Applications of the Cumulative Rate to Kidney Cancer Statistics in Australia

Janelle Brennan[1], K.C. Chan[2], Rebecca Kippen[3], C.T. Lenard[4], T.M. Mills[5], and Ruth F.G. Williams[4]

[1] Department of Urology, Bendigo Health, and St. Vincent's Hospital Melbourne, Australia
(E-mail: janellebrennan@gmail.com)
[2] Computer Science and Information Technology, La Trobe University, Bendigo, Australia
(E-mail: ka.chan@latrobe.edu.au)
[3] School of Rural Health, Monash University, Bendigo, Australia
(E-mail: rebecca.kippen@monash.edu)
[4] Mathematics and Statistics, La Trobe University, Bendigo, Australia
(E-mail: c.lenard@latrobe.edu.au)
[5] Bendigo Health and La Trobe University, Bendigo, Australia
(E-mail: t.mills@latrobe.edu.au)

Abstract. Cancer incidence and mortality statistics in two populations are usually compared by using either the age-standardised rate or the cumulative risk by a certain age. We argue that the cumulative rate is a superior measure because it obviates the need for a standard population, and is not open to misinterpretation as is the case for cumulative risk. Then we illustrate the application of the cumulative rate by analysing incidence and mortality data for kidney cancer in Australia using the cumulative rate. Kidney cancer is also known as malignant neoplasm of kidney: we use the term kidney cancer in this paper. Kidney cancer is one of the less common cancers in Australia. In 2012, approximately 2.5% of all new cases of cancer were kidney cancer, and approximately 2.1% of all cancer related deaths in Australia are due to kidney cancer. There is variation in incidence and mortality by sex, age, and geographical location in Australia. We examine how the cumulative rate performs in measuring the variation of this disease across such subpopulations. This is part of our effort to promote the use of the cumulative rate as an alternative to the age-standardised rates or cumulative risk. In addition we hope that this statistical investigation will contribute to the aetiology of the disease from an Australian perspective.
Keywords: Kidney cancer, Renal cell carcinoma, Incidence, Mortality, Cumulative rate, Descriptive epidemiology.

1 Introduction

We define kidney cancer, which is also known as malignant neoplasm of kidney, as the disease classified as C64 according to the *International Statistical Classification of Diseases and Related Health Problems*, 10th Revision (ICD10) by Australian Institute of Health and Welfare [1].

The *incidence* of kidney cancer is the number of new cases diagnosed each year in a given region, in this case Australia. For each year, the *mortality* of kidney cancer is the number of deaths for which the primary cause of death is kidney cancer in Australia. Incidence and mortality are whole numbers.

The incidence of kidney cancer has been increasing worldwide (AB 2011, [5], [6]. The reason for this is unknown, especially as there are marked geographic variations, both within the same country and between countries [6]. Further studies are necessary to improve the identification of risk factors that may lead to cancer prevention.

Some of the increase in kidney cancer incidence has been attributed to the increased use of diagnostic imaging with ultrasound, computerised tomography and magnetic resonance imaging, resulting in increased detection of renal cell carcinoma (RCC), and possibly downward stage migration. Overdetection cannot entirely explain all of these variations, especially in Europe where there exist variations within a single country with a national health care system [6]. In addition, the heterogeneity of kidney cancer incidence rates suggests the existence of modifiable risk factors and potentially unknown genetic, infective, dietary, environmental or behavioural factors that influence prevalence.

Stage migration has also been observed in the last 2–3 decades with more localized tumours being found in the modern era. There is now uncertainty regarding the optimal management of patients with small renal tumours, especially the elderly, with a greater emphasis on ablative or non-operative management [10]. Despite the frequent use of aggressive therapy, mortality rates for elderly patients with kidney cancer in the USA have remained stagnant over the past 25 years [9].

It is important for Australia to have an initial framework for understanding the current state of kidney cancer in our society, and examination of the trends in incidence, mortality and survival may allow the identification of modifiable risk factors and also guide future workforce planning. A starting point is to report the historical data, such as the Australian experience, to be able to see patterns that may help our understanding of the epidemiological differences of kidney cancer. This is particularly important given the increasing incidence rate of kidney cancer with the associated increase in health care costs.

The aim of this paper is to compare the impact of kidney cancer on various sub-populations in Australia through incidence and mortality statistics

There are two standard methods for making such comparisons. The first is by using age-standardised rates, the second is to use cumulative risks. We have reservations about both these methods.

Calculating age-standardised rates involves introducing an arbitrary, standard population. This allows us to compare the incidence rates in two populations that have different age structures. For example, the Australian Institute of Health and Welfare (AIHW) [1] provides age-standardised rates based on three, different, standard populations: the Australian 2001 population, the Sergi world standard population, and the WHO standard population—and these three rates are quite different from each other. For example, in 2012, the three age-standardised incidence rates for kidney cancer are 12.4, 8.6, and 9.4 per 100,000 persons in Australia respectively. This is confusing for the general reader.

Furthermore, if we want to compare the Australian incidence rate with the incidence rate of another country, then we may have to re-calculate the rates for at least one of the countries using a suitable standard population.

Finally, it is unlikely that, 100 years from now, we will still be using the Australian 2001 population as a standard, and to make comparisons between then and now will involve re-calculation.

The second standard method for making comparisons is based on the cumulative risk by a certain age. For example, AIHW [1] reports that the risk of being diagnosed with kidney cancer by age 75 in Australia is 1 in 101. This measure is open to misunderstanding. The model on which the calculation of this risk or probability is based on the assumption that the only cause of death is kidney cancer. This has been pointed this out in [4, p. 443], [7] and the underlying mathematical model has been explained in [8].

The age-standardised rate and the cumulative risk have the same intention: namely, to introduce a level playing field to facilitate comparing incidence (or mortality) rates in populations with different age-structures. However, both methods involve introducing assumptions that are not correct. The age-standardised rate is based on assuming that the populations have an age-structure that they do not have. The cumulative risk is based on assuming that the disease in question is the only cause of death.

The cumulative rate does not have these deficiencies. In this paper we compare the incidence and mortality of kidney cancer for various sub-populations in Australia using the cumulative rate.

2 Methods

Historical data on the incidence and mortality of kidney cancer were obtained from Australian Institute of Health and Welfare [1]. These data sets contain the incidence of kidney cancer for 1982–2012, the mortality for kidney cancer for 1968–2013, and the population counts for those years. Data are stratified by age group and sex.

The cumulative incidence rate by age 75 is calculated as follows.

Group	Age group	Population	Incidence
1	$[0, 4]$	$n(1)$	$x(1)$
2	$[5, 9]$	$n(2)$	$x(2)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
k	$[5k-5, 5k-1]$	$n(k)$	$x(k)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
15	$[70, 74]$	$n(15)$	$x(15)$

Table 1. Data for calculating cumulative rate by age 75

The cumulative incidence rate by age 75 is given as

$$a(75) = 5 * \sum_{k=1}^{k=15} (x(k)/n(k)) \ . \tag{1}$$

The cumulative rate by age 75 is, essentially, the sum of the age-specific incidence rates for each age from 0 to 75 (if we assume that the age-specific incidence rate is constant throughout any particular age group). Notice that this does not involve any arbitrary standardised population and it requires no special assumptions as does the cumulative risk. Note that the cumulative rate and the cumulative risk are approximately equal in value [8].

3 Results

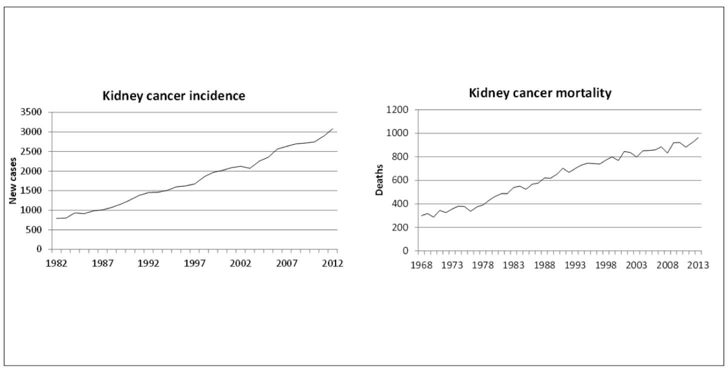

Fig. 1. Incidence (1982–2012) and mortality (1968–2012) of kidney cancer in Australia

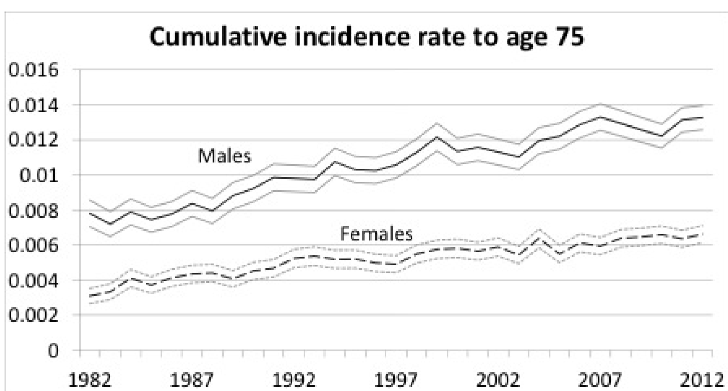

Fig. 2. Cumulative incidence by age 75 of kidney cancer in Australia

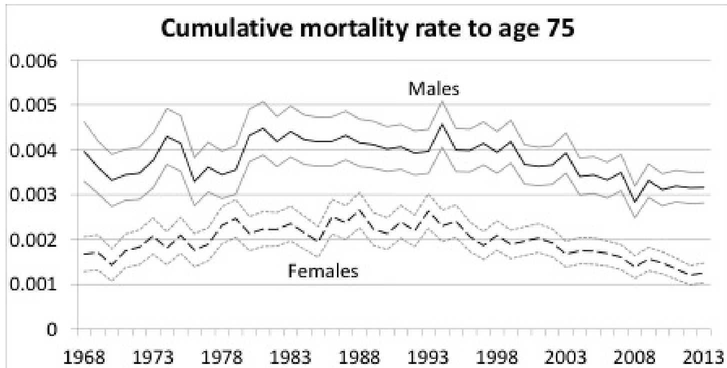

Fig. 3. Cumulative mortality by age 75 of kidney cancer in Australia

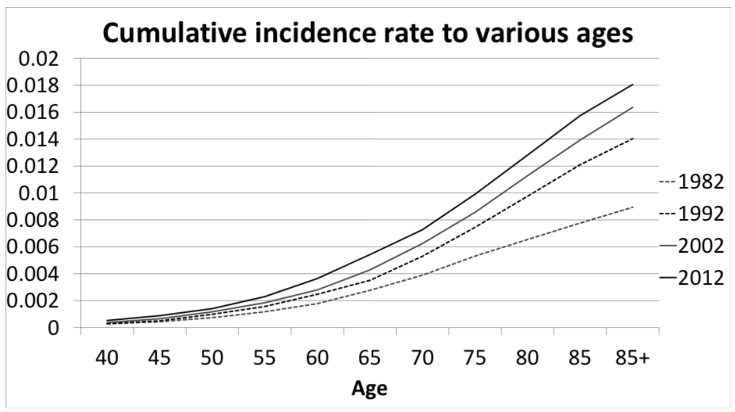

Fig. 4. Cumulative incidence for various ages of kidney cancer in Australia over several years

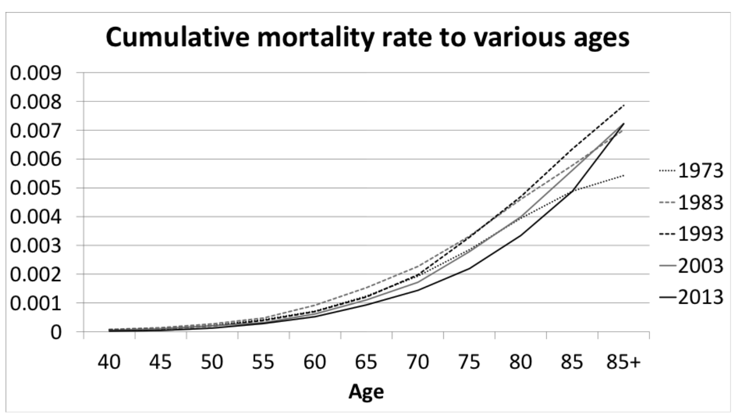

Fig. 5. Cumulative mortality for various ages of kidney cancer in Australia over several years

4 Conclusions

Acknowledgements

We thank the organisers of 4th SMTDA2016 Valletta, Malta, 1–4 June 2016, University of Malta for the opportunity to present our work. Bendigo Health is supported by the government of Victoria.

References

1. Australian Institute of Health and Welfare (AIHW). *Australian Cancer Incidence and Mortality (ACIM) Books.* Canberra: AIHW, 2016. URL: http://www.aihw.gov.au/acim-books. Viewed on 12 April 2016.
2. P. Satasivam, S. O'Neill, G. Sivarajah, A. Sliwinski, C. Kaiser, O. Niall, J. Goad and J. Brennan. The dilemma of distance: patients with kidney cancer from regional Australia present at a more advanced stage. *BJU International*, 113, Supplement 2, 57–63, 2014.
3. K.C. Chan, C.T. Lenard, T.M. Mills and Ruth F.G. Williams. Bowel cancer demographics. In: Karagrigoriou A, Oliveira T, Skiadas CH. (eds). *Statistical, Stochastic and Data Analysis Methods and Applications.* International Society for the Advancement of Science and Technology, Athens, 2015, (to appear)
4. Day N.E. A new measure of age standardized incidence, the cumulative rate. In: Payne R, Waterhouse J. (eds) *Cancer Incidence in Five Continents, Vol. III,* 443-452. IARC Scientific Publications, No. 15. International Agency for Research on Cancer, Lyon, 1976.
5. P. De, M.C. Otterstatter, R. Semenciw, L.F. Ellison, L.D. Marrett, and Dryer D. Trends in incidence, mortality, and survival for kidney cancer in Canada, 1986–2007. *Cancer Causes & Control*, 25(10), 1271–1281, 2014.
6. P. Li, A. Znaor, I. Holcatova, E. Fabianova, D. Mates, M.B. Wozniak, J. Ferlay, and G. Scelo. Regional geographic variations in kidney cancer incidence rates in European countries. *European Urology.* 67(6), 1134–1141, 2015.
7. C.T. Lenard, T.M. Mills, and R.F.G. Williams. The risk of being diagnosed with cancer. *Australian & New Zealand J. Public Health*, 37, **5**, 489, 2013.
8. C.T. Lenard, T.M. Mills, and R.F.G. Williams. Cumulative incidence rates of cancer. *The Mathematical Scientist*, 39, **2**, 83–89, 2014.
9. M. Sun, A. Becker, Z. Tian, F. Roghmann, F. Abdollah, A. Larouche, P.I. Karakiewicz, and Q.D. Trinh. Management of localized kidney cancer: calculating cancer-specific mortality and competing risks of death for surgery and nonsurgical management. *European Urology*, 65(1), 235–241, 2014.
10. H.J. Tan, C.P. Filson, and M.S. Litwin. Contemporary, age-based trends in the incidence and management of patients with early-stage kidney cancer. *Urologic Oncology*, 33(1), 21.e19–21.e26, 2015.
11. V. Thursfield and H. Farrugia. *Cancer in Victoria: Statistics & Trends 2014*. Cancer Council Victoria, Melbourne 2015.
12. G. Udny Yule. On some points relating to vital statistics, more precisely statistics of occupational mortality. *Journal of the Royal Statistical Society*, 97, **1**, 1–84, 1934.