Annals of Epidemiology 37 (2019) 81–83

Contents lists available at ScienceDirect

Annals of Epidemiology

Brief communication

Introduction of a novel measure of premature mortality caused by chronic conditions: real-world examples from prostate and testis cancers in Canada, 1980–2015

Truong-Minh Pham, MD, PhD [a, *], Lorraine Shack, PhD [a], Winson Y. Cheung, MD, MPH [b]

[a] Surveillance and Reporting, Cancer Research and Analytics, Cancer Control Alberta, Alberta Health Services, Edmonton and Calgary, Canada
[b] Department of Oncology, Cumming School of Medicine, University of Calgary, Calgary, Canada

ARTICLE INFO

Article history:
Received 17 May 2019
Accepted 21 July 2019
Available online 26 July 2019

Keywords:
Premature mortality
Years of life lost
Average life span shortened
Prostate cancer
Testis cancer

Premature mortality in terms of years of life lost (YLL) is not often used in monitoring the burden of chronic health conditions on a population. Two algorithms for calculation of YLL are primarily responsible for comparability between studies. In addition, results derived from different life tables pose further challenges in surveillance of premature mortality over time. In this article, we attempt to introduce a novel measure of premature mortality, which was recently proposed by our group for monitoring changes in premature mortality over time.

Brief description of the use of premature mortality in Canada

Premature mortality refers to people who die of a health condition *earlier* than expected. Two common measures of premature mortality include YLL and average years of life lost (AYLL). Because the anticipated longevity of individuals is often difficult to establish, two major algorithms are commonly used in deriving YLL: the threshold method and the life table method. Importantly, results can differ significantly depending on the method used. In Canada, one approach is preferred over the other based on the setting whereby the life table method is more frequently applied by researchers [1], whereas the threshold method is more frequently used by governmental agencies [2–6]. For instance, Alberta Health [2] and Statistics Canada [3] have adopted a threshold at 75 years of age, whereas Canadian Institute for Health Information [4] has adopted a threshold at 70 years of age to estimate YLL. A threshold of 75 years was also recently adopted by other Canadian jurisdictions, such as Public Health Ontario [5] and Manitoba Health, Seniors and Active Living [6].

Comparability challenges of premature mortality between studies

The threshold method represents a simple calculation that subtracts age at death from a prespecified age limit, above which deaths are considered “mature” and therefore no longer contribute to YLL. However, the choice of 70 or 75 years as the age limit is rather arbitrary. This contrasts the life table method, which allows deaths at any age to contribute to the YLL calculation. Consequently, two reasons principally explain discrepancies between results derived from two methods. First, subtraction from an age limit by the threshold method most often yields a smaller YLL estimate than life expectancy indicated by life tables. For instance, a man who died in the year 2005 at 60 years of age contributes 15.0 years according to

The authors have no conflicts of interest to disclose.

* Corresponding author. Surveillance and Reporting, Cancer Research and Analytics, Cancer Control Alberta, Alberta Health Services, Suite 1400, Sun Life Building, 10123-99 Street, Edmonton, AB T5J 3H1, Canada. Tel.: +1-780-643-7193; fax: +1-780-643-4380.
E-mail addresses: TruongMinh.Pham@ahs.ca, ptrminh@gmail.com (T.-M. Pham).

https://doi.org/10.1016/j.annepidem.2019.07.011
1047-2797/

Table 1
Number of deaths*, age-standardized rate (ASR), years of life lost (YLL), YLL rate, average YLL (AYLL), and average life span shortened (ALSS) due to prostate† and testis‡ cancers in Canadian men, 1980–2015

Year	Prostate								Testis							
	Threshold method at 75 y of age§		Life table method‖						Threshold method at 75 y of age§		Life table method‖					
	Death	YLL (y)	Death	ASR¶ per 100,000 men	YLL (y)	YLL rate¶ per 1000 men	AYLL per decedent (y)	ALSS among decedents (%)	Death	YLL (y)	Death	ASR¶ per 100,000 men	YLL (y)	YLL rate¶ per 1000 men	AYLL per decedent (y)	ALSS among decedents (%)
1980	806	6583	2034	15.4	18,451	1.36	9.1	10.6	39	1527	43	0.3	1551	0.11	36.1	47.1
1981	863	6879	2194	16.2	19,743	1.42	9.0	10.5	46	1898	50	0.3	1923	0.13	38.5	50.7
1982	905	7150	2175	15.7	19,958	1.40	9.2	10.7	46	1883	48	0.3	1889	0.13	39.4	51.9
1983	963	7454	2288	16.3	20,906	1.44	9.1	10.6	48	1849	50	0.4	1861	0.13	37.2	49.0
1984	896	6843	2395	16.3	21,148	1.40	8.8	10.3	50	1870	50	0.3	1879	0.12	37.6	50.0
1985	1091	8563	2628	17.5	24,414	1.59	9.3	10.8	43	1549	46	0.3	1623	0.10	35.3	45.9
1986	1157	9176	2746	17.8	25,623	1.63	9.3	10.9	43	1749	44	0.3	1781	0.12	40.5	53.3
1987	1155	9015	2847	17.6	26,409	1.62	9.3	10.8	43	1634	49	0.3	1716	0.11	35.0	45.2
1988	1202	9151	3037	18.4	27,432	1.65	9.0	10.5	47	1751	52	0.3	1842	0.12	35.4	45.7
1989	1221	9038	3048	17.7	27,497	1.59	9.0	10.5	46	1828	50	0.3	1881	0.13	37.6	48.9
1990	1263	9744	3212	17.8	30,852	1.72	9.6	11.1	35	1255	37	0.2	1356	0.09	36.6	47.1
1991	1297	10,266	3426	18.7	32,521	1.78	9.5	10.9	36	1228	39	0.2	1335	0.08	34.2	43.7
1992	1297	9716	3494	18.6	32,521	1.72	9.3	10.7	32	1211	34	0.2	1285	0.08	37.8	48.5
1993	1334	9832	3582	18.6	33,145	1.72	9.3	10.6	23	849	27	0.2	931	0.06	34.5	43.6
1994	1334	9717	3624	18.4	33,125	1.69	9.1	10.5	47	1656	50	0.3	1785	0.11	35.7	45.8
1995	1336	10,033	3760	18.5	34,618	1.72	9.2	10.6	39	1317	41	0.2	1447	0.08	35.3	45.0
1996	1256	9368	3588	17.2	32,555	1.58	9.1	10.4	33	1189	38	0.2	1316	0.08	34.6	43.7
1997	1202	9166	3622	16.8	32,668	1.54	9.0	10.3	29	977	35	0.2	1090	0.06	31.1	38.7
1998	1223	9169	3664	16.5	32,929	1.51	9.0	10.3	35	1260	37	0.2	1375	0.09	37.2	47.4
1999	1182	8646	3601	15.9	31,884	1.43	8.9	10.1	31	1088	37	0.2	1201	0.08	32.5	40.3
2000	1204	8847	3718	15.9	34,244	1.49	9.2	10.5	33	1184	37	0.2	1337	0.08	36.1	44.9
2001	1170	8700	3825	14.3	34,677	1.41	9.1	10.3	26	923	28	0.2	1041	0.06	37.2	46.8
2002	1142	9216	3708	13.6	33,991	1.36	9.2	10.4	27	866	28	0.2	991	0.06	35.4	44.5
2003	1077	8536	3658	13.0	32,697	1.27	8.9	10.1	33	1189	38	0.2	1353	0.08	35.6	44.5
2004	1017	7731	3685	12.5	31,972	1.18	8.7	9.8	42	1466	46	0.2	1656	0.10	36.0	44.8
2005	990	8205	3586	11.8	33,137	1.20	9.2	10.4	40	1485	43	0.2	1701	0.10	39.6	49.2
2006	931	7643	3564	11.2	32,182	1.13	9.0	10.1	30	1185	33	0.2	1350	0.08	40.9	50.6
2007	962	7561	3632	11.0	32,293	1.10	8.9	10.0	28	1019	31	0.2	1178	0.07	38.0	46.9
2008	1002	8166	3720	10.9	33,529	1.11	9.0	10.1	32	1131	36	0.2	1317	0.08	36.6	44.9
2009	948	8134	3745	10.5	33,473	1.06	8.9	10.0	25	730	29	0.1	901	0.05	31.1	37.9
2010	978	8124	3833	10.4	36,231	1.11	9.5	10.5	39	1372	41	0.2	1626	0.09	39.6	48.5
2011	945	7800	3693	9.7	34,755	1.03	9.4	10.4	31	1048	37	0.2	1293	0.07	34.9	42.2
2012	958	8154	3708	9.3	34,721	1.00	9.4	10.4	44	1572	52	0.2	1898	0.10	36.5	44.0
2013	1082	8866	3947	9.6	37,313	1.04	9.5	10.5	34	1077	38	0.2	1323	0.07	34.8	42.1
2014	1073	8579	4135	9.5	38,154	1.01	9.2	10.2	28	924	30	0.1	1116	0.06	37.2	45.4
2015	1112	9016	4011	9.0	37,786	0.98	9.4	10.4	32	1251	36	0.2	1466	0.08	40.7	49.6

* Mortality data for Canada was obtained from the World health Organization mortality database which is available at http://www.who.int/healthinfo/mortality_data/en/.
† Prostate cancer was defined as codes 185, and C61 according to the international classification of diseases and injuries (ICD) ninth Revision (ICD-9), and ICD-10, respectively.
‡ Testis cancer was defined as codes 186, and C62 according to the ICD-9, and ICD-10, respectively.
§ Results were based on a subset of data where deaths occurred prior to 75 years, and YLL was calculated using the threshold method at 75.
‖ Results were based on the full data where deaths occurred from all ages, and YLL as well as subsequent measures were calculated using the life table method.
¶ Rates were adjusted to the World Standard Population.

the threshold of 75 years of age, whereas he would contribute 21.9 years according to the life table method. Second, the threshold method excludes a subset of decedents in the YLL calculation (those who died after the threshold age). Results based on recent work from our group showed that such an analysis would exclude approximately 35% female breast cancer deaths in 1980 if an age threshold of 70 years was applied, whereas the analysis would fail to consider about 50% of female breast cancer deaths in 2010 [7]. All of this calls into question how best to compare premature mortality if studies did not consistently apply the same methods or thresholds.

The life table method also poses some, albeit different, challenges especially when using YLL and AYLL to examine changes in premature mortality over time or across health conditions. Because life expectancy of the general population has improved with time, this influences the YLL and AYLL calculation. Furthermore, YLL reflects the population burden as a whole and relates to number of deaths. Indeed, YLL caused by a particular condition from an "older" era may not always be comparable with YLL based on data from more recent years because the number of deaths most likely increased due to population growth. Likewise, YLL calculated for a particular health condition may vary significantly from that derived for another condition because of different prevalence. A prevalent condition like prostate cancer would result in larger YLL when compared with a less frequent condition like testis cancer within the same study population. The AYLL, on the other hand, reflects YLL burden to the individual. As with the YLL measure, AYLL calculated in more recent years may not be comparable with that obtained from more distant years because life expectancy has improved with time.

Introduction of a novel measure

Owing to these significant issues, we have proposed a novel measure termed average life span shortened (ALSS) [7–10]. In brief, ALSS represents a ratio of the number of years of life lost in relation to the expected life span. Some hypothetical examples will more clearly demonstrate how ALSS is derived. A man who died from prostate cancer in the year 1985 at 60 years of age would have lost 18.5 years of life as indicated by the 1985–1987 Canadian male life table. His life span was shortened by 23% because 18.5 years of life were lost over the expected life span of 78.5 years. In contrast, another man who died from prostate cancer in the year 2005 at 60 years of age would have lost 21.9 years of life according to the 2005–2007 male life table. As a result, his life span would be shortened by 26%. A general formula for ALSS measure can be expressed as follows:

$$ALSS = \frac{100^* \sum d_i * e_i}{\sum d_i^*(a_i + e_i)}$$

where d_i is the number of deaths at *age i*; e_i is the normative life expectancy at *age i*; and a_i is the age at death.

Results of ALSS are typically expressed as a percentage, specifically indicating the ALSS among all patients who died of a particular health condition. Because changes in life tables over time are implicitly taken into account in the ALSS calculation, interpretation of the results does not need to further consider changes in the life table structure. When attempting to examine changes in premature mortality over time, ALSS would remain stable if the life span of patients increases at a similar rate to that of the general population. Conversely, ALSS would decrease over time if the life span of patients increases at a faster rate than that of the general population.

Table 1 shows real-world data from two male genital cancers in Canada first to draw attention to comparability issues and second to demonstrate how the ALSS measure could be implemented in surveillance over time and across health conditions. We calculated YLL by both threshold and life table methods to show differences in YLL estimates by two methods of YLL calculation. Generally, YLL obtained from the threshold method at 75 years was lower than that derived from the life table method over the entire study period. It is particularly true for prostate cancer because deaths often occurred at late ages. Over the study time frame, there were approximately one-third or one-fourth of prostate cancer deaths that occurred before 75 years of age (Table 1). Being stable over the entire 35-year period, ALSS indicates almost no improvement of life span of men with either prostate or testis cancers. In other words, the life span of patients with prostate and testis cancers in Canada was prolonged at a similar rate as the general population experienced over the study period. However, men with prostate cancer lost a smaller portion of their life compared with those with testis cancer.

Conclusion

In this article, we briefly introduced our novel ALSS measure, which is an addition to the existing "life lost" measures. We demonstrated that results derived from our novel measure may be more useful for clinicians and health decision-makers. This novel ALSS measure could be implemented not only for monitoring premature mortality of cancer but also for other chronic health conditions such as diabetes and cardiovascular diseases.

Acknowledgments

Authors' contribution: Truong-Minh Pham conceived the work. All authors drafted the manuscript, revised it critically, and gave final approval of the version submitted to the journal. We are grateful to the World Health Organization and sincerely thank their staff for their efforts in collecting and monitoring the mortality database. The content in this article is solely responsibility of the authors and the views of authors do not necessarily represent those of their affiliated organizations.

This work received no funding or grants from any institutions or organizations.

References

[1] Boswell-Purdy J, Flanagan WM, Roberge H, Le Petit C, White KJ, Berthelot JM. Population health impact of cancer in Canada, 2001. Chronic Dis Can 2007;28:42–55.
[2] Goverment of Alberta. Health indicator - potential years of life lost. https://www.albertahealthservices.ca/publications/ahs-pub-pr-def-potl-life-lost.pdf. [Accessed 19 March 2019].
[3] Statistics Canada. Table 13-10-0742-01 - Mortality and potential years of life lost by selected causes of death and sex, three-year average, Canada, province, territories, health regions and peer groups occational. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310074201. [Accessed 19 March 2019].
[4] Canada's International Health System. Performance over 50 years: examining potential years of life lost. https://secure.cihi.ca/free_products/International_PYLL_EN.pdf. [Accessed 19 March 2019].
[5] Public Health Ontario. Potential years of life lost snapshot 2003-2012. https://www.publichealthontario.ca/en/data-and-analysis/chronic-disease/pyoll. [Accessed 19 March 2019].
[6] Manitoba Health. Seniors and Active Living. Annual Statistics 2017-2018. https://www.gov.mb.ca/health/annstats/index.html. [Accessed 19 March 2019].
[7] Pham TM, Sikdar KC, Kaposhi B, Lupichuk S, Yang H, Shack L. Premature mortality due to breast cancer among Canadian women: an analysis of a 30-year period from 1980 through 2010. Eur J Public Health 2018;28:348–52.
[8] Pham TM, Sikdar KC, Cheung WY, Roa W, Eckstrand A, Kaposhi B, et al. Premature mortality due to malignancies of the central nervous system in Canada, 1980–2010. Neuroepidemiology 2018;50:195–200.
[9] Pham TM, Kubo T, Fujino Y, Fujimoto N, Tomisaki I, Minato A, et al. Premature mortality due to malignancies of the kidney and bladder in Japan, 1980-2010. J Epidemiol 2018 (Advance publication).
[10] Atchison KM, Pham TM, Sikdar KC, Weeks LA, Karosas APV, Sinnarajah A, et al. Premature deaths due to head and neck cancers in Canada: a nationwide analysis from 1980 to 2010. Laryngoscope 2019 (Advance publication).