Updated New Zealand health system cost estimates from health events by sex, age and proximity to death: further improvements in the age of 'big data'

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ABSTRACT

AIMS: We aimed to: (i) update previous health system cost estimates (Blakely et al *NZMJ* 2014;127(1393)) using updated costing data and more refined methods; and (ii) provide context around current developments in the improved networking of health information systems in New Zealand.

METHODS: As per our previous work, national health event data were linked for hospitalisations, inpatient procedures, outpatient events, pharmaceuticals, laboratory tests, and primary care consultations for the whole country. For each health event a cost was assigned. Health expenditure by sex and age, and proximity to death (last 6 or 12 months of life), was then calculated.

RESULTS: The updated and more accurate method allocated lower amounts of total public health expenditure than the previous work: $6.1, $6.0 and $6.7 billion dollars (inflation-adjusted to 2011 NZ$) in 2007/08, 2008/09 and 2009/10 financial years, respectively. But the latter is still only 52% of total health system costs ($6.7/$12.98 billion). Health system costs for people not within six months of death were similar to the previous work, except for being reduced in the most elderly age groups (range: $495 per person-year in 10–14 year old females; to $5,239 per person-year in 85–89 year old males). Costs in the last six months of life remained highly variable by age group (by a factor of 14 and being maximal at $23,400 or more among 1–4 year olds). The proportion of cumulative health expenditure in the last year of life declined with increasing age of death: eg, 47%, 25%, 13% and 6% for individuals aged 40, 70, 80 and 90 respectively.

CONCLUSIONS: Health system costs vary markedly across the life course, and are skewed to the last year of life. This analysis has benefited from quality improvements in cost data and method refinements, but further improvements in coming years are likely. This is particularly so with access to additional data sources, and with the move towards better integration of "big data" in the New Zealand health sector.

We have previously published, in this journal, estimates of health system costs by sex, age and proximity to death, using rich New Zealand data ('Health Tracker').[1] Since then, there have been substantial improvements with the data sources, and 'learnings' about the reliability of various facets of the data. Also, improvements to the allocation of person-time and timing of cost occurrence have been developed. For example, standard treatment of health costings assigns individuals to the date of discharge, a practice which is not problematic for short-stay events, but is problematic for long-stay events (eg, multi-year admissions to hospital-level care leading to death) if all that cost is then attributed to the last year (or last six months) of life. Additionally, we have identified an error in our previous calculations of person-time which impacted on first year of life and last year (and six months) of life costings.

Given all these changes, our primary aim in this paper was to present updated results for all the objectives and analyses in the previously published article, namely: to estimate health system costs by demographics; for people within and not within six or 12 months of death; to estimate what proportion of health system costs over a person's life occur in the last year of life; and to determine how much impact using costs stratified by proximity to death has on future national health expenditure projections (in the face of population growth, aging and increasing longevity).

Our second aim was to provide additional context to the current developments in access to health data in New Zealand. Third, we aimed to outline the next steps to further improve the quality of New Zealand health system costing data for research.

By way of background, we note that 83% of all health system expenditure in New Zealand is estimated to be publically funded,[2] with many of the health events (eg, hospitalisations and outpatients) not involving any fee-for-service. The remainder of the costs are private and include out-of-pocket payments and co-payments in primary care and for health insurance. There is growing research interest in understanding health system costing at the national level in New Zealand (eg, for all costs[1] and for cancer costs[3]), but also at the district health board (DHB) level (eg, Chan et al[4]).

Methods

We repeat below the basic methods detailed in our previous paper analysing cross-sectional health system cost data (albeit with some minor changes) and follow this with a list of more substantively updated and refined methods.

Linked administrative health care datasets with costs attributed

The New Zealand health system has had a unique identifier of high quality since about 1990 (the National Health Index [NHI], identifier). The following datasets were linked using a unique identification number based on the NHI identifier to create a record for each New Zealander of all publically funded health care events (eg, hospital admission, and laboratory test) occurring from July 2007 to June 2012. However, only the actual 2007/08 to 2009/10 financial years were used to estimate the costs, a restriction for two reasons. First, it is necessary to discard the most recent year of data for costs, as it is not possible to 'know' whether someone is within a year of death. Second, it became apparent that for earlier and later years, data were not complete on all health events and costs.

Each health event was then assigned a cost weight or unit price: casemix-funded hospitalisations (using Ministry of Health cost weights per event[5]; primarily medical/surgical events); community laboratory tests; non-admitted patient events (eg, outpatients and emergency departments); community pharmaceuticals dispensed (including patient contribution); expected general practice costs (ie, using the capitation funding formula) and some actual general practice consultations (when not an enrolled patient in a capitated practice (ie, the general medical subsidy)). Goods and sales taxes were excluded as this is a transfer payment. All costs were inflation-adjusted to 2011 New Zealand dollars.

Data not (as of early 2015) included in our Health Tracker analysis included: lead maternity carer-provided care; rest-home and hospice care; mental health care; dental health care outside of hospitals; patient transport (eg, National Travel Assistance); care directly funded by Accident Compensation Corporation (ACC); and community physiotherapy. For the purposes of our objectives, missing rest-home and hospice care means costs proximal to death will be underestimated (although these data should become accessible for research in coming years; see Discussion).

Data management and person-time allocation

We used tabular analyses on the 2007/08 to 2009/10 data, calculating summed and average costs per person-year in each strata of interest: sex by five-year age group by financial year (2007/08, 2008/09, 2009/10) and whether within six or 12 months of death or not. We censored people at death. Immigration data were not linked in with these files, preventing correct censoring for emigration, but data were restricted to individuals who were both listed as a New Zealand resident on the NHI, and had a record in at least one of the data sources used (including being enrolled with a primary health organisation) in the particular financial year. Finally, we calculated person-time weighted average costs over 2007/08 to 2009/10.

Estimating future health expenditure

We assembled Statistics New Zealand (SNZ) population count projections from 2011 to 2041 for the median growth scenario, for males and females by five year age-group (using the table builder at: http://www.stats.govt.nz/). The total population is projected to increase by 25% over these 30 years, but by over 150% for ages 75 and older. We then estimated future sex by age-specific mortality rates, by applying a 2% per annum mortality rate reduction to the single year of age mortality rate from the 2010–12 SNZ life-tables. (A 2% per annum mortality rate reduction equates to gains of 2.5 years in life expectancy per decade seen in recent decades in New Zealand, a pattern that seems likely to continue[6]).

We also undertook sensitivity analyses using SNZ projected mortality counts and rates with death data obtained from the projection from 2011 (base year) to 2061.[7] (These SNZ projections equate to 1.3% (85–89 year old males) to 3.4% (55–59 year old males and females) annual percentage changes in mortality rates, for 35+ year olds.) We then applied health system costs for health events per person-year, both 'simplistically' using health system costs observed in 2009–11 not stratified by proximity to death, and then using costs separately for people within six or 12 months of death. We did not add in any trend data for changes in either health service usage by age-group or changes in health costs over time given the very large uncertainties involved. For example, for the latter there is uncertainty around the future ability of PHARMAC to keep constraining costs of pharmaceuticals, vaccines and devices; and also the variable potential performance of the New Zealand economy (which provides the resources to fund health services), given its dependence on commodity prices for exports and on international tourism levels.

Updated data and methods since the previous analyses

Since the previous analyses,[1] we made a number of data and methods enhancements. These are detailed in full in the Appendix, but include: the use of financial years instead of calendar years; a revised core population of New Zealand residents; more accurate allocation of costs by timing; revised restrictions when considering casemix funding; changes to the cost weight used for the calculation of hospitalisation costs; along with a number of other fairly minor improvements.

Results

The health system costs associated with individual health events included in Health Tracker in 2011 NZ$, summed to $6.1, $6.0 and $6.7 billion in 2007/08, 2008/09 and 2009/10 financial years, respectively. But the latter still remained only 52% of total health system costs (6.7/12.98 billion). Pooling these years, the per person-year costs by sex, age and proximity to death are shown in Table 1 and Figure 1. Costs per person-year disregarding proximity to death varied approximately 10-fold from $535 for 10–14 year olds (sexes combined) to $5,600 for 85–89 year olds (Table 1).

The median values for the 21 age groups, regardless of proximity to death, were $1,518 per year for males and $1,457 per year for females. Removing person-time for people within six or 12 months of death did not alter these costs much at young ages (due to death being rare), but did quite considerably reduce the costs among the very old. For example, the cost per person-year among 90–94 year olds (sexes combined), regardless of proximity to death, was $5,600, but was reduced to $4,629 if not in the last six months of life.

Considering the assigned costs among people within six months of death, these costs varied only three-fold between age groups (in the under 95-year-old population). That is, there was less percentage or relative variation by age in costs during the last six months of life. A similar pattern was apparent also for costs in the last 12 months of life (Table 1).

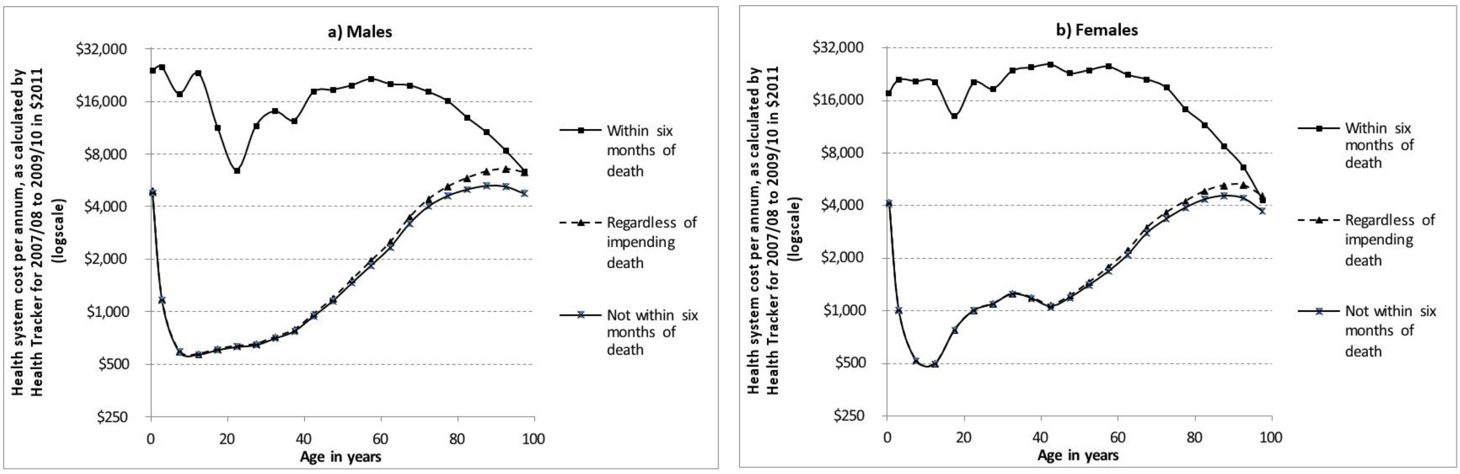
Differences in costs over the life course between males and females showed a

Table 1: Estimated health system costs attributable to specific health events for New Zealand citizens from Health Tracker (per person-year and per death event during 2007/08 to 2009/10, in 2011 NZ$ inflation-adjusted values).*

	Per person-year									Per death					
Age group in years	**Regardless of proximity to death**			**Not in the last 6 months of life**			**Not in the last year of life**			**In the last 6 months of life**			**In the last year of life**		
	Female	**Male**	**Both sexes**	**Female**	**Male**	**Both sexes**	**Female**	**Male**	**Both sexes**	**Female**	**Male**	**Both sexes**	**Female**	**Male**	**Both sexes**
<1	4,189	**4,890**	4,550	4,116	4,766	**4,451**	4,102	**4,751**	4,437	17,662	**24,092**	21,311	21,074	**27,170**	24,534
1–4	1,009	**1,166**	1,089	1,003	1,158	**1,083**	1,001	**1,155**	1,080	21,082	**25,138**	23,367	28,748	**33,087**	31,193
5–9	517	**589**	554	515	587	**552**	513	**586**	551	20,556	**17,521**	18,915	37,616	**23,554**	30,011
10–14	498	**569**	535	495	565	**531**	493	**563**	529	20,396	**23,311**	21,970	31,407	**38,236**	35,096
15–19	**777**	609	692	773	**601**	686	**772**	597	683	**12,965**	11,213	11,774	**16,238**	16,161	16,185
20–24	**1,006**	632	824	1,000	**626**	818	**998**	624	816	**20,219**	6,397	10,149	**26,445**	8,516	13,383
25–29	**1,096**	650	891	1,090	**641**	883	**1,087**	636	880	**18,557**	11,565	14,106	**26,119**	17,277	20,490
30–34	**1,253**	713	1,008	1,243	**701**	997	**1,239**	694	992	**23,670**	14,029	17,524	**34,263**	21,253	25,970
35–39	**1,193**	784	1,004	1,175	**769**	988	**1,164**	764	980	**24,714**	12,386	17,515	**39,219**	17,035	26,265
40–44	**1,079**	964	1,025	1,051	**936**	997	**1,039**	923	985	**25,713**	18,107	21,431	**37,511**	26,732	31,443
45–49	**1,221**	1,186	1,205	1,187	**1,144**	1,166	**1,168**	1,123	1,147	**22,857**	18,613	20,391	**35,249**	27,977	31,023
50–54	1,457	**1,518**	1,486	1,400	1,449	**1,424**	1,369	**1,418**	1,392	**23,892**	19,757	21,511	**37,070**	29,280	32,584
55–59	1,777	**1,944**	1,859	1,681	1,830	**1,754**	1,635	**1,772**	1,702	**25,000**	21,488	22,996	**37,233**	32,873	34,745
60–64	2,219	**2,489**	2,351	2,089	2,319	**2,201**	2,030	**2,237**	2,131	**22,392**	20,070	21,034	**33,065**	30,305	31,450
65–69	2,985	**3,450**	3,211	2,788	3,175	**2,976**	2,693	**3,064**	2,874	**21,067**	19,747	20,290	**31,843**	28,553	29,907
70–74	3,640	**4,393**	3,999	3,350	3,994	**3,657**	3,226	**3,812**	3,504	**18,948**	18,070	18,443	**28,002**	27,270	27,581
75–79	4,234	**5,177**	4,669	3,893	4,589	**4,213**	3,769	**4,386**	4,051	14,244	**16,012**	15,251	20,585	**22,892**	21,899
80–84	4,834	**5,791**	5,238	4,344	4,989	**4,615**	4,199	**4,729**	4,420	11,606	**12,900**	12,277	16,517	**18,504**	17,548
85–89	5,213	**6,318**	5,600	4,551	5,239	**4,790**	4,384	**4,926**	4,570	8,773	**10,620**	9,541	12,521	**15,131**	13,607
90–94	5,241	**6,537**	5,600	4,413	5,204	**4,629**	4,248	**4,897**	4,422	6,626	**8,348**	7,178	9,417	**11,729**	10,158
95+	4,533	**6,238**	4,902	3,712	4,738	**3,930**	3,647	**4,442**	3,814	4,283	**6,345**	4,770	5,952	**8,791**	6,623

Notes: Bolded values show the higher costs when comparing females relative to males and vice versa.
*But due to current data limitations this is still for only 52% of total health system costs ($6.7/$12.98 billion), see Discussion.

Figure 1: Estimated health system costs attributable to specific health events for New Zealand citizens during 2007/08 to 2009/10, disregarding proximity to death, and separately for within and not within six months of death.*

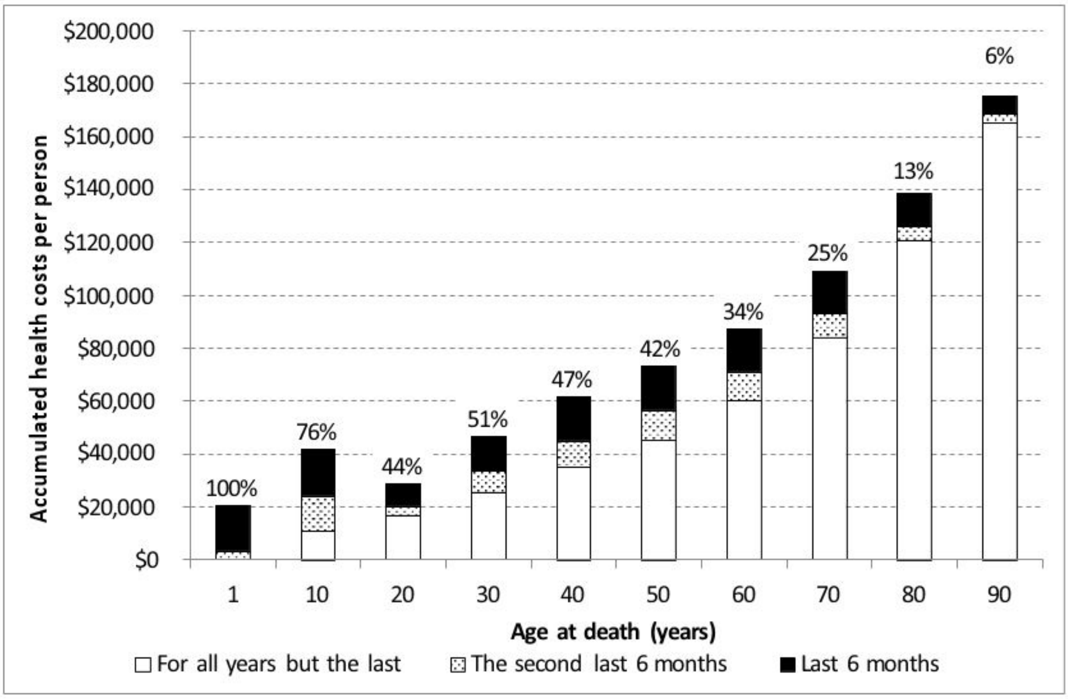


*But due to current data limitations this is still for only 52% of total health system costs ($6.7/$12.98 billion), see Discussion.

mixed picture (Table 1). Costs were higher for males up to age 15 years, then costs were higher for females up to age 50 years (no doubt partly due to obstetric- and women's health-related costs). There were quite large sex differences in costs in the last six months of life (often higher in females). This probably reflects higher incidence rates of sudden death in males without preceding chronic illnesses (eg, occupational injuries and suicide).

To indicate the distribution of costs at different points in the life course, Figure 2 presents the cumulative health system costs (in 2011 NZ$) for deaths at different ages. This analysis is artificial as it assumes a steady state (as per 2011) for life span, treatment effectiveness and costs throughout the life course with no discounting. (This 'artificiality' is, however, similar to the way period life expectancy is calculated, whereby mortality rates

Figure 2: Estimated cumulative health system costs from specific health events for New Zealand citizens (in 2011 NZ$) for deaths at different ages (see text for simplifying assumptions). Labels above each bar show the percent in last year of life.*



* But due to current data limitations this is still for only 52% of total health system costs ($6.7/$12.98 billion), see Discussion.

observed at one point in time are assumed to apply to a synthetic population over their lifetime.) Even so, these results give some indication of how the proportion of assigned health expenditure in the last year of life declines as the age at death increases, eg, 76% for death at age 10 years, 42% at age 50 years, 25% at age 70 years, 13% at age 80 years, and 6% at age 90 years.

Table 2 shows the estimated future health system costs with and without accounting for proximity to death (both 6- and 12-month scenarios), and for the 'simplistic' scenario of ongoing 2% per annum reduction in mortality rates into the future for all sex by age groups and the more sophisticated SNZ estimates of mortality counts and rates.

Figure 3 shows these results for the period of 12 months proximal to death and the 2% per annum reduction scenario. It is important to note that these estimated future health system costs are only based on: expenditure as captured by assigned health events (the total health spending is more than this individually-linked data—see the Methods and Discussion sections); demographic projections (eg, productivity and expectation trends are not included). Thus, interpretation should be more on the relative patterns, not the absolute dollar amounts.

Regardless of the scenario, not accounting for proximity to death overestimates these future health system costs. That is, not allowing for deaths in the future being 'pushed out more' to older ages resulted in overestimated costs. This overestimate was by 1.3% to 4.5% by 2041, depending on scenario.

Discussion

What is new about these updated results?

This current work has produced updated values for all of the analyses in our previous study published in this journal.[1] The general patterns are similar to that previously published, with two exceptions. Firstly, the costs being studied within the last six months of life now decline from around age 60 years for both sexes (rather than continuing to increase with age as suggested previously; Figure 1). Secondly, the costs regardless of impending death now plateau in the 80+ age-group (rather than continuing to increase; Figure 1). These new results arise from the methods improvements around attributing costs proximal to the time of death (see Methods).

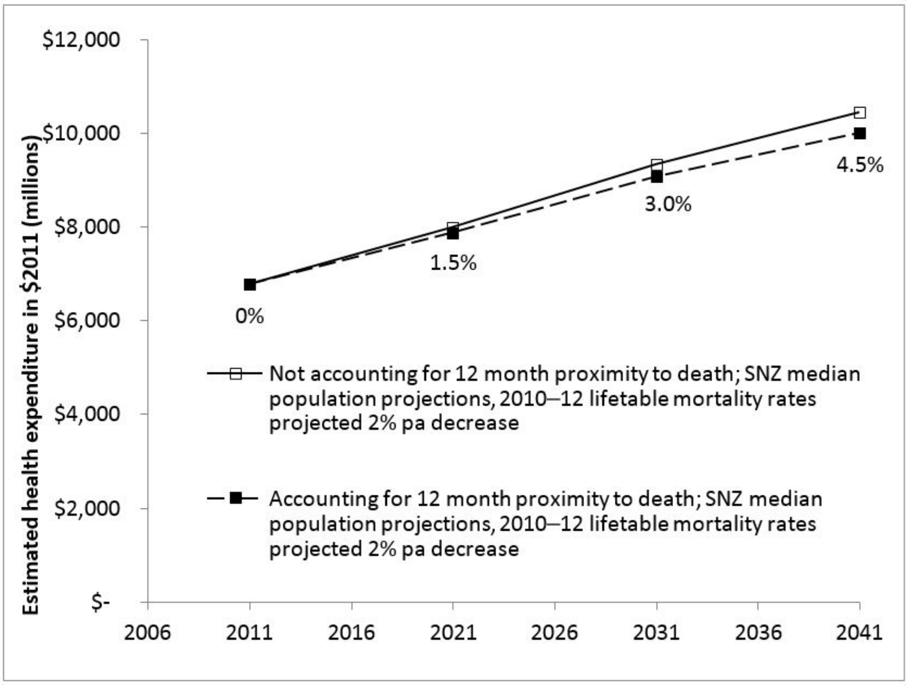
These results are also more consistent with our knowledge of how the health system in New Zealand typically operates

Table 2: Estimated future health system costs* (in 2011 NZ$ million) for the total New Zealand population with and without accounting for proximity to death, for varying scenarios of future mortality rates and six versus 12-month proximity to death.

	2011	2021	2031	2041
a. Assuming 2% per annum reduction in mortality rates uniformly for all sex by age groups				
i. By 6-month proximity to death				
Accounting for proximity to death	6,569	7,690	8,907	9,878
Not accounting for proximity to death	6,569	7,725	8,988	10,009
% overestimate due to not accounting	0.0%	0.5%	0.9%	1.3%
ii. By 12-month proximity to death				
Accounting for proximity to death	6,767	7,866	9,056	9,986
Not accounting for proximity to death	6,767	7,982	9,327	10,432
% overestimate due to not accounting	0.0%	1.5%	3.0%	4.5%
b. Assuming SNZ projected future mortality rates uniformly by sex by age groups				
i. By 6-month proximity to death				
Accounting for proximity to death	6,568	7,683	8,896	9,862
Not accounting for proximity to death	6,568	7,721	8,981	9,992
% overestimate due to not accounting	0.0%	0.5%	1.0%	1.3%
ii. By 12-month proximity to death				
Accounting for proximity to death	6,764	7,854	9,043	9,987
Not accounting for proximity to death	6,764	7,978	9,321	10,418
% overestimate due to not accounting	0.0%	1.6%	3.1%	4.3%

* But due to current data limitations this is still for only 52% of total health system costs ($6.7/$12.98 billion) in 2011, see Discussion.

Figure 3: Estimated future health system costs (in 2011 NZ$) for the total New Zealand population. Labels are percentage overestimates when not accounting for proximity to death.



Note: Using 2007/08 to 2009/10 data for health system costs for health events from Health Tracker (Table 1), inflation- adjusted to 2011 NZ$. Mortality rates in 2011 sourced from Statistics New Zealand (SNZ) 2010–12 official life-tables, with age-specific mortality rates reduced by 2% per annum into the future. As noted elsewhere, this analysis is still for only 52% of total health system costs.

ie, less intensive provision of health services for the very old for whom such interventions as major surgery might be less appropriate and in some cases for whom palliative care might be the service being provided.

Updated consideration of study limitations

Researchers and policymakers can have confidence about the general patterns suggested by these results, but they should remain particularly cautious about the accuracy of all the specific values reported in this study. Furthermore, some of our analyses (as shown in Figure 2), involve assumptions eg, a steady state in costs throughout the life course (which is in contrast to the historical pattern of increases in health costs in high-income countries). Below we provide an updated list of the other major limitations with these cost estimates identified to date:

1. Using the linked administrative datasets in Health Tracker, $6.7 billion (2011 inflation adjusted NZ$) of almost exclusively Government health expenditure was attributed to individual patient events in 2009. But this is still only just over half (52%) of the combined Vote:Health ($12.98 billion, nominal) appropriation in 2009–10. One reason is that we have restricted hospitalisation costs to only those that are casemix-funded (as detailed earlier). Also, important components of Vote:Health expenditure are not yet available to us, including data on maternity care, immunisation, cervical screening, specific programmes (eg, diabetes care improvement package, performance-related payments), and more importantly for this study, Disability Support Services and other funding covering rest home and palliative care. The latter will have resulted in us underestimating some of the near-end-of-life costs. Nevertheless, due to capital and 'back office' expenditure on administration, not all of Government funding can readily be attributed to individual patient events (eg, over 10% of public funding goes to prevention and public health services, and health administration[2]).

   That said, this Health Tracker dataset is an extremely rich dataset for analyses, and will continue to improve in the future. As examples, it is already contributing data for other work by the National Health Committee on a high-level scan of health spending in order to select domains of health service use for further work on prioritisation,[8] and for Treasury projections of future health expenditure.[2]
2. Primary care costs are very simply assigned on a per capita basis (considering age, sex and ethnicity) to the New Zealand population using the country's health system's capitation formula. Therefore, our analyses will tend to underestimate costs near death if primary care utilisation increases near death. But, given that primary care expenditure is not a large component of end-of-life care in New Zealand,[4] this probably would not cause much of an underestimation in the costs in the last six months of life.
3. Current Health Tracker data also include very little privately funded health expenditure. But, given that 83% of all health system expenditure is estimated to be publically funded in New Zealand,[2] this limitation is not too severe.
4. This study did not estimate costs by ethnicity, since it seems likely that any such cost differences will be due to conflated differences in need, access and utilisation of health services, and as such requires separate and careful analysis and interpretation. But, given the importance of health inequalities in New Zealand society, this should be a priority area for future work.
5. Many of the datasets used in this analysis use 'prices' that are potentially charged by agencies to funding bodies and which do not necessarily represent the actual cost of the health event. For example, many community lab contracts are bulk-funded and so the prices are only indicative and potentially have not been updated for a number of years. This pricing issue

may mean that true costs are actually higher where costs go up, but where prices charged stay the same and become out-of-date. But if lower costs are achieved (eg, from operational efficiencies obtained) then prices charged might be sometimes higher than the true costs.

6. Our modelling around future health costs does not fully address any future compression or expansion of morbidity that is not captured directly by proximity to death. Further details of this are in the Appendix.

What is the context for further developments?

While we have made use of Health Tracker in this study, we have also been considering big picture issues for the New Zealand health system.[6] One of us (TB) has been engaged in national- level 'big data' and health systems discussions. We are also aware that DHB level interest in 'big data' is growing (eg, Counties Manukau DHB has been using Ministry of Health data to inform health service and policy development for a number of years, see: http://www.countiesmanukau.health.nz/about-us/performance-and-planning/health-status-documents/).

But now there is a likely imminent step-change in data access occurring in New Zealand, with moves to place routine health data (eg, mortality, hospitalisation, laboratories, etc) linkable via the NHI into the SNZ Integrated Data Infrastructure (IDI).[9] In the last decade, research groups such as PREDICT/VIEW at the University of Auckland (https://www.fmhs.auckland.ac.nz/en/soph/about/our-departments/epidemiology-and-biostatistics/research/view-study/research.html; accessed 11 February 2015) and BODE[3] at the University of Otago (www.otago.ac.nz/bode3; accessed 11 February 2015) have received copies of multiple routine administrate health datasets for their dedicated research purposes—what is sometimes called 'bespoke' linkage. But in the age of 'big data',[10] research productivity can be enhanced (and duplication and errors minimised) by allowing researchers easier and fuller access to fully integrated data. Successful international examples of this move from 'bespoke' to 'fully integrated and wider access', include the "ScottisH Informatics Programme (SHIP)" (http://www.scot-ship.ac.uk/) and the Ontario Institute for Clinical Evaluation Sciences (http://www.ices.on.ca/). The New Zealand Ministry of Health has already migrated health data to the SNZ IDI, and is working through the feasibility of placing most national health data collections in the IDI to facilitate research (personal communication, Jackie Fawcett, Ministry of Health, December, 2014). To support this initiative, a Virtual Health Information Network (VHIN) has been established with joint membership of university academics and public sector researchers. One of the goals of the VHIN is to encourage sharing of knowledge about health data (eg, metadata) and analytical approaches (eg, rationale of the methods, definitions, cross-checking with clinicians, data management and analysis code) between researchers in a collaborative model that enhances the productivity and accuracy of New Zealand health research using routine data. Formal structures for such a VHIN are evolving (eg, health researchers using the IDI may be strongly encouraged, or even required, to make available to other researchers their programing code).

What all these developments mean is improvements in the type of analysis presented in this article are imminent—and will allow for both improved research by New Zealand researchers and more nuanced decision-making by policy makers and planners.

Regarding cost data specifically, we foresee two parallel streams to improve the quality of data for modelling in the next five years. First, the 'bottom-up' costing in this paper can be complemented by allocating remaining Vote:Health (and Vote:ACC) across individuals under plausible scenarios. For example, taking the total maternity care budget, and allocating it across woman pro-rata to age-specific birth rates. Second, and a 'longer-term' option which should replace the previous blended 'bottom-up' and 'top-down' approach, is to continue to work on the individual-level data and costing rules, and 'liberate' them for researcher use (cost models are already in use within the Ministry, for example)—perhaps through the SNZ IDI and VHIN.

Conclusions

Health system costs are large in New Zealand, vary across the life-course, and are skewed to the last year of life (eg, around 25% of costs being in the last year of life of a 70-year-old). This analysis has benefited from quality improvements in cost data and methods refinements relative to the previously published work on health costs in New Zealand. Nevertheless, the patterns in the costs are largely unchanged from previously—except the decline in some costs with age among older New Zealanders. Furthermore, we show (as before) that projections of future health system expenditure are slightly overestimated when not accounting for proximity to death in costs.

Further health data improvements in coming years are likely with access to additional data sources (eg, from Disability Support Services) and as New Zealand continues to move towards better integration of 'big data' in the health sector. It is often said that "New Zealand has some of the best health data in the world". The goal now should be to better harness these data for informing policy and undertaking world-class research, matching and even exceeding the potential realised in other jurisdictions such as Scotland and Ontario.

Appendix: additional methods details

Updated data and methods since the previous analyses

Since the previous analyses,[1] the following data and methods enhancements were performed:

1. **Years covered:** The financial years 2007/08, 2008/09 and 2009/10 are now used instead of calendar years 2007, 2008, 2009.
2. **Core population:** A revised core population of New Zealand residents was used. Previously the population inclusion criteria was broader and included those not listed as New Zealand resident if they had health system records with points of contact three or more months apart in any one year (including enrolment with a primary health organisation).
3. **Cost allocation:** More accurate allocation of costs by timing was performed. That is according to usual 'administrative' practice, costs were previously assigned to the end date of an event regardless of duration of event. That led to skewed costs in the last six months of life. In the current analyses, we re-allocated costs evenly over the duration of each event in time.
4. **Use of casemix-funding:** Another modification was made after more exhaustive examination of the input datasets. Hospitalisation costs were restricted to casemix-funding only as cost weights applied to non-casemix-funded events are unlikely to accurately reflect the true (opportunity) cost to the New Zealand health sector. Furthermore, without this restriction there was a risk of double counting the costs of some events where they appear in two datasets (eg, emergency department events in the National Non Admitted Patients Collection and those in the NMDS). We therefore decided to only allocate costs to those events that we have high confidence in: casemix-funded hospitalisations; community laboratory tests; non-admitted patient events (eg, outpatient and emergency department events); community pharmaceuticals dispensed (including patient contribution); general practice consultations (both that calculated based on the capitation funding formula routinely used in New Zealand, and fee-for-service when not an enrolled patient in a capitated practice). Restricting to these files resulted in around 50% of all Vote:Health funding being allocated to event-based expenditure. The 'missing' 50% includes the files not yet linked (maternity, rest-home, community mental, dental and physiotherapy care; see above) and inpatient events excluded from casemix-funding (which include but are not limited to

inpatient mental health events; events directly funded by ACC; events where the admitted person was a boarder; cancelled treatments; some transplant events; some spinal injuries; some same day chemotherapy for cancer events; some same day lithotripsy, colposcopies, cystoscopies, colonoscopies, gastroscopies, and bronchoscopies; and some same day blood transfusions).

5. **Calculation of hospitalisation costs:** In addition to the exclusion of non-casemix-funded hospitalisations, the cost weight used for the calculation of hospitalisation costs changed from using one cost weight for all years, to using the cost weight used for funding in the specific financial year (ie, a different cost weight for each year, along with the appropriate year's unit price). The reasons for this were pragmatic, but also because it reflects how events were actually costed that year.
6. **Other improvements:** A number of other fairly minor improvements were made (eg, with the calculations of PHO data), the details of which are available from the authors on request.

The SAS code used in our analyses is available by contacting the authors (if not available on our website: http://www.otago.ac.nz/bode3).

Compression or expansion of morbidity: implications for modelling of future costs

Our modelling around future health costs does not fully address any future compression or expansion of morbidity that is not captured directly by proximity to death. For example, the diabetes epidemic may increase morbidity (and demand for health services) if our society is less successful at reducing incidence than we are at keeping people alive with diabetes, thereby seeing an expansion in morbidity (diabetes disease severity held constant, and likewise other causes of morbidity held constant). Conversely, if New Zealand society successfully controls obesity trends, this may reduce morbidity prevalence (through diabetes, but also cardiovascular disease, musculoskeletal and other impacts). Determining past trends in compression or expansion in morbidity is challenging,[11,12,13] let alone estimating future trends. That said, we suggest that one method to include in future expenditure projections is to use disability-adjusted life expectancy (DALE; as estimated in the recent New Zealand Burden of Disease study[14]), assume the same ratio of DALE to life expectancy (DALE:LE) in the future, and then back estimate by what percentage the prevalent years of life lived with disability (pYLDs) would need to change in the future to keep the DALE:LE ratio constant (or whatever other ratio is considered plausible). The percentage change in pYLDs across all sex by age groups necessary to generate the desired DALE:LE ratio in the future can then be used as a proxy for morbidity change, and therefore rescaling of the costs not within the last six or 12 months of life shown in Table 1.

Competing interests: Nil

Funding:

The Burden of Disease Epidemiology, Equity and Cost-Effectiveness Programme is funded by the Health Research Council of New Zealand (10/248).

Acknowledgment:

Access to Health Tracker data was provided by the Ministry of Health. In particular, we acknowledge the efforts and foresight of Craig Wright in initially assembling the data and managers within the Ministry who had the foresight to ensure this data source was created and made available. We thank Bronwyn Croxson and Dr Wing Cheuk Chan for helpful comments on early versions of this work and the two anonymous journal reviewers for very helpful comments.

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www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2015/vol-128-no-1422-25-september-2015/6662

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