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Mortality Improvement for Canadian Pensioners: Proposed Projection Scales

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Outline

1. Introduction
2. Phases of Study
3. Methodology & Results, Phase II
4. Mortality Improvement Rate: Formulas
5. Projection Scales: Proposal
6. Conclusion

1. Introduction

Acknowledgements:
- Financial support from Canadian Institute of Actuaries, and formerly from *Chaire d'actuariat,* Université Laval and SOA
- Data and support:
  - Office of the Chief Actuary (CPP)
  - *Régie des rentes du Québec* (QPP)
- CIA CCPME: Committee on Canadian Pensioners Mortality Experience
- and many reviewers, colleagues, students

CCPME

- Created in 2008 by CIA
- Commissioned two studies in 2009
- Data collected in 2010
- Data analysis and review 2010 and 2011
- Reports drafted and reviewed:
  - Registered Pension Plan Study in 2012
  - **CPM Study in 2011 and 2012**
- CIA Annual Meeting: June 2012 Presentation

CPM

- Canadian Pensioners Mortality = CPM
- Pensioner data only, from CPP and QPP administrators
  - Separate and combined results
  - **Data comprehensive and high quality**
  - Data segmented by pension income level
  - Almost 8 million exposed lives (86.9 M life-years exposure from 1967 to 2008)
  - pensions payable since 1967

Messages, CIA June 2012 Session

1. It is **time to change** the Canadian standard for mortality tables for pension plans: Canadian evidence for this
2. **Income is important** for pensioner mortality (with time, gender, age, source)
3. Mortality trend: **Higher improvements rates** observed in recent past= **troubling news**
4. Impact might be **material for many plans**

2. CPM Study Phases

1: Get high quality data: CPP + QPP = CAN

2: Measure qx at recent point in time:

- 2005-2007, centered in **2006**
- **Phase II Report**: May 31st, 2012

3: Measure mortality trends: projection scales

- With recent experience over 15 years for short term scale: 1992-2007 ➡ 2006 to 2021
- Long term scale based on C/QPP Actuarial Reports
- **Phase III Report**: Draft July 17th , 2012

3. Methodology & Results, Phase II

- Deaths & Exposure measured
- **5** variables: source, gender, age, **income**, **year**
- Exact age, constant force of mortality for fractional ages
- Exact age compares to "Nearest Birthday"
- Provides point estimate and confidence intervals
- Graduation: Gompertz, modified at extreme ages, values within bounds of 1 std dev.

Income

- 5 income classes
- Split in % of C/QPP Maximum Pension
  - **1**: <35%, **2**: 35%-94%, **3**: >95%
- Remove lower pensions (Class 1) to get proxy for mortality of pension plans members
- **Class 4** = **Class 2** (mid) + **Class 3** (high)
- Class 5 = All income

Results shown here

- Ratios of q(x) : CPM-CAN/ UP-94 @ 2006 +
- 2006: No projection for CPM-CAN
- 2012: 6-Year Projection with short term scale
- UP-94: Scale AA, static proj. to 2006 or 2012

CPM vs UP-94 in **2006**: ratios q(x) Male

CPM vs UP-94 in **2012**: ratios q(x) Male

CPM vs UP-94 in **2006**: ratios q(x) Female

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CPM vs UP-94 in **2012**: ratios q(x) Female

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CPM vs UP-94: 2006 and beyond

- Male: depends on income class, but lower than UP-94 in 2012 until age **84**
  - Class 4 ages 74-77: under 102%;
  - Wide gap between income classes,
- For Female: CPM mortality is lower (age<**87**)
- Projected to 2015, 2020: lower ratios
- Next Charts: compare Classes 2, 3 & 4 only
- Also: compare Sources CPP, QPP, CAN

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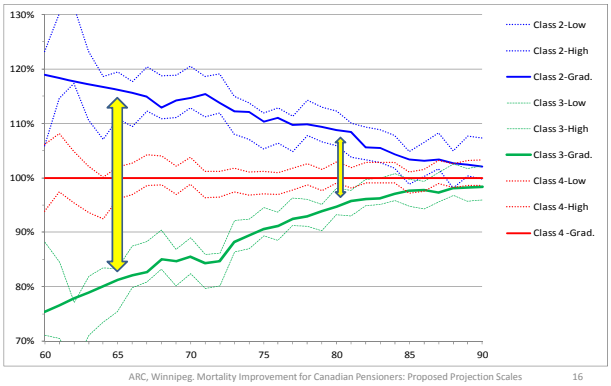
CPM-CAN 2005-2007 Male: Classes 2, 3 & 4



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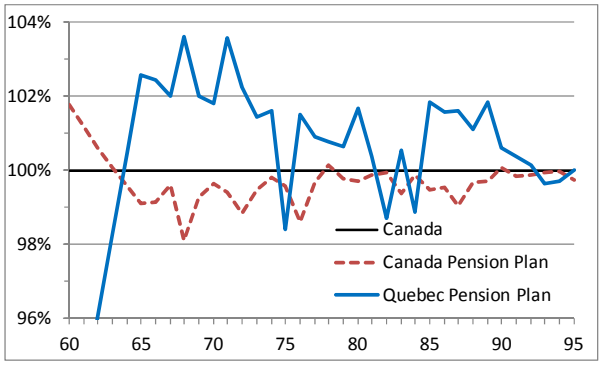
Source 2005-07 Male: CAN, CPP, QPP



4. Mortality Improvement Rate, Formulas

Next Slide show formulas for reference

Charts follow and illustrate trends

Excerpts from Phase III Draft Report (2012-07)

Formulas: force, prob., weights

Deaths and exposure (exact): $\hat{\mu}_x = \frac{D_x}{E_x}$

Probability of death, from force: $\hat{q}_x = 1 - e^{-\hat{\mu}_x}$

Variance of force, and of prob.:

$$\mathrm{Var}(\hat{\mu}_x) = \sigma^2_{\hat{\mu}_x} = \frac{\hat{\mu}_x}{E_x} = \frac{D_x}{E_x^2}$$

$$\mathrm{Var}(\hat{q}_x) = \left(e^{-\hat{\mu}_x}\right)^2 \times \mathrm{Var}(\hat{\mu}_x)$$

Weight:

$$w_t = \frac{1}{\mathrm{Var}(\hat{q}_x)} = \frac{(E_x)^2}{(1-\hat{q}_x)^2 \times D_x}$$

Formulas: Regression

Improvement rate: $q_x^{init\_year+t} = q_x^{init\_year} \times (1 - IR_x)^t$

Regression on ln(qx): linear form

$$\ln\left(q_x^{init\_year+t}\right) = \ln\left(q_x^{init\_year}\right) + t \times \ln(1 - IR_x)$$

$$y_i = \beta_0 + \beta_1 \times x_i$$

Weighted Linear Regression (Min W, find slope):

$$W = \sum_{i=1}^{n} w_i \times (y_i - \beta_0 - \beta_1 \times x_i)^2$$

Formulas: slope, IR_x

Slope factor, weighted linear regression:

$$\hat{\beta}_{1(w)} = \frac{\sum_{i=1}^{n} w_i \times x_i \times y_i - \frac{\left(\sum_{i=1}^{n} w_i \times x_i\right) \times \left(\sum_{i=1}^{n} w_i \times y_i\right)}{\sum_{i=1}^{n} w_i}}{\sum_{i=1}^{n} w_i \times x_i^2 - \frac{\left(\sum_{i=1}^{n} w_i \times x_i\right)^2}{\sum_{i=1}^{n} w_i}}$$

Improvement rate: $IR_x = 1 - e^{\beta_1}$

Formulas: bounds, R^2

Confidence interval: upper and lower bounds

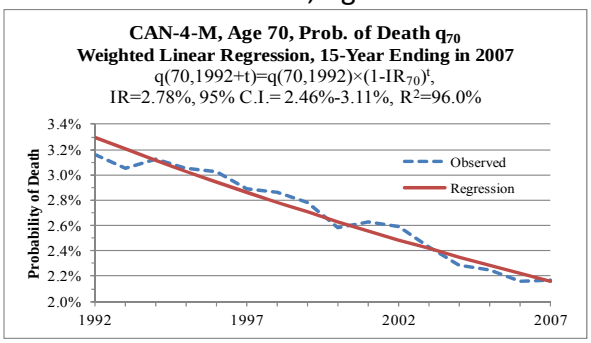
$$LB = \hat{\beta}_{1(w)} - t_{\alpha/2,n-2} \times s_{\hat{\beta}_1} \qquad rate(LB) = 1 - e^{LB}$$

$$UB = \hat{\beta}_{1(w)} + t_{\alpha/2,n-2} \times s_{\hat{\beta}_1} \qquad rate(UB) = 1 - e^{UB}$$

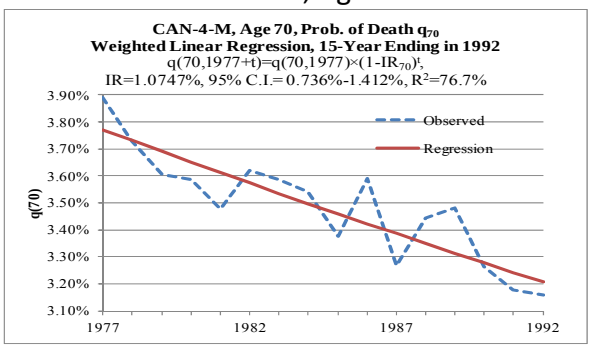
Worth of regression: **R^2**

$$R^2 = \frac{\sum_{i=1}^{n} w_i \times (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n} w_i \times (y_i - \bar{y})^2}$$

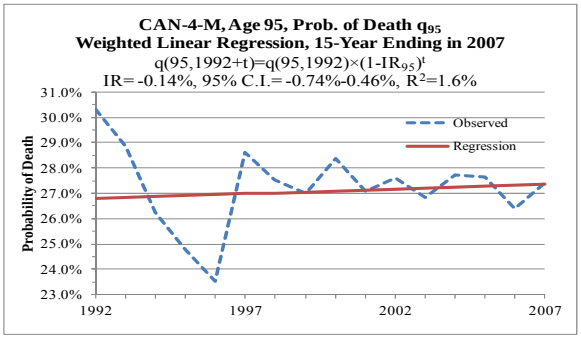
15-Year Regression Ending in 2007, CAN-4-M, Age 70



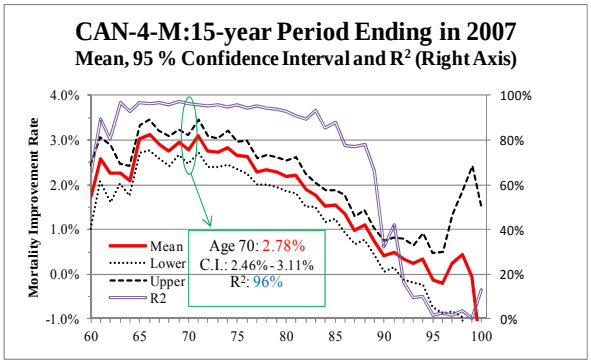
15-Year Regression Ending in 1992, CAN-4-M, Age 70



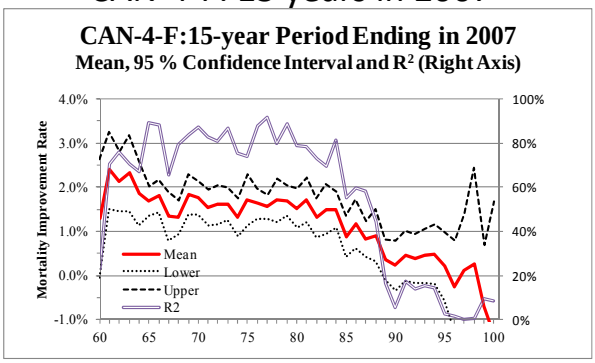
15-Year Regression Ending in 2007, CAN-4-M, Age 95



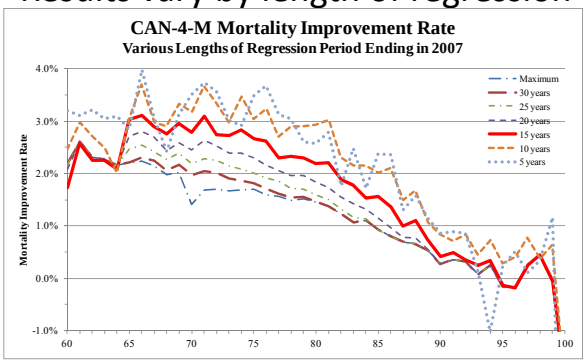
CAN-4-M: 15 years in 2007



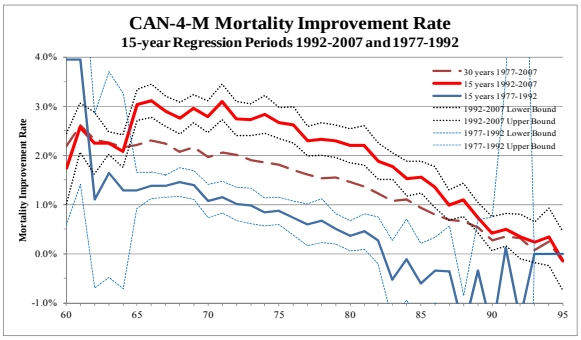
CAN-4-F: 15 years in 2007



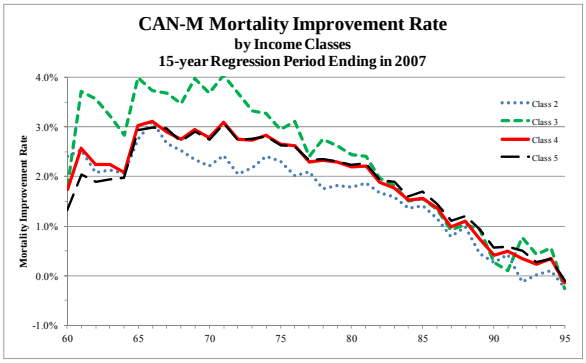
Results vary by length of regression



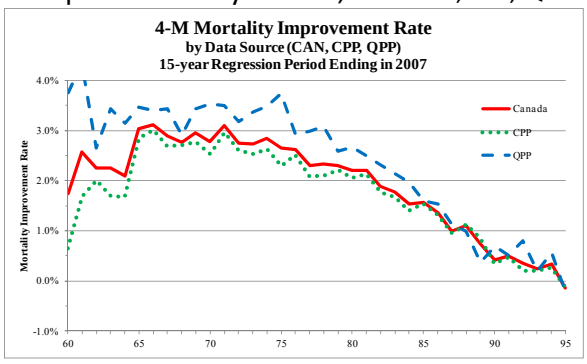
Results of Last 30 Years (Males)



Improvement by Classes, CAN-M:2,3,4,5



Improvement by Source, 4-M:CAN, CPP, QPP



5. Projection Scales, Proposal

- 15-year: 1992 to 2007 mirrored to 2006-2021
- CPM-CAN Experience
- Income class 4
- Long term: blend of CPP and QPP
  - 2060 assumptions in December 2009 Report
- Mid term: transition from 2021 to 2030
- Based on blended C/QPP 2020 assumptions, adjusted
- Impact: q(x) decreases faster, higher e(x) higher ä(x), higher actuarial liabilities

Proposal: 3 Projection Scales

Short term scale: 2006 to 2021, 15 years

$$ {}^{Male}q_x^{2006+k} = {}^{Male}q_x^{2006} \times \left(1 - {}^{Male}IR_x^{\text{Short term}}\right)^k ; 1 \le k \le 15 $$

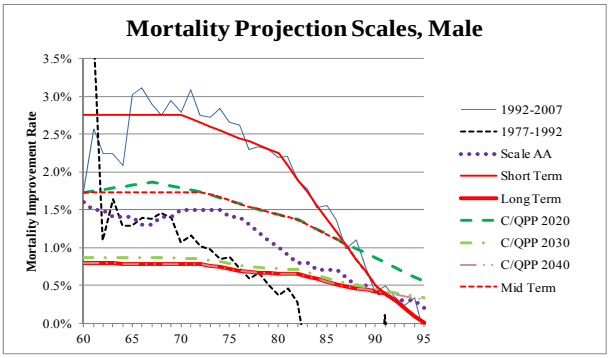
Mid term scale: 2021 to 2030, 9 years

$$ {}^{Male}q_x^{2006+k} = {}^{Male}q_x^{2006} \times \left(1 - {}^{Male}IR_x^{\text{Short Term}}\right)^{15} \times \left(1 - {}^{Male}IR_x^{\text{Mid Term}}\right)^{k-15} ; 16 \le k \le 24 $$

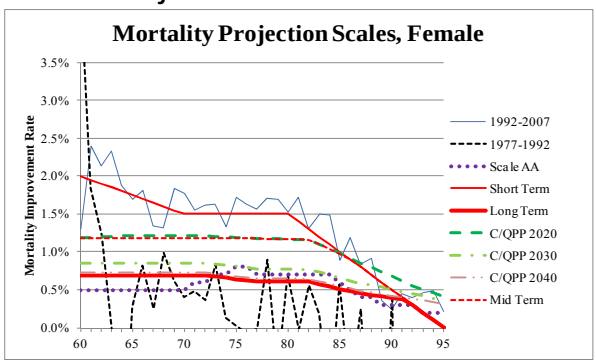
Long term scale: 2030 and after

$$ {}^{Male}q_x^{2006+k} = {}^{Male}q_x^{2006} \times \left(1 - {}^{Male}IR_x^{\text{Short Term}}\right)^{15} \times \left(1 - {}^{Male}IR_x^{\text{Mid Term}}\right)^{9} \times \left(1 - {}^{Male}IR_x^{\text{Long Term}}\right)^{k-24} ; k \ge 25 $$

Projection Scale: Male



Projection Scale: Female



Results

- Charts show impact on a generational basis
- Change from UP-94 G to CPM-CAN-4 2005-2007
- UP-94 G : AA Projection Scale
- CPM-CAN-4 2005-2007: Short/Mid/Long Projection Scales
- Effect on complete life expectancy and PV of life annuity-due $\dot{e}_x$ & $\$1{,}000 \times \ddot{a}_x$

PV, i=3%, Valuation in 2012: Male

Age	UP-94G	CPM-CAN-4-M	% Increase
60	17,032	17,506	2.78%
65	14,729	15,097	**2.50%**
70	12,434	12,648	1.72%
75	10,099	10,169	**0.68%**
80	7,876	7,811	-0.83%
85	6,032	5,727	-5.06%

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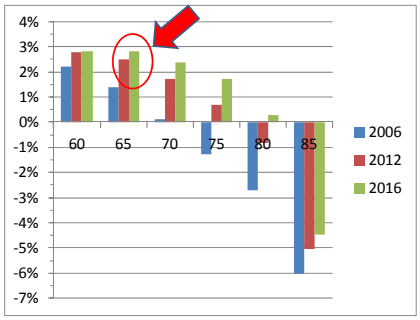
Impact on PV at 3%: Male (generational)

- % Increase in ä(x)
- From UP-94 G to CPM-CAN-4-M
- Generational: with impact of projection scales
- 3 Valuation Years



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PV, i=3%, Valuation in 2012: Female

Age	UP-94G	CPM-CAN-4-M	% Increase
60	18,201	18,857	**3.61%**
65	16,033	16,572	**3.36%**
70	13,812	14,198	**2.80%**
75	11,472	11,733	**2.27%**
80	9,146	9,255	**1.19%**
85	6,983	6,903	**-1.14%**

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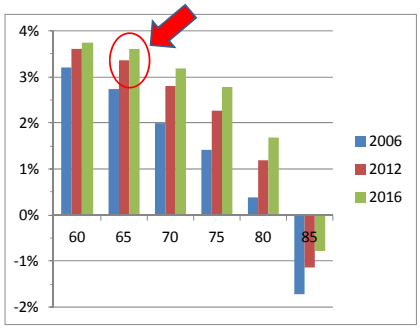
Impact on PV at 3%: Female (generational)

- % Increase in ä(x)
- From UP-94 G to CPM-CAN-4-F
- Generational: with impact of projection scales
- 3 Valuation Years



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6. Conclusion

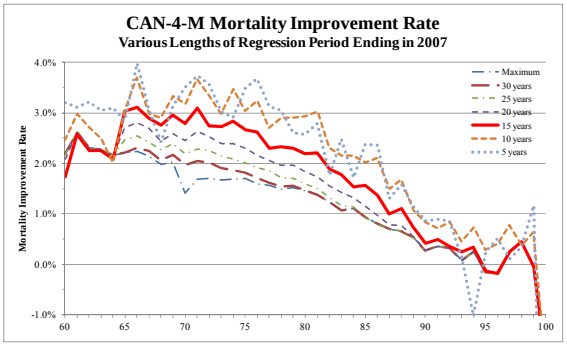
- Canadian pattern of mortality known
- Cost of pensions using UP-94 and AA may be underestimated
- Recent trend in mortality
  - faster decrease than thought with previous scales
  - not known when it will trail off
  - No crystal ball: use consensus for long term

Next Steps

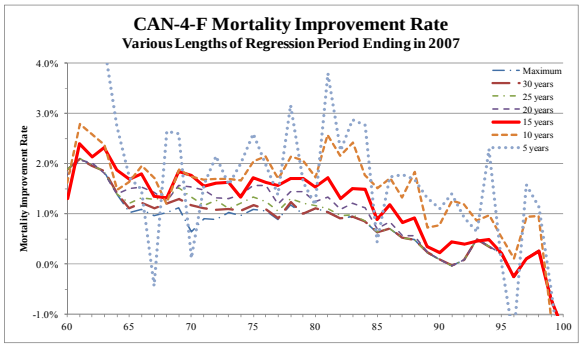
- CIA: decision to release Phase II and Phase III reports
- CIA: may provide additional comments
- Discussion at CIA Fall 2012 Pension Seminar
- Actuarial Standards Board (Canada): decide future recommendations for mortality tables for pensions plans purposes

Thank you !

Length of Regression: CAN-4-M in 2007



Length of Regression: CAN-4-F in 2007



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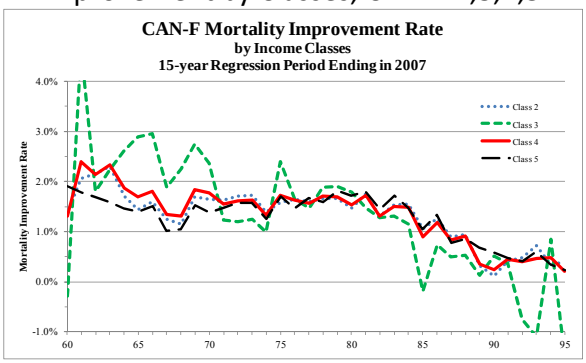

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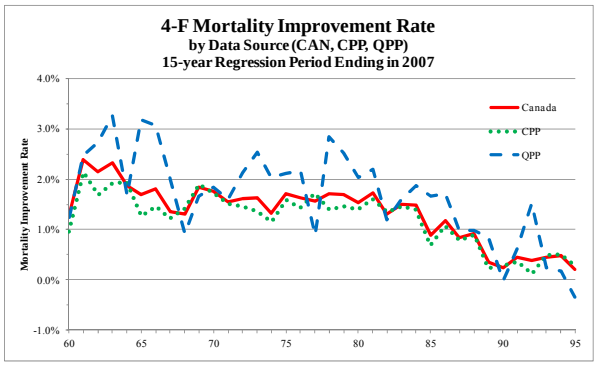
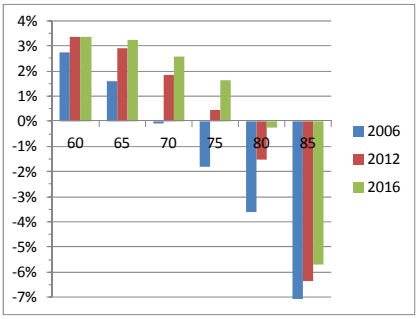


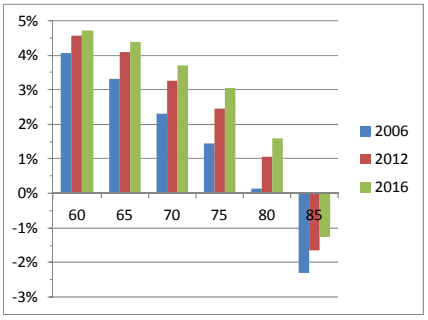
Impact on Life Expectancy: Male (generational)

- % Increase in complete e(x)
- From UP-94 G to CPM-CAN-4-M
- Generational: with impact of projection scales
- 3 Valuation Years



Impact on Life Expectancy: Female (generational)

- % Increase in complete e(x)
- From UP-94 G to CPM-CAN-4-F
- Generational: with impact of projection scale
- 3 Valuation Years



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