Health Data Research Network Canada has developed a strategic plan to support innovation in the use of data, focusing specifically on multi-regional data use [13]. Strategic goals include developing and improving services and supports for data access, diversifying data use, establishing partnerships, strengthening data use to improve equity and supporting Indigenous-led data sovereignty, and ensuring purposeful and ongoing public and community involvement. Building on this initiative, and modelling similar research collaborations, such as MINDMAP [14], which is an integrated database infrastructure for research in ageing, a platform must be developed to determine how datasets could be integrated, considering availability of data and associated costs. Previous work has been undertaken to combine data from different cohorts to examine life course trajectories. For instance, harmonisation of five prospective cohort studies from Belarus and the United Kingdom was completed to examine associations of parental education, sex, and race/ethnicity with children's weight trajectories [15]. This example illustrates the possibility of combining cohorts to model trajectories; however, it is noted caution should be taken in interpreting findings given the heterogeneity across cohorts, and that a single cohort could drive a particular finding.

## Consideration of Special Populations

This review only focused on studies that included general population samples. Future work should consider and identify how data on special or vulnerable populations, including Indigenous and ethnically diverse samples, can be included to ensure a database/harmonised dataset is representative of the entire Canadian population. It is also important to consider principles that have been put in place to protect and respect data sovereignty. For instance, the Ownership, Control, Access and Possession (OCAP) principles have been created to respect Indigenous data sovereignty [16, 17]. If harmonisation were to take place, further exploration of key constructs and measures would be needed to determine appropriate and relevant measures for different populations. To do this, stakeholders and representatives from these groups must be involved in all aspects of the research process.

## Strengths & Limitations

This environmental scan is the first to comprehensively review Canadian data sources that may be harmonised to create a pooled life course dataset. This is particularly important given the growing need to leverage pre-existing data to overcome the time, cost, and feasibility constraints of collecting longitudinal data across all life stages, while still capturing continuity across

life stages to inform life course-oriented research and policy. Using a comprehensive approach that drew on Maelstrom and the Atlas of Longitudinal Datasets, we identified a wide range of Canadian data sources spanning multiple life stages, many of which can be linked to existing administrative data. However, it is possible studies may have been missed, or data on these platforms were not complete. For most studies, individual websites and documentation were reviewed to ensure the most accurate data were included in the current review. In a potential harmonisation of data, restrictions accessing data may still exist, including fees or delays in accessing data, which may create added challenges. Whenever harmonisation is used, there is the potential for a loss of information as data from different studies may have to be categorised to ensure comparability. Although this is a limitation of harmonisation, evidence generated could provide an indication of where continued or future research should be focused. Given screening and data extraction were conducted by a single reviewer rather than in duplicate, the possibility of error in study selection or extraction cannot be excluded. As an exploratory exercise, a single exemplar measure was selected for each sub-domain of intrinsic capacity, functional ability, and the environment. These measures were chosen to test comparability across studies and life stages, and were not intended to be exhaustive. Where a study is not listed against a selected measure, this indicates that the specific exemplar was not available, and not that the domain is unmeasured in that study. Many of the included studies collect other measures within the same domains, including alternative assessments of cognition, and a fuller mapping of all available measures within each domain was beyond the scope of this scan. Additionally, this review did not examine the demographic, socioeconomic, or lifestyle variables held within the included studies. Our mapping was restricted to the domains of intrinsic capacity, functional ability, and the environment, and characterising how variables such as race and ethnicity, immigration status, sex and gender, income, and education are defined and measured across studies was not an objective of this current scan. This is an important gap, as these variables are central to intersectional analysis, and a harmonised dataset that pools individuals across studies can only support equity-oriented research if they are captured comparably.

## Conclusions

Combining and comparing studies from Canada, could allow for complex life course-related questions to be asked and answered. Utilising pre-existing data will maximise research potential and allow for the opportunity for research aimed at different life stages to improve trajectories of health and well-being. However, it is important work is continued to address how harmonisation would be possible, considering methodological challenges across different study designs and data sources, and how to overcome these challenges. This scan provides a map of the Canadian life course data landscape, identifying where data align and could plausibly be harmonised; however, a much more detailed assessment and harmonisation steps would be needed to determine whether this could be applied in practice. The measures examined in this review were exemplars, selected to explore comparability

rather than to prescribe what should be harmonised. The main task is therefore identifying key constructs, establishing what each means at each life stage, and then identifying measures within existing data that are applicable and relevant to each stage. This would form the basis of a staged program of work, beginning with a consensus-building process among data custodians and content experts, informing a formal harmonisation feasibility study, and supported by a federated platform in which custodians retain control of their data. Establishing where the data align and where they fall short is a precondition for any harmonisation effort, and it points to where investment in Canadian life course research infrastructure is most needed.

## Conflict of Interest

All authors declare no conflicts of interest.

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## Data Availability

No new data were generated or analysed during this study. All information supporting the findings of this review are included in the manuscript.

## Ethics Statement

Ethics approval and informed consent were not required for this study, as it is a review of publicly available data.

## AI Disclosure Statement

The authors declare that no generative AI tools were used in the preparation of this manuscript.



## References

1. Government of Canada. Population estimates on July 1, by age and gender 2025. <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501> (accessed January 29, 2025).
2. World Health Organization. Decade of healthy ageing: baseline report. 2020.
3. Statistics Canada. A portrait of Canada's growing population aged 85 and older from the 2021 Census 2022. <https://www12.statcan.gc.ca/census-recensement/2021/as-sa/98-200-X/2021004/98-200-X2021004-eng.cfm> (accessed November 7, 2023).
4. Russ SA, Hotez E, Berghaus M, Verbiest S, Hoover C, Schor EL, et al. What Makes an Intervention a Life Course Intervention? *Pediatrics* 2022;149:e2021053509D. <https://doi.org/10.1542/peds.2021-053509D>
5. Ben-Shlomo Y, Cooper R, Kuh D. The last two decades of life course epidemiology, and its relevance for research on ageing. *International Journal of Epidemiology* 2016;45:973–88. <https://doi.org/10.1093/ije/dyw096>
6. Nagel DA, Charlton P, Azar R, Koenig L, Burns K, Kean T. RADAR-ES: A Methodological Framework for Conducting Environmental Scans in Health Services Delivery Research. *J Prim Care Community Health* 2025;16:21501319251363783. <https://doi.org/10.1177/21501319251363783>
7. Charlton P, Kean T, Liu RH, Nagel DA, Azar R, Doucet S, et al. Use of environmental scans in health services delivery research: a scoping review. *BMJ Open* 2021;11:e050284. <https://doi.org/10.1136/bmjopen-2021-050284>
8. Nurturing Care Framework for Early Childhood Development 2018. <https://nurturing-care.org/> (accessed April 22, 2025).
9. World Health Organization. Integrated management of childhood illness. n.d.
10. Ross DA, Hinton R, Melles-Brewer M, Engel D, Zeck W, Fagan L, et al. Adolescent Well-Being: A Definition and Conceptual Framework. *J Adolesc Health* 2020;67:472–6. <https://doi.org/10.1016/j.jadohealth.2020.06.042>
11. World Health Organization. Framework to implement a life course approach in practice 2025. <https://www.who.int/publications/i/item/9789240112575> (accessed December 5, 2025).
12. Richards M, Deary IJ. A life course approach to cognitive reserve: a model for cognitive aging and development? *Ann Neurol* 2005;58:617–22. <https://doi.org/10.1002/ana.20637>
13. Strategic Plan | Health Data Research Network Canada n.d. <https://www.hdrn.ca/en/about/strategic-plan> (accessed November 7, 2023).
14. Beenackers MA, Doiron D, Fortier I, Noordzij JM, Reinhard E, Courtin E, et al. MINDMAP: establishing an integrated database infrastructure for research in ageing, mental well-being, and the urban environment. *BMC Public Health* 2018;18:158. <https://doi.org/10.1186/s12889-018-5031-7>
15. Hughes RA, Tilling K, Lawlor DA. Combining Longitudinal Data From Different Cohorts to Examine the Life-Course Trajectory. *American Journal of Epidemiology* 2021;190:2680–9. <https://doi.org/10.1093/aje/kwab190>
16. The First Nations Information Governance Centre. The First Nations Principles of OCAP® 2025. <https://fnigc.ca/ocap-training/> (accessed January 21, 2025).
17. Walker J, Pyper E, Jones CR, Khan S, Chong N, Legge D, et al. Unlocking First Nations health information through data linkage. *International Journal of Population Data Science* 2018;3. <https://doi.org/10.23889/ijpds.v3i1.450>

