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Using Statistics Canada LifePaths Microsimulation Model to Project the Health Status of Canadian Elderly

Jacques Légaré
Yann Décarie

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Using Statistics Canada LifePaths Microsimulation Model to Project the Health Status of Canadian Elderly[1,2]

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[1] This is a revised and upgraded version of a paper presented at :

- The First General Conference of the International Microsimulation Association (Vienna, August 20-22, 2007)
- The Health Statistics Data User Conference (Ottawa, September 24-25, 2007)
- The SEDAP New Researchers Conference (Hamilton, October 19-20, 2007)

[2] We would like to thank all people who have helped us in building this research project: Dr Geoff Rowe from Statistics Canada, Dr Janice Keefe from Mount Saint Vincent University, and all the members of our research team (Équipe de Recherche sur le Vieillissement des Populations – *ERVIPOP*). Financial support was provided by the Alzheimer Society of Canada (§ 0640) and the Canadian Institutes of Health Research (MOP-81108).

Abstract

Complex population projections usually use microsimulation models; in Canada, Statistics Canada has developed a global dynamic microsimulation model named LifePaths in the Modgen programming language to be used in policy research. LifePaths provides a platform to build on for our research program, conjointly with Dr Janice Keefe from Mount Saint Vincent University, on projections of the Canadian chronic homecare needs for the elderly up to 2031 and of the human resources required. Beside marital status, family networks and living arrangements, future health status of the elderly is a key variable, but an intricate one. Since health status transitions were previously conditioned only on age and sex, we will use here the current disability module of LifePaths with longitudinal data from Canada's National Population Health Survey (NPHS). These new health status transitions are considering other significant explicative variables like marital status, education etc. We will then present projections of future Canadian elderly by health status and a comparison with nine European countries for the Future Elderly Living Conditions in Europe (FELICIE) Research Program which has used the same approach. Our previous researches have shown the importance of future disability level for the management of an elderly society. The main output of the present paper would first produce, with new health scenarios, new estimates for Canada of elderly in poor health, for those aged 75 and over. Secondly, it would produce an interesting comparative analysis, useful especially for implementing new policies for the well-being of the Canadian elderly.

Keywords: Microsimulation, Elderly population, Aging, LifePaths, Health, Canada.

JEL Classification: C15, I19

Résumé

On utilise de plus en plus fréquemment des modèles de microsimulation pour projeter une population et le Canada ne fait pas exception. Statistique Canada à développé un modèle dynamique de microsimulation nommé LifePaths dans un langage de programmation spécialisé pour la conception de ce type de modèle appelé Modgen. LifePaths est un outil puissant sur lequel nous avons basé notre programme de recherche, conjointement avec Dr Janice Keefe de Mount Saint Vincent University, et qui a comme objectif de projeter les besoins de la population âgée Canadienne en terme de services à domicile de longue durée jusqu'en 2031 et les besoins en terme de ressources humaines qui s'y rattachent. En plus de variables comme l'état matrimonial, le réseau familial et le mode de vie, le futur état de santé des personnes âgées, est une variable importante, mais intrigante. Précédemment, les probabilités de transitions de la variable « état de santé » étaient seulement en fonction de l'âge et du sexe, mais maintenant nous allons utiliser le nouveau module de santé qui se trouve dans LifePaths qui considère plusieurs autres variables explicatives comme l'état matrimonial, l'éducation etc. et qui utilise les données longitudinales provenant de l'Enquête nationale sur la santé de la population. Nous allons donc présenter ici nos projections de personnes âgées Canadiennes selon leur état de santé, car nos précédentes recherches ont démontrées l'importance de cette variable dans l'organisation d'une société vieillissante et les comparer avec ceux de neuf pays européens qui forment un groupe de recherche axé sur l'avenir des conditions de vie des personnes âgées en Europe (Future Elderly Living Conditions in Europe - FELICIE). Les principaux résultats de cet article sont premièrement de produire, avec de nouveaux scénarios de santé, de nouvelles estimations pour les personnes âgées canadiennes de 75 ans et plus. Deuxièmement, nous allons présenter une analyse comparative avec les données européennes qui, selon nous, va être très utile pour l'élaboration et l'amélioration des politiques concernant le bien être des personnes âgées canadiennes.

Mots clés : Microsimulation, personnes âgées, vieillissement, LifePaths, santé, Canada.

Classification JEL: C15, I19

1. INTRODUCTION

Population aging among developed countries is well on its way. The growing proportion of the elderly population and the changes occurring within the whole age structure of the population threaten the sustainability of social security systems, especially with regards to pensions and health care. In the next 25 years, the most important increases within the elderly population, both in Canada and Europe, are expected to occur among the oldest old, *i.e.* people aged 75 years old and over. This rapid growth reflects the aging of the baby-boom cohort as well as an improved survival to and beyond age 75. Although many older people remain in good health until quite advanced ages, risks of becoming disabled increase significantly at age 75 and over. The growing oldest old population has therefore important implications regarding support systems, both formal and informal (Carrière *et al*., 2006). Drawing conclusions on future needs from actual characteristics of the elderly may be misleading; since tomorrow's elderly population will be different (Carrière *et al*., 2007). Therefore, in order to be policy relevant, elderly population projections and their implied needs for support should include decisive factors like marital status, living arrangements, health conditions, and potential support from surviving partner and children.

2. MAIN OBJECTIVES

2.1 First objective

This paper is part of a broader program of research aiming at producing a set of projections up to 2031 of the chronic homecare needs of Canadian elderly and the human resources required to assist them. The first objective of this paper is to assess the impact of an optimistic disability scenario on future numbers of elderly Canadian in poor health aged 75 years and over using Statistics Canada LifePaths microsimulation model. More specifically, a module to project future health status of Canadian elderly was used to produce two scenarios: the Base LifePaths Disability scenario and the Healthy scenario in which it is assumed that additional years gained in life expectancy will be years without disability. We have established indicators characterizing the older population by linking disability status to marital status and surviving children. This relates to priority questions in terms of caring for a larger elderly population with various characteristics of informal support and of disability status (Figure 1).

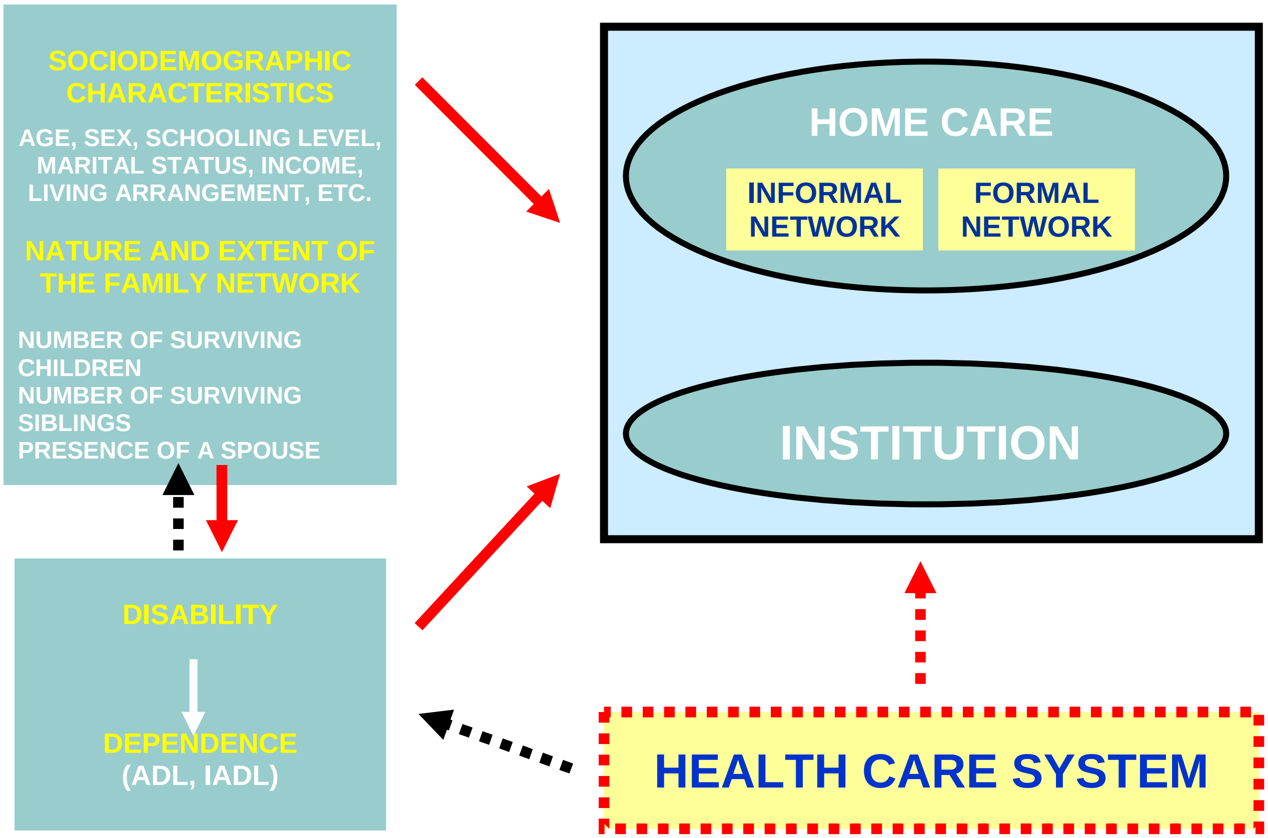

Figure 1 Demand for home care services

2.2 Second objective

The second objective of this paper is to compare Canada with nine European countries (Belgium, Czech Republic, England and Wales, Finland, France, Germany, Italy, Netherlands, Portugal) who participate in the research program "Future Elderly LIving Conditions In Europe" (FELICIE). International comparisons are relevant because they allow the investigators to assess the specificities of Canadian aging. In this case, comparative data are available since two groups of researchers, one Canadian and one European, have been working in close collaboration in the field of the demography of aging. These research programs have now ended and the results have been widely disseminated within the national and international scientific community (see Carrière et al 2007 and Gaymu et al 2008). Both research programs produced microsimulated projections for the next 25 years that give already comparable results on marital status, family network and support, and on living arrangements and needs for care. Here, the present research allows the health dimension to be comparable in order to use the same future health scenarios; in the first one the gain in life expectancy results in a proportional growth in the years in disability while in the second one the added years in life expectancy are years without disability.

3. METHOD

3.1 Measures

In this paper, disability was defined using some attributes of the Health Utility Index (HUI). The HUI, based on the Comprehensive Health Status Measurements System (CHSMS), takes into account both the quantitative and qualitative aspects of health (Torrance *et al*, 1996). It provides information on the functional health of an individual using a series of attributes. For the purpose of this study, information on an individual's mobility, dexterity, cognition, and pain and discomfort were used to develop four levels of disability (none, mild, moderate, and severe):

- *No disability*
- *Mild disability:*

  Mobility problems but do not need any help; Dexterity problems but do not need any help from someone else (may or may not use special equipments); Somewhat forgetful and slight difficulty in thinking; Moderate and/or severe pain prevents performing some or few tasks.
- *Moderate disability:*

  Requires wheel chair or mechanical support to walk; Dexterity problem and needs help to perform some tasks; Very forgetful and a lot of difficulty in thinking; Severe pain prevents performing most tasks.
- *Severe disability:*

  Cannot walk or needs help from others to walk; Dexterity problems and needs help for most or all tasks; Unable to remember or think.

To evaluate the health status of a population, demographers and epidemiologists have created an indicator based on life table's parameters. Here, what is used is the Disability Free Life Expectancy (DFLE). Life Expectancy (all health status combined) (LE) could be divided in two parts: DFLE and Life Expectancy with Disability (LEWD). LEWD can be calculated by multiplying persons-years in the life table by disability rates by age (Sullivan Method).

Then, $LE_x = DFLE_x + LEWD_x$ (x = age) (1)

Recent trends show that LE, as well as DFLE and LEWD, increases with time (Table 1 and Table 2).

Table 1 Trends in Canadian life expectancy and disability free life expectancy at birth with the base scenario

Year	Life expectancy (LE)	Disability free life expectancy (DFLE)	Life expectancy with disability (LEWD)
2001	78,0	63,8	14,2
2011	79,7	64,6	15,1
2021	81,2	65,2	15,9
2031	82,4	65,7	16,7

Table 2 Trends in Canadian life expectancy and disability free life expectancy at age 45 with the base scenario

Year	Life expectancy (LE)	Disability free life expectancy (DFLE)	Life expectancy with disability (LEWD)
2001	34,8	23,5	11,3
2011	36,1	24,0	12,1
2021	37,3	24,4	12,9
2031	38,3	24,7	13,7

The healthy scenario keeps the LEWD at the same level throughout the projection period, 11,3 years, meaning that all added years in life expectancy are disability free years. In this paper, all added disability free years will be added to DFLE at age 45 as our target population is the elderly aged 75 + from year 2001 to 2031.

3.2 Model

The family network parameters of the projections (*e.g.* number of surviving children, surviving spouse) are based on Statistics Canada LifePaths microsimulation model, which makes use of a number of surveys (Wolfson and Rowe, 2004). The longitudinal aspect of the model allows the user to take into account part of the complexity of the life cycle (birth, death, immigration status, inter-provincial migration, marital history, educational history, employment history, and presence of children at home) of individuals who constitute the Canadian population. The microsimulation creates a synthetic cohort of individuals going through their life cycle with different probabilities of having specific events occurring, probabilities that vary across individuals depending on their characteristics. Every time an event occurs (*e.g.* leaving school), probabilities of other events occurring in the future will vary according to the changing characteristics of this individual.

3.3. LifePaths Microsimulation Model

The results in this paper are generated with a Canadian dynamic longitudinal microsimulation model called LifePaths. This model has been developed for several years by Statistics Canada in a programming language named Modgen. As we can see on the web site of Statistics Canada (Statistics Canada, 2004), this model can be considered to be an overlapping cohort model that produces for each run a representative microcosm of the Canadian population. The oldest birth cohort represented in LifePaths was born in 1872. That year was chosen so that in the year 1971 the model would have a complete and representative set of all ages from the newborns to the elderly. This means that starting in 1971 LifePaths produces cross-sectional annual tabulations that can be compared to historical data. The year 1971 is the first year for which high quality socio-demographic data were available in the form of a Census with contemporary design.

Also, the life course of an individual, called case, is simulated in LifePaths as a series of events that occur in continuous time (so they are not artificially restricted to annual intervals) using behavioural equations estimated from a large number of historical micro-data sources. But, over the course of a simulation, LifePaths keeps updating its list of pending events to ensure that the next scheduled event is the one that currently has the shortest waiting time. This provides a straightforward way of dealing with competing events. Waiting times provide a unifying framework for representing decision-making. Probabilistic decisions can be implemented so that the choice among alternatives is determined by comparing two or more waiting times.

Moreover, a LifePaths simulation consists of a set of mutually independent cases. Each case contains exactly one dominant individual in the first generation. The spouse and children of the dominant individual are simulated as part of the case. They are created to satisfy the marriage and the fertility equations[3].

3.4 Application of LifePaths Microsimulation Model

LifePaths takes into consideration a large number of variables representing events occurring in the life course of an individual. In the present research project, we have used a limited number of those variables:

- Age
- Sex
- Schooling level
- Region
- Marital status
- Age of spouse
- Place of birth
- Surviving children
- Disability (and institutionalization)

It is important to keep in mind that LifePaths is a dynamic model implying that some other variables not listed here can affect the results.

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[3] For more detailed information on Statistics Canada LifePaths microsimulation model, see Statistics Canada (2004).

Another important concept in a model like LifePaths is the Monte Carlo variation. All cases simulated in this model are using waiting times that incorporate a stochastic component. It is one of the reasons why LifePaths can reproduce the diversity observed in real populations. On the other hand, this variability affects the reliability of aggregate tabular results in the same way results taken from a small sample would be affected if drawn from a large population. In order to avoid this kind of problem occurring when dealing with rare events, we decided to simulate as much as six million cases for both base and healthy scenarios.

One of the key variables of this project and of all studies concerning chronic homecare needs of the elderly is disability. The data used to generate this variable are coming from Canada's National Population Health Survey (NPHS). The NPHS first cycle of data collection took place in 1994-1995 and will continue every second year thereafter for 20 years. The NPHS fulfilled both cross-sectional and longitudinal needs during its first three cycles, but with Cycle 4 (2000-2001) this survey became strictly a longitudinal one with two components: the household survey and the health care institutions survey (Rowe, 2006).

This paper presents simulation results for the period 2001 to 2031. Year 2001 is our benchmark because it is the last Canadian Census with most available results, whereas 2031 is corresponding to the year when the bulk of the baby-boomers will reach the age of 75, an age when physical and mental impairments rise rapidly.

The last part of this paper is a comparison of the situation of Canada with FELICIE countries. One should be aware that the disability module in LifePaths is dynamic whereas it is static in the FELICIE model. Such a situation makes the comparison more difficult when looking at the constant scenario while in the healthy scenario the comparison is less at risk.

4. MICROSIMULATION RESULTS[4]

4.1 Health Status of Canadian Elderly

Even if there is no doubt that there are close links between mortality and morbidity, the first one is quite simple to measure while measuring the health of a person or a population is quite more complex. There is no unanimity about definitions of what we refer to when we say that a person is in good health or poor health.

However, many people agree that a measure of health should be closely linked to disability: the ability to independently perform activities of daily living. To be in poor health then refers to a person that is in need of care and eventually formal services. Given the four levels of disability defined previously in Canadian surveys, it is usually admitted that those with no disability or with a mild disability are considered in good health, leaving in the poor health group those with a moderate or a severe disability and of those living in institutions.

Past trends in health status are not very straightforward and most of the time it is impossible to assert if in the future we will face an extension or a compression of morbidity (Robine, 2005). In the present study, the parameters of our base LifePaths scenario are kept constant throughout the projected period, while in our healthy scenario the additional years gained in life expectancy are assumed to be healthy years which means a compression of morbidity.

In 2001, there are approximately two men for every three women in the population in poor health aged 75 years and over (Table 3). However regardless of the scenario an increase of men in poor health is expected to occur at a much faster pace than for women in the decades to come. One must keep in mind that the sex-related differential of life expectancy is expected to decrease. But the sharp increase in number of people in poor health from 2021 on is mostly due to the baby-boomers reaching the age of 75.

[4] This analysis is based on Statistics Canada’s LifePaths microsimulation model. The assumptions and calculations underlying the simulation results were prepared by Yann Décarie and Jacques Légaré and the responsibility for the use and interpretation of these data is entirely that of the authors.

In order to have the healthy scenario become effective from 2001, the disability parameters have been modified from 2000, thus making small differences in the numbers of people in poor health.

Table 3 Canadian people aged 75+ in poor health*, according to two scenarios, 2001 to 2031

Year		Men		Women	
		Base scenario	Healthy scenario	Base scenario	Healthy scenario
n_{2001}		196 019	192 900	307 787	302 924
Standardized to 100 in 2001	2001	100	100	100	100
	2011	149	122	134	110
	2021	213	170	180	145
	2031	333	271	270	226

*People in poor health are those moderately or severely disabled.

The size of the family network of people in poor health is a key determinant of their probability to rely on formal home care services. Consequently, it is important to assess how many of those individuals can benefit of the presence of surviving children. In the present study, the use of microsimulations and the substantial numbers of simulated cases generate a much more complete portrait than what could have been obtained with a survey sample. In 2001, elderly men and women in poor health without surviving children show similar proportions; however the situation of men in the next decades is expected to evolve more rapidly than women. As mentioned above, most of the increase takes place between 2021 and 2031, period during which most baby-boomers will reach the age of 75 (Table 4).

Table 4 Canadian people aged 75+ in poor health* without surviving children, according to two scenarios, 2001 to 2031

Year		Men		Women	
		Base scenario	Healthy scenario	Base scenario	Healthy scenario
n_{2001}		49 606	48 768	59 125	58 421
Standardized to 100 in 2001	2001	100	100	100	100
	2011	128	106	108	89
	2021	163	131	127	103
	2031	277	223	224	182

*People in poor health are those moderately or severely disabled.

Elderly people experiencing the highest risks of being dependent of formal sources of assistance are those with a reduced family network, *i.e.* people without neither a spouse nor surviving children. Even if people in such a situation represents slightly more than 15% of all the individuals aged 75 and over in poor heath, the numbers will increase sharply for men throughout the projection period, whereas the women situation will vary slowly and even improve before 2021 in the healthy scenario (Table 5). Of course, as Wolfson and Rowe (2004, p.8) outlined "such results are a lower bound of "needy" elderly because we have not taken into account of whether the adult children live nearby, nor whether the adult child or spouse is in sufficient good health that he or she could in fact provide support".

Table 5 Canadian people aged 75+ in poor health* not married** and without surviving children, according to two scenarios, 2001 to 2031

Year		Men		Women	
		Base scenario	Healthy scenario	Base scenario	Healthy scenario
n_{2001}		29 590	29 063	49 744	49 131
Standardized to 100 in 2001	2001	100	100	100	100
	2011	137	113	106	87
	2021	178	142	120	96
	2031	323	255	204	161

*People in poor health are those moderately or severely disabled.

**Married people include people in Common-Law Union.

4.2 A comparison with FELICIE countries

Such an exercise for the Canadian population is very interesting per se, but an international comparison brings the specificities of the aging situation in Canada for the coming years into focus.

Regardless of the scenario, the growth of the Canadian total population aged 75 and over is expected to be substantially more important than in European countries for the period 2001-2031. More specifically, the Canadian elderly population will be multiplied by approximately 2.5 while in Europe it will increase by 1.5 (Figure 2 and Figure 3).

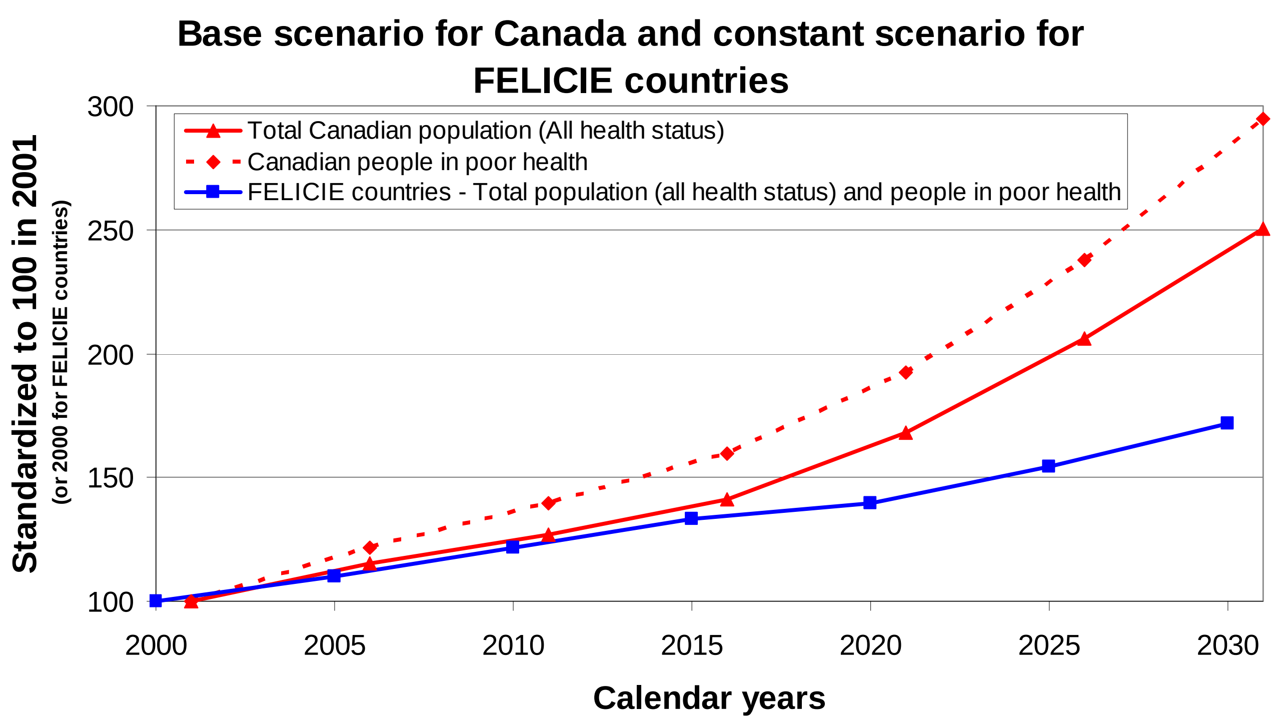

Figure 2 Trends in total population (all health status) and people in poor health, aged 75+, Canada and FELICIE countries

One can observe that numbers of elderly Canadian in poor health will significantly increase, especially from year 2021 on. With the base scenario, the growth in Canada will be twice as more important during the period 2021-2031 compared to the two preceding decades. Since the base scenario for Canada creates an expansion of morbidity without any modification of the disability parameters, this expansion is only due to the varying characteristics of the population at risk. The results for FELICIE countries are quite different because in the constant disability scenario it is assumed that the share of years lived in disability remains constant (Gaymu et al, 2008). Thus, we can clearly see that, in Figure 2, both curves for total elderly population and for elderly in poor health are absolutely the same since they are superposed.

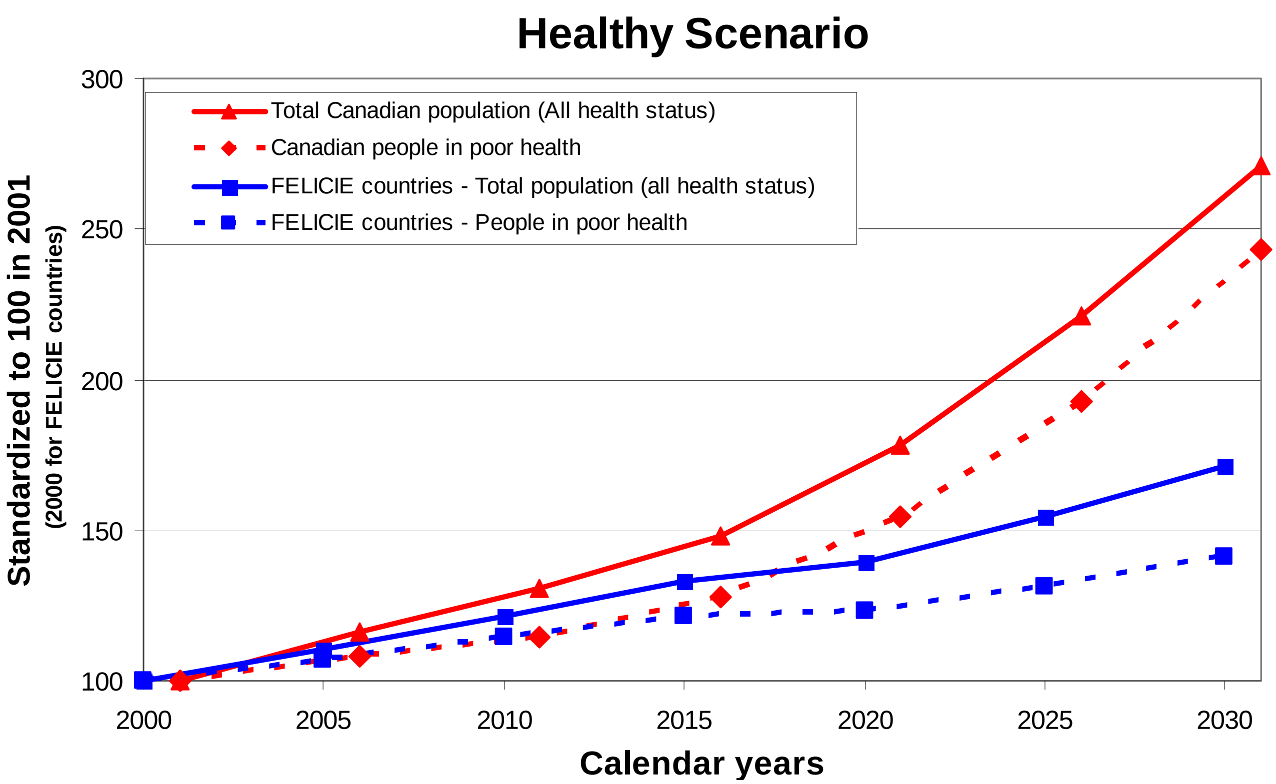

Figure 3 Trends in total population (all health status) and people in poor health, aged 75+, Canada and FELICIE countries

In our opinion, it is of interest for both the scientific community and the Canadian policy makers to put the Canadian case into an international perspective. Up to 2015, trends in total and disabled population aged 75 and over are similar. From 2015 on, the impact of a larger baby-boom in Canada differentiate considerably Canada from FELICIE countries both in terms of total and disabled populations.

A comparison with European countries is particularly relevant for two dimensions. First of all, the aging process is more “mature” in these countries than in Canada. Secondly, the Canadian social security system shows more similarities with the European ones than with the American one. Elderly demographics have impacts on policies designed both for the elderly and their carers. Obviously, contextualising the Canadian situation among other European industrialized countries would allow Canada to benefit from to the experience of countries like France and Germany that are more advanced in terms of alimonies to persons cared and/or their carers.

5. SOME LIMITATIONS

In the current version of LifePaths, there are no transition probabilities for a certain number of variables necessary to reach our research program objectives. Consequently, by using cross-sectional information, we have estimated the probabilities of classifying each factor/covariate pattern in the different categories of these variables. In this paper, however, it is not an issue because the projections do not involve these variables.

Indeed, the projections of Canadian chronic homecare needs (which is the main objective of our research programme) involve cross-sectional incorporation of parameters related to key variables. The left part of Figure 4 lists the characteristics needed for this cross-sectional part of the projections. The microsimulation produces additional characteristics for each individual, but only the ones presented in Figure 4 are used. We first have to run the microsimulation to obtain the population by age, sex, schooling level, region of residence, marital status, age of spouse, place of birth, and number of surviving children. We also need to differentiate who lives in an institution and who lives in a private household. Only the population living in private households is kept since by definition home care services are strictly aimed at this population. This first step provides a picture of the Canadian population for any given year up to 2031 according to the characteristics on the left of Figure 4. Probabilities of disability status need for assistance, living arrangement, receipt of assistance, and source of assistance are then applied to these populations in the sequence shown in Figure 4. As shown, there is an assumption that living arrangements are partly determined by the need for assistance. Thus, living with others is partially seen as a strategy to cope with a need for assistance related to a disability. This was done only for the non-married population, since married individuals are assumed to live with their spouse.

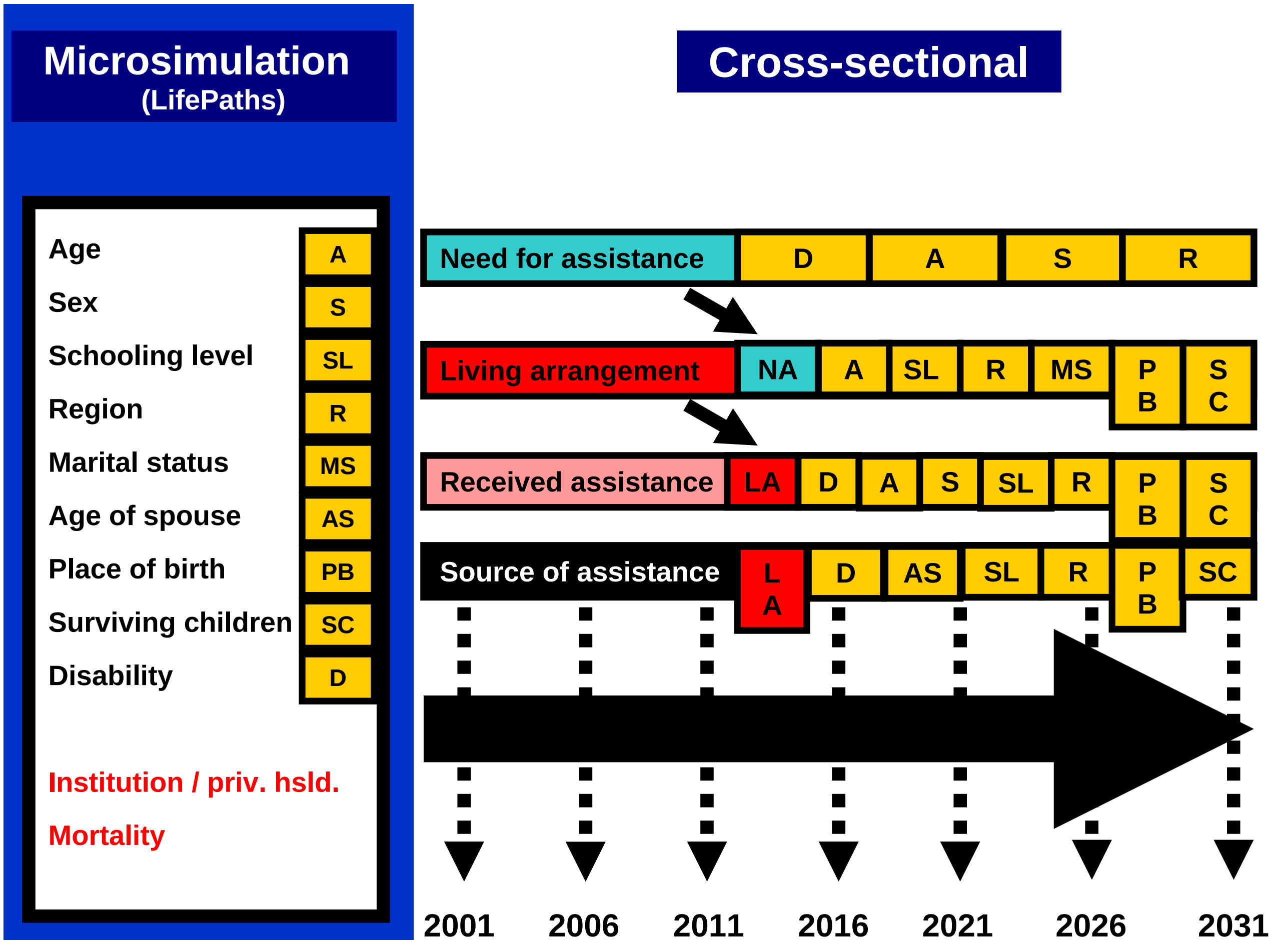

Figure 4 The microsimulation model

6. CONCLUSION

Simulating the Canadian population with an optimistic disability scenario largely reduce the number of Canadian elderly aged 75 years and over in poor health. In 2031, we should find approximately 20% less people in poor health in the healthy scenario than in the base scenario. Moreover, the base scenario predicts a small expansion of disability due to the internal changes occurring in the characteristics of the Canadian population and that are taken into account by LifePaths. Consequently, the differences between the number of Canadian elderly in poor health and those observed in FELICIE countries are larger than expected because their constant scenario keeps their disabled people in the population at the same proportion throughout the period.

Furthermore, up to 2015, the relative increase in the Canadian and in the FELICIE countries total population (all health status) and people in poor health aged 75 years and over is similar. Afterwards, the impact of the larger baby-boom that occurred in Canada differentiates considerably the latter from FELICIE countries in terms of total population (all health status) and people in poor health. Indeed, both the total population aged 75 and over and the sub-population in poor health are expected to grow more rapidly in Canada than in Europe. Concerning the total populations, the difference between Canada and Europe is larger in the healthy scenario because both disability and mortality levels are linked together in the Canadian microsimulation model.

Finally, one must keep in mind that reaching the age of 75 corresponds to the beginning of a frailty period, implying increased needs for specific care. The rapid growth of our projected Canadian elderly population should raise the awareness of Canadian policy makers about the issues on future homecare needs and homecare services. Thus, tomorrow's problems can be avoided by today's actions.

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