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RESEARCH

Trends in cause specific mortality across occupations in Japanese men of working age during period of economic stagnation, 1980-2005: retrospective cohort study

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Abstract

Objective To assess the temporal trends in occupation specific all causes and cause specific mortality in Japan between 1980 and 2005.

Design Longitudinal analysis of individual death certificates by last occupation before death. Data on population by age and occupation were derived from the population census.

Setting Government records, Japan.

Participants Men aged 30-59.

Main outcome measures Age standardised mortality rate for all causes, all cancers, cerebrovascular disease, ischaemic heart disease, unintentional injuries, and suicide.

Results Age standardised mortality rates for all causes and for the four leading causes of death (cancers, ischaemic heart disease, cerebrovascular disease, and unintentional injuries) steadily decreased from 1980 to 2005 among all occupations except for management and professional workers, for whom rates began to rise in the late 1990s ($P<0.001$). During the study period, the mortality rate was lowest in other occupations such as production/labour, clerical, and sales workers, although overall variability of the age standardised mortality rate across occupations widened. The rate for suicide rapidly increased since the late 1990s, with the greatest increase being among management and professional workers.

Conclusions Occupational patterns in cause specific mortality changed dramatically in Japan during the period of its economic stagnation and resulted in the reversal of occupational patterns in mortality that have been well established in western countries. A significant negative effect on the health of management and professional workers rather than clerks and blue collar workers could be because of increased job demands and more stressful work environments and could have eliminated or even reversed the health inequality across occupations that had existed previously.

Introduction

During the past half century Japan has achieved considerable success in population health.[1] Since 1986, the country has ranked first internationally in female life expectancy at birth.[2] A primary driver of this prolonged life expectancy could be strong socioeconomic development, the achievement of universal healthcare coverage, improved diet, and changes in health behaviour.[1 3] Japan's strong economic growth, however, stopped in the 1990s after its "bubble economy" collapsed, and in 1998, triggered by the Asian financial crisis and a series of bankruptcies among big finance firms, Japan experienced the first negative economic growth in its postwar history.[4] Over the past two decades, the Japanese economy has been basically stagnant. The unemployment rate, still lower than that in other

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Appendix 1: Occupational classification and specific occupations from Japanese vital statistics
Appendix 2: Supplementary tables (A-C)

developed countries, rose from 2.0% in 1991 to 5.5% in 2003.[5] The easing in employment contract regulations in the late 1990s increased the proportion of non-regular workers among male employees from 9% in 1991 to about 19% in the late 2000s.[5]

There is an ongoing debate about Japan's unstable labour market, including concerns about increased unemployment, job insecurity, and widening social disparities and income inequality.[6] The relatively poorer performance of life expectancy in Japanese men in recent years, compared with women, could be attributable to these rapid changes in the labour market, most remarkably symbolised by the record high male suicide rate since 1998.[7 8] We analysed the temporal trends in occupation specific, all cause, and cause specific mortality among Japanese men aged 30-59 in the three decades from 1980 to 2005, when Japan experienced an economic expansion followed by its most serious postwar economic crisis.

Methods

Data sources

We obtained individual death certificates from the occupation specific vital statistics recorded by the Ministry of Health, Labour, and Welfare, Japan from 1980 to 2005.[9] Every five years, in the same year as the national population census, the government collects information on occupation as well as cause of death from death certificates submitted to the local government by the family of a person who had died.[10] To calculate occupation specific death rates, we also obtained information on occupation specific populations from the national population census, which is implemented at five year intervals on 1 October.[11] Following relevant studies,[12 13] we used data only on men because of the poor reliability of the information on occupations for women. In Japan, women are more likely to work on a part time or a non-regular basis (range 44-53% of total workers in 2007), and 27% of married women were full time homemakers in 2000.[11]

Measurements

Data on the death certificate include the underlying cause of death, filled out by physicians and based on the sequence of morbid events leading to death and coded according to ICD-9 (international classification of diseases, ninth revision, 1980-90) and ICD-10 (10th revision, 1995-2005).[14 15] Some codes were inappropriate for analysis of cause of death or were ill defined (such as heart failure) and were redistributed to be comparable and consistent across data by using an algorithm developed by Naghavi and colleagues.[16] Occupations were classified into 10 categories: professional and engineering (hereinafter professional); management; clerical; sales; services; security services (security); agriculture, forestry, and fisheries (agriculture); transportation and communication (transportation); production and labour work (production/labour); and unemployed. We used the International Standard Classification of Occupations to create these categories.[17 18] In the years when occupation specific vital statistics were undertaken, the family members of dead people were required to select one occupational category from the list of 10 occupations. The list was provided to the family with detailed descriptions and definitions of those categories, as well as job examples for each category (see appendix 1 on mbj.com) and jobs that were not included in the category.

Statistical analysis

We used data for people aged 30-59. We excluded those aged 20-29, including students in universities and other higher education institutions. We also excluded the population aged 60 and over, which was the typical retirement age in Japan during the study period. With data based on a five year age interval, we computed the age standardised mortality rate, directly adjusted to the 1985 Japan standard population[19] with the same occupational categorisation as the national census (denominator) and the number of deaths (numerator) for all causes and the five leading causes of death: cancers, ischaemic heart disease, cerebrovascular disease, unintentional injuries, and suicide. We then computed the age standardised mortality rate for the four leading cancers (stomach cancer; larynx, trachea, bronchus, and lung cancer; colorectal cancer; and liver cancer) and categorised occupations into management, professional, the unemployed, and "others" including clerical, sales, services, security, agriculture, transportation, and production/labour on the basis of our analysis of the trend of the age standardised mortality rates.

Data were analysed with a generalised estimating equation model, with an assumed Poisson distribution for the outcome and an exchangeable correlation structure. To model the possible change in mortality in the two specific occupational groups in 2000, we included a term in all models for management and professional workers. A simple step term was included to reflect the potential change in 2000 across all occupational categories, and an interaction of the step term with management and professional workers was used to identify any additional changes in mortality in these two specific occupations. Time and an interaction between time and management and professional workers were also included in the model, to allow for the possibility of differential changes in death rates over time in these occupational categories. Models were built with backwards stepwise model building.

To evaluate if the variability of age standardised mortality rates across occupations has increased over time, we computed the coefficient of variation of rates. The coefficient of variation is a commonly used normalised measure of variability, defined as the ratio of the standard deviation to the mean. It is suitable for evaluating temporal changes in variability and deals with the possible incomparability of the original standard deviation when its average changes over time.

We analysed the data using Stata version 11 (StataCorp, College Station, TX).

Results

In the study period, a third of the total male working population were employed in production/labour. The population share of each occupation was mostly stable, although the proportion of professionals increased from 7.4% to 12.6%. The proportion of management workers decreased from 8.2% to 3.2% (table 1⇓, and see table A in appendix 2 on bmj.com for details).

Age standardised mortality rates from all causes and from major conditions declined from 1980 to 2005, whereas the decline in mortality from cardiovascular diseases stabilised after 1995 (table 2⇓). The exception was suicide, for which the age standardised mortality rates in 2005 increased by 21.2 per 100 000 compared with 1990. Cancer, the leading cause of death among working age men, showed the largest reduction (−42%) followed by mortality from cerebrovascular disease (−33%).

Age standardised mortality rates for all causes substantially declined for all occupations and for unemployed people, except for management and professional workers. Rates for management and professional workers began to increase in the late 1990s: from 152 in 1995 to 245 in 2000 for management and from 192 in 1995 to 272 in 2000 for professionals (fig 1⇓, and see table B in appendix on bmj.com for complete data).

From 1980 to 1995, the all causes age standardised mortality rate largely decreased among sales (−71%), clerical (−66%), and production/labour workers (−64%), while the reductions among other occupations were relatively small (−26% to −40%). The age standardised mortality rates for all cancers, ischaemic heart disease, cerebrovascular disease, and unintentional injuries showed mostly similar occupation specific trends to the all causes rate. The rate for suicide, however, did not show a declining trend. In particular, management workers showed the highest increase in the rate for suicide from 1980 to 2005 (271%), followed by security (138%) and services (95%) workers, whereas the rate for suicide among sales, clerical, and production/labour workers did not rise even in the most recent period (after 1995) (see table B in appendix 2 on bmj.com).Table 3 shows the results of the generalised estimating equation model⇓. All professions showed a long term downward trend in mortality across the study, though management and professional workers had lower risk of death in the period before 2000. There was, however, evidence of a large change in risk in 2000, with management and professional workers having increased risk of some categories of death (and in all cause mortality) relative to other professions. There was an increase in suicide mortality in 2000 across all occupations but a larger increase among management and professional workers. All workers saw an increase in suicide mortality in 2000, but this increase was greater among management and professional workers. Increases in the suicide mortality rate among the management and professional workers were similar to those for other illnesses, representing about a 70% increase in deaths after 2000. Before 2000, however, the management and professional workers experienced significantly lower mortality rates across all six causes of death, with rate ratios of 0.61 to 0.82 (table 4⇓), all of which were significant. After 2000 this situation was reversed for all cause and all cancer mortality, and the mortality rate for suicide and cerebrovascular disease equalised to those of the non-management and professional workers.

The coefficient of variations of the age standardised mortality rate across occupations, excluding unemployed people, showed an increased trend for all causes and the five leading causes of death (table 5⇓). The coefficient of variation for the all causes rate across occupations increased from 0.29 in 1980 to 0.46 in 2005. The temporal trend of the coefficient of variation for the suicide rate increased from 0.33 in 1980 to 0.58 in 2005, while the coefficient of variation for the suicide rate including unemployed people became smaller (table 5[5]).

Figure 2⇓ (and table C in the appendix on bmj.com) shows the trends in age standardised mortality rates by the four leading sites of cancer. Mortality from stomach cancer showed the largest reduction in this period, whereas rates for lung cancer and colorectal cancer seem to have plateaued. The occupational patterns described for all cancer mortality also seem to be reflected in these cancer specific data series, suggesting that the reversal in declining cancer mortality among management and professional workers occurred across a broad range of cancer sites.

Discussion

In Japan, trends in mortality varied substantially across occupations and the variability widened from 1980 to 2005, but socioeconomic disparities between occupational groups reduced because of rising mortality among management and professional workers. Many studies in other countries have reported growing health inequality across social classes in from 1980 to 2000.[13 20-23] For example, Mackenbach and colleagues reported widening disparities in health between manual and non-manual workers in five European countries between 1981-5 and 1991-5.[24] The overall mortality in management and professional workers in Japan, in particular among management, has increased since 2000, whereas that in other workers has showed a steady decline. It should also be noted that, unlike the other four leading causes of death, mortality from suicide showed an upward trend regardless of occupation, along with stagnation in the declining trend in mortality from ischaemic heart disease. As with other causes, management workers showed the poorest performance, with the largest increase in mortality from suicide in later years.

Economists have argued that lingering economic stagnation has been responsible for changes in work environments and employment systems, making the lives of working age people erratic and stressful.[6] Together with the introduction of ICD-10, this might be one of the potential factors to account for the trend in cardiovascular mortality ceasing to fall after 1995. This could also explain Japan's counterintuitive trends in occupation specific age standardised mortality rates in recent years. Companies downsized their organisations after the economic recession in the 1990s and consequently the share of managers in the labour market decreased from 6.7% in 1995 to 3.2% in 2005.These changes in work environment could increase responsibilities and job demands of managers compared with manufacturing and clerical workers. Yearly working hours for clerical, sales, and production/labour workers decreased from 2162 hours in 1980 to 1970 hours in 2000.[25] Growing evidence suggests a strong link between job stress and various health outcomes, including metabolic risk factors, mental disorders, and mortality.[26]

Our results are consistent with those from some recent studies that reported that risk factors for cancers and cardiovascular disease—such as being overweight, high alcohol consumption, lower concentrations of high density lipoprotein cholesterol, and physical inactivity—are more prevalent in higher grades of occupations such as professional and management workers in recent years in Japan, potentially because of high job demands among those workers.[27-29] The authors of these studies have suggested the existence of unique patterns in occupational health gradients in Japan, which could be in part because of strong pressures on high grade workers in Japan, stemming from Japan's particular work culture.[3 30] On the other hand, the observed increased gradients in age standardised mortality rates of professionals and managements from 1995 to 2000 might be attributable to the radical changes in socioeconomic conditions of the 1990s rather than to inherent characteristics of Japan's work environment. This observation is, however, contrary to the reduced mortality rates from unintentional injuries and some other causes after the economic crisis.[31]

A possible explanation for the observed increasing trend in mortality for lung cancer and colorectal cancer could be in part because of differences in access to preventive services across occupations. In Japan, under the Industrial Safety and Health Law employers must pay for annual health screening for all employees. In 2004, 73% of men aged 45-54 had an annual health examination.[32] Given the increased pressures on management and professional workers, however, their tight daily schedules might prevent them from using the opportunity of health examination and subsequent healthcare benefits, as well as necessary medical care, despite universal health coverage.[1] According to the official cancer registry statistics, the incidence rates of the four cancers analysed here have been stable or declining since 1990.[33] Therefore, it is unlikely that the observed reversal in trends in mortality from cancer among management and professional workers is because of increased incidence.

Interestingly, we found that variability in suicide rate decreased among all men of working age. When we excluded unemployed men from our analysis, however, the rate increased (table 5⇓). At the same time, the age standardised mortality rate from suicide increased among workers and not among unemployed people (see table B in appendix on bmj.com). These data support claims that the changing work environment could be primarily responsible for increasing suicide rates in recent years. In a prospective cohort study in Japan, Fujino and colleagues showed that unemployment was not associated with the risk of suicide,[34] while Granados suggested countercyclical trends of suicide mortality related to Japan's economic fluctuations.[35] Kondo et al also reported that the percentage of reported poor health among unemployed people was 16.5% before the economic crisis in 1998 and 12.6% afterwards.[7] Because of potential misclassification in this category, these findings require further studies with better data, but the evidence from available studies suggests that unemployment per se is not the driving force behind the changes in mortality patterns observed in this study. An alternative explanation could be that during the study period the unemployment rate doubled, with a relatively higher increase among younger people, and the characteristics of unemployed people could have changed over time, becoming closer to that of general workers in terms of their health risks.[36]

Limitations

Our study has substantial advantages because of the complete enumeration data used and the application of multiple approaches to standardise the variability in age composition and definitions of cause of death across years. Some caution is nevertheless needed when interpreting our findings, primarily because of potential information bias or misclassifications in occupational categories. Lack of further information, such as employment conditions and company size, prevented us from examining the detailed mechanisms underlying our findings. In addition, numerator-denominator bias attributable to the use of different sources to gather information on the number of deaths and occupations, which can occur if the distribution of populations across occupations are different between the two data sources,[37] must be considered. For example, the family of a dead person choose his or her last occupation from 10 occupational categories that included unemployment, opening the risk of misclassification bias, especially when, for example, unemployment occurred only shortly before death. To deal with this potential problem, we excluded unemployed people from our primary analysis because misclassification is most likely in this category.[12] Furthermore, family members might be less likely to report that the person who had died was unemployed if he or she had had a prestigious job before death, potentially resulting in overestimation of mortality rates among such groups. We conducted a sensitivity analysis under the assumption that the entire reduction of professional and management workers of working age represented a shift of these employees into the "other" category, but that dead people continued to be recorded as "professional and management" on death certificates. If we adjust for this effect, the relative risk of death among professional and management workers in 2005 remained higher than it was before 1995 (0.99, 95% confidence interval 0.87 to 1.13). Our results, though not as strong, remain unchanged under even the most unrealistic assumptions about the strength of this numerator-denominator bias. Another possible limitation of our research is the model selection method. Our statistical analysis modelled the effect of the recession with a step term estimated from a combination of published work on the point at which increased mortality was observed and empirical observation of the trends in the data. Because of the small number of data points available, we could not test a wider range of model choices without a high risk of spurious statistical results. There were also only six time points, so the findings might be sensitive to boundary effects in the model. A more robust analysis of a wider range of time points might enable a more sensitive comparison of mortality between occupational categories. More time will need to pass before a longer series can be analysed and definitive judgments made about the apparent changes in mortality rates presented here.

Conclusion

This study has implications for the health effects of the spread of globalisation over the past two decades, which has made global and domestic economies more and more volatile and unstable. In the case of Japan, a major economic collapse in the 1990s, followed by years of economic stagnation and changes in working environment, could have been a factor associated with radical changes in patterns of mortality that had been established since 1980. In addition, certain trends in key causes of mortality were reversed or arrested, and there was a rapid increase in the suicide rate. This emphasises the priority that needs to be placed on suicide prevention among working age men and the importance of reacting quickly to the health consequences of economic collapse. Economic crises might not simply constitute a threat to health equality but can have a complex impact on various subpopulations regardless of their socioeconomic status.

The lessons of Japan's reversal of health outcomes in the 1990s would be particularly relevant given that many similar economies might be beginning to experience the same phenomenon since the 2008 global financial crisis. Policymakers and health professionals should be aware of the pace and magnitude of the impact on population health from a major economic event. The changes experienced in Japan also serve as a reminder that the health gains in modern societies might not necessarily be guaranteed and could be vulnerable to sudden socioeconomic changes.

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What is already known on this topic

Japanese health is now under threat, especially among men of working age, because of the lingering economic stagnation since the 1990s, which is characterised by the record high rate of suicide among men

Trends in occupational variations in the mortality rate during the period of Japan's recent economic stagnation are largely unknown

What this study adds

Risk of mortality in management workers in Japan, which was previously the lowest, largely increased after 1995, whereas in other non-professional workers mortality steadily decreased between 1980 and 2005

During this time mortality from suicide increased in all occupations, with the largest increase among management and professional workers

Economic crises might not simply negatively affect health equality but can have a complex impact on various subpopulations regardless of their socioeconomic status

the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: Not required

Data sharing: No additional data available.

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Tables

Table 1| **Proportion of population by occupation among Japanese men aged 30-59 according to national population census, 1980-2005 (%)**

Occupation	1980 (n=24 250 948)	1985 (n=25 896 538)	1990 (n=25 961 345)	1995 (n=26 059 598)	2000 (n=25 935 755)	2005 (n=25 621 203)
Professional	7.4	9.5	10.6	12.1	13.2	12.6
Management	8.2	6.3	6.6	6.7	4.1	3.2
Others*	80.3	78.9	78.4	76.0	75.7	75.9
Unemployed	4.1	5.3	4.4	5.2	7.0	8.3

*Clerical, sales, services, security, agriculture, transportation, and production/labour.

Table 2| **Number of deaths and age standardised mortality rates per 100 000 (95% confidence intervals) from all causes and five leading causes of death among men aged 30-59 in Japan, 1980-2005**

Cause of death	1980 (n=87 629)	1985 (n=94 214)	1990 (n=87 915)	1995 (n=83 634)	2000 (n=85 545)	2005 (80 702)	*% change	†Absolute difference
All causes	388.5 (385.9 to 391.1)	365.7 (363.4 to 368.0)	306.6 (304.5 to 308.8)	295.7 (293.7 to 297.7)	293.6 (291.6 to 295.6)	279.2 (277.2 to 281.1)	−28	−109
All cancers	144.5 (142.9 to 146.1)	121.4 (120.1 to 122.8)	116.1 (114.9 to 117.4)	106.9 (105.7 to 108.1)	100.3 (99.1 to 101.4)	102.4 (101.3 to 103.5)	−29	−42
Ischaemic heart disease	43.9 (43.0 to 44.8)	40.4 (39.6 to 41.2)	38.4 (37.7 to 39.2)	30.8 (30.2 to 31.5)	30.5 (29.9 to 31.2)	32.3 (31.6 to 32.9)	−26	−12
Cerebrovascular disease	57.9 (56.9 to 58.9)	41.9 (41.1 to 42.7)	33.8 (33.1 to 34.5)	30.5 (29.8 to 31.1)	26.8 (26.2 to 27.4)	25.4 (24.8 to 26.0)	−56	−33
Unintentional injuries	37.3 (36.5 to 38.1)	34.6 (33.8 to 35.3)	32.2 (31.5 to 32.9)	31.7 (31.1 to 32.4)	28.3 (27.6 to 28.9)	25.7 (25.1 to 26.3)	−31	−12
Suicide	33.7 (33.0 to 34.5)	43.2 (42.4 to 44.0)	30.9 (30.2 to 31.6)	31.9 (31.1 to 32.5)	50.3 (49.4 to 51.1)	53.1 (52.2 to 54.0)	57	19

*Difference between 1980 and 2005 rates expressed as percentage of 1980 rate.

†Absolute difference in age standardised mortality rate per 100 00 between 1980 and 2005.

Table 3| **Ratios of age standardised mortality rates for all causes, all cancers, ischaemic heart disease, cerebrovascular disease, unintentional injuries, and suicide mortality: results of generalised estimating equation models for trend analysis**

Cause of death/variable	Rate ratio	z statistic	P value
All causes			
Intercept	342.85	291.73	<0.001
Time	0.9	−34.75	<0.001
Occupation:			
Non-management/professional* *v* management/professional	0.7	−7.38	<0.001
Step function:			
1980-95* *v* 2000-5	0.96	−3.94	<0.001
Occupation and step:			
Non-management/professional after 2000* *v* management/professional after 2000	1.69	32.71	<0.001
All cancers			
Intercept	113.42	138.58	<0.001
Time	0.94	−9.3	<0.001
Occupation:			
Non-management/professional *v* management/professional	0.82	−2.6	0.009
Step function:			
1980-95 *v* 2000-5	0.76	−9.67	<0.001
Occupation and step:			
Non-management/professional after 2000* *v* management/professional after 2000	1.86	17.38	<0.001
Ischaemic heart disease			
Intercept	39.75	62.9	<0.001
Time	0.88	−12.61	<0.001
Occupation:			
Non-management/professional* *v* management/professional	0.77	−1.91	0.06
Step function:			
1980-95* *v* 2000-5	0.99	−0.2	0.8
Occupation and step:			
Non-management/professional after 2000* *v* management/professional after 2000	1.55	8.56	<0.001
Cerebrovascular disease			
Intercept	49.87	75.88	<0.001
Time	0.8	−22.13	<0.001
Occupation:			
Non-management/professional* *v* management/professional	0.63	−3.83	<0.001
Step function:			
1980-95* *v* 2000-5	1.03	0.91	0.4
Occupation and step:			
Non-management/professional after 2000 v management/professional after 2000*	1.72	10.54	<0.001
Unintentional injury			
Intercept	38.42	60.68	<0.001
Time	0.94	−8.45	<0.001
Occupation:			
Non-management/professional* *v* management/professional	0.54	−3.71	<0.001
Step function:			
1980-95* *v* 2000-5	0.9	−3.71	<0.001
Occupation and step:			
Non-management/professional after 2000* *v* nmanagement/professional after 2000	1.55	9.88	<0.001
Suicide			
Intercept	32.61	55.1	<0.001
Time	0.97	−2.32	0.02

Table 3 (continued)

Cause of death/variable	Rate ratio	z statistic	P value
Occupation:			
Non-management/professional* *v* management/professional	0.61	−3.07	0.002
Step function:			
1980-95* *v* 2000-5	1.49	8.53	<0.001
Occupation and step:			
Non-management/professional after 2000* *v* management/professional after 2000	1.68	6.79	<0.001

*Reference category.

Table 4| **Ratios of age standardised mortality rates by cause of death, before 1995 and after 2000, for management/professional versus non-management/professional**

Causes of death	Before 1995	After 2000
All causes	0.70 (0.63 to 0.76)*	1.18 (1.07 to 1.31)*
All cancers	0.82 (0.78 to 0.95)*	1.52 (1.29 to 1.80)*
Ischaemic heart disease	0.77 (0.59 to 1.01)	1.19 (0.89 to 1.59)
Cerebrovascular disease	0.63 (0.50 to 0.80)*	1.08 (0.84 to 1.40)
Unintentional injury	0.54 (0.40 to 0.75)*	0.84 (0.61 to 1.18)
Suicide	0.61 (0.45 to 0.84)*	1.03 (0.73 to 1.45)

*P<0.05.

Table 5| **Trend in variability of mortality rates across occupations. Figures are coefficient of variation (95% confidence interval) of age standardised mortality rate from all causes and five leading causes of death among working men aged 30-59 in Japan, 1980-2005**

	1980	1985	1990	1995	2000	2005
Excluding unemployed men						
All causes	0.29 (0.14 to 0.44)	0.27 (0.13 to 0.42)	0.34 (0.16 to 0.53)	0.40 (0.18 to 0.63)	0.43 (0.18 to 0.67)	0.46 (0.19 to 0.73)
All cancers	0.21 (0.10 to 0.32)	0.20 (0.10 to 0.30)	0.27 (0.13 to 0.40)	0.35 (0.16 to 0.53)	0.40 (0.17 to 0.62)	0.44 (0.19 to 0.69)
Ischaemic heart disease	0.28 (0.13 to 0.42)	0.29 (0.14 to 0.45)	0.35 (0.16 to 0.53)	0.37 (0.17 to 0.58)	0.40 (0.17 to 0.62)	0.46 (0.19 to 0.73)
Cerebrovascular diseases	0.35 (0.16 to 0.54)	0.32 (0.15 to 0.49)	0.39 (0.17 to 0.61)	0.44 (0.19 to 0.69)	0.47 (0.19 to 0.75)	0.48 (0.20 to 0.77)
Unintentional injuries	0.49 (0.20 to 0.78)	0.44 (0.19 to 0.70)	0.48 (0.20 to 0.77)	0.53 (0.21 to 0.85)	0.56 (0.21 to 0.92)	0.55 (0.21 to 0.90)
Suicide	0.33 (0.15 to 0.51)	0.36 (0.16 to 0.57)	0.46 (0.19 to 0.75)	0.50 (0.20 to 0.81)	0.56 (0.21 to 0.87)	0.58 (0.21 to 0.92)
Including unemployed men						
All causes	1.10 (0.16 to 2.03)	1.05 (0.18 to 1.92)	1.20 (0.11 to 2.30)	1.18 (0.12 to 2.25)	1.07 (0.17 to 1.97)	1.08 (0.17 to 2.00)
All cancers	0.81 (0.24 to 1.38)	0.82 (0.24 to 1.39)	0.96 (0.21 to 1.72)	0.89 (0.23 to 1.56)	0.85 (0.24 to 1.47)	0.94 (0.22 to 1.67)
Ischaemic heart disease	0.99 (0.20 to 1.77)	1.03 (0.19 to 1.86)	1.25 (0.08 to 2.43)	1.16 (0.13 to 2.19)	1.06 (0.18 to 1.93)	1.09 (0.16 to 2.02)
Cerebrovascular diseases	0.92 (0.22 to 1.61)	0.89 (0.23 to 1.55)	0.99 (0.20 to 1.78)	1.05 (0.18 to 1.93)	0.95 (0.22 to 1.68)	1.00 (0.20 to 1.81)
Unintentional injuries	0.65 (0.24 to 1.06)	0.59 (0.24 to 0.95)	0.75 (0.24 to 1.26)	0.90 (0.23 to 1.58)	0.79 (0.24 to 1.34)	0.81 (0.24 to 1.37)
Suicide	1.20 (0.10 to 2.33)	1.05 (0.18 to 1.94)	1.22 (0.10 to 2.34)	1.13 (0.13 to 2.17)	1.03 (0.18 to 1.94)	0.93 (0.21 to 1.69)

Figures

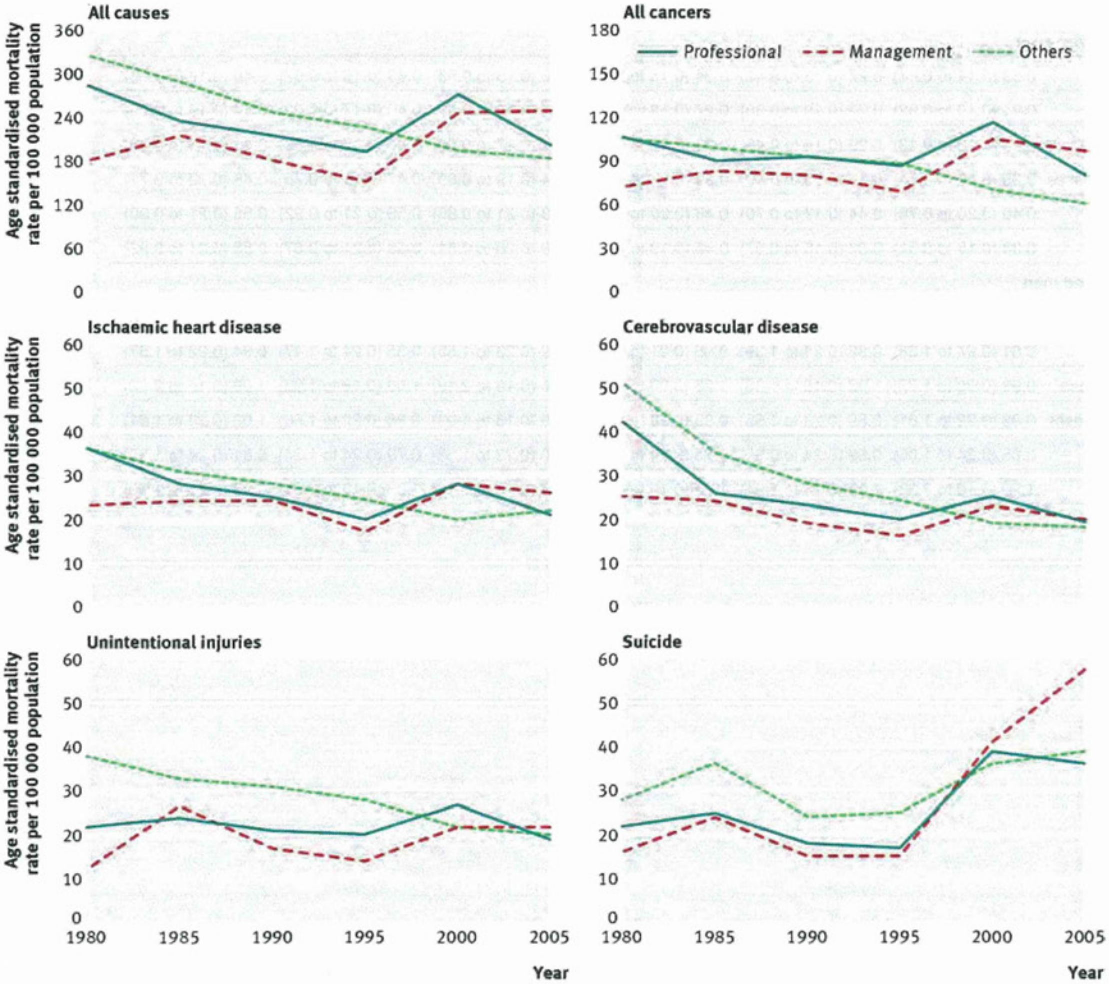

Fig 1 Temporal trends and comparisons of age standardised mortality rates (per 100 000) from all causes and five leading causes of death, 1980-2005, among men aged 30-59 in Japan

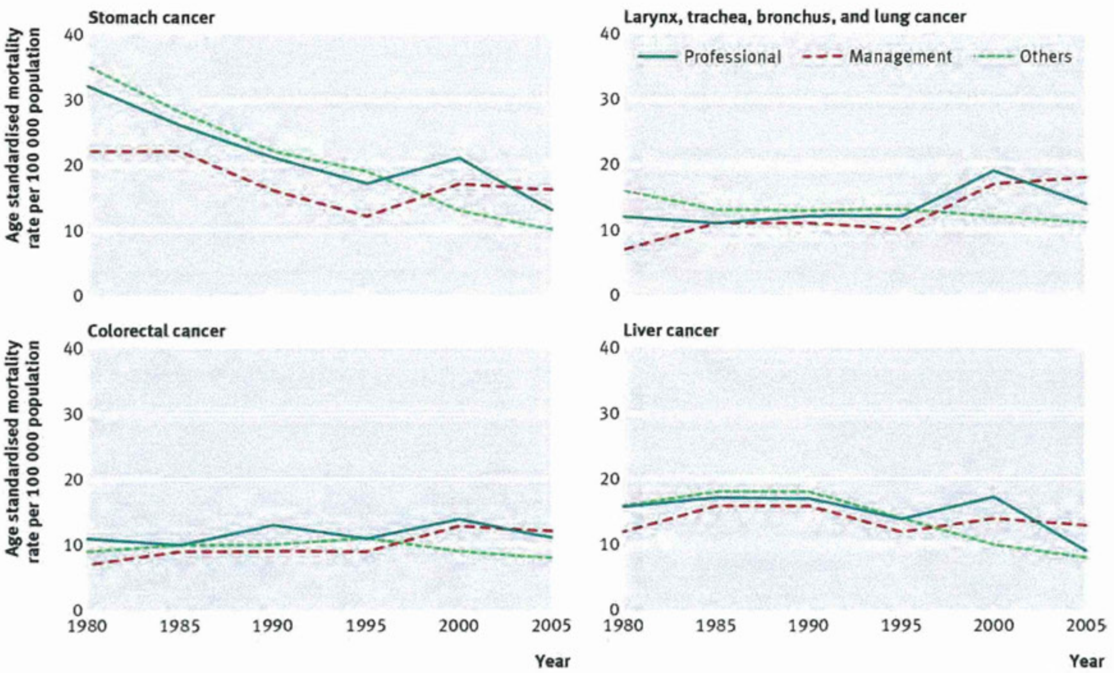

Fig 2 Temporal trends and comparisons of age standardised mortality rates (per 100 000) of four leading cancers, 1980-2005, in men aged 30-59 in Japan

GBD 2010 country results: a global public good

The Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010) constitutes an unprecedented collaboration of 488 scientists from 303 institutions in 50 countries, focusing on describing the state of health around the world using a uniform method. Results for the world and 21 regions for 1990 and 2010 have been reported for 291 diseases and injuries, 1160 sequelae of these causes, and 67 risk factors or clusters of risk factors.[1-7] The burden of each disease, injury, or risk factor has been quantified in terms of deaths, years of life lost due to premature mortality (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs).

Although only global and regional results have been reported so far, the underlying unit of analysis for GBD 2010 was 187 countries. Age-specific mortality was analysed for each country for each year from 1970 to 2010. Causes of death were estimated for each country from 1990 to 2010 with country-specific data and models. Disease and injury sequelae were estimated in most cases with a Bayesian meta-regression method (DisMod-MR) that includes estimation of systematic differences in incidence, prevalence, or excess mortality between countries within regions.[5] Systematic analysis of risk factor exposure, excess health risks associated with each risk–outcome pair, and counterfactual minimum risk levels of exposure were used to compute attributable burden. On the basis of these analyses, GBD 2010 provides a complete assessment of the burden of diseases, injuries, and risk factors for 187 countries including quantification of uncertainty in the estimates for 1990 and 2010, albeit with important limitations because of the scarcity of data for some outcomes in some countries and the need to use a range of statistical models to generate estimates. The availability of standardised estimates for each of the 187 countries over time provides an unprecedented opportunity to undertake comparative assessments, to benchmark country performance in control of critical diseases, injuries, and risks, and to stimulate evidence-based action.

Most of the scientists in the GBD 2010 collaboration volunteered their own time or raised their own funds to participate.[8] A key motivation for them was the opportunity to publish more detailed analyses of data, methods, and results for specific diseases, injuries, and risk factors. Many reports are in submission or in preparation and provide more detail for specific diseases, injuries, risk factors, and countries.[9] Although we expect that these reports will be important contributions to the scientific literature, we recognise that country results from the GBD are a global public good that could be a useful or even critical input into a more informed national, regional, and global dialogue about health challenges. Already, governments of several developed and developing countries have approached us seeking access to more detailed results. Because we believe that the dissemination and rapid availability of the detailed results is a moral imperative, we are providing global access to these details on March 5, 2013, through a series of online visualisations. To allow sufficient time for members of the GBD 2010 collaboration to report their own research findings, we will defer dissemination of public-use datasets of the underlying results presented in the visualisations until Sept 1, 2013. In this way, we believe that we can provide global access to these important results while at the same time respecting the intellectual investment of the collaboration's members. Nonetheless, anticipating that some governments might wish to have immediate access to more detailed information as an input to national policy dialogue, we have provided and will continue to provide detailed national disease burden results on request. We also encourage use of the visualisations or snapshots of their images for teaching, communication, and other educational purposes.

Alongside the reporting of global and regional results in *The Lancet*, five data visualisations were made available in December, 2012. For visualisation of country-level data, the Institute for Health Metrics and Evaluation (IHME) has developed new visualisations with expanded scope and functionality, which are being launched on March 5. Data visualisations can make complex information accessible and interpretable without advanced statistical or epidemiological training. The primary purpose of these visualisations is to allow health specialists, policy makers, the media, donors, and the general public to explore the patterns of health in different age and sex groups, countries, and time periods. Providing information on patterns of health to this broad audience could enhance the scope and quality of national, regional, and global dialogue about the main

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For **data visualisations** see http://www.ihmeuw.org/GBDregionalviz

For more on the **expansion of scope and functionality of these visualisations** see http://www.ihmeuw.org/GBDcountryviz

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***Figure 1:* Screenshot of an output from GBD Compare showing a treemap of YLLs in India in 2010**
Communicable, maternal, neonatal, and nutritional causes are coloured red; non-communicable causes are blue; and injuries are green. The shading of each colour can be altered to convey information about rates of change from 1990 to 2010, or the size of uncertainty intervals; in this figure, shading is according to rates of change. In some cases the labels for the boxes are not visible, but hovering over each rectangle provides full detail. This figure illustrates how, despite substantial reductions in mortality of children younger than 5 years and adults, communicable, maternal, neonatal, and nutritional disorders still account for 50·4% of YLLs. Results are for the fourth level of disease disaggregation.[10] YLLs=years of life lost due to premature mortality.

health challenges facing countries and pinpoint needs for realignment of resource allocation and strategic prioritisation. An important secondary purpose is to broaden the community of scientists who scrutinise the results. Such scrutiny will probably identify key scientific findings that have not yet been highlighted in GBD 2010 summary publications, discern many ways in which future estimates can be improved through inclusion of other data sources, discover alternative approaches to correct for bias or otherwise enhance the quality and comparability of data, identify outliers in existing estimates, and, perhaps most importantly, stimulate interest in new primary data collection.

We are now making available many ways to examine GBD 2010 results: a general instrument to explore the burden of disease, four supplemental visualisations that provide different perspectives to examine the same underlying results, a benchmarking method, and two visualisations to explore some of the GBD primary input data. GBD Compare is the primary way to explore patterns of the burden of diseases, injuries, and risk factors both within a country and between countries. It has five different views, and for each of these views there are thousands of ways to explore the GBD findings. The treemap that is produced is effectively a rectangular pie chart, in which the size of each box for a disease or injury is proportional to the share of the total contributed by that disease (figure 1). Treemaps can be displayed for deaths, YLLs, YLDs, or DALYs. A treemap can be generated for any of the 20 GBD age groups or some summary age groups for males, females, or both sexes combined; for different geographical units (global, region, country); and for different years between 1990 and 2010. As part of the development of GBD Compare, we interpolated results for 1995 and 2000 using a very simple approach; care should be taken to avoid overinterpretation of the results for these years. Users can also display risk factor attribution to each of

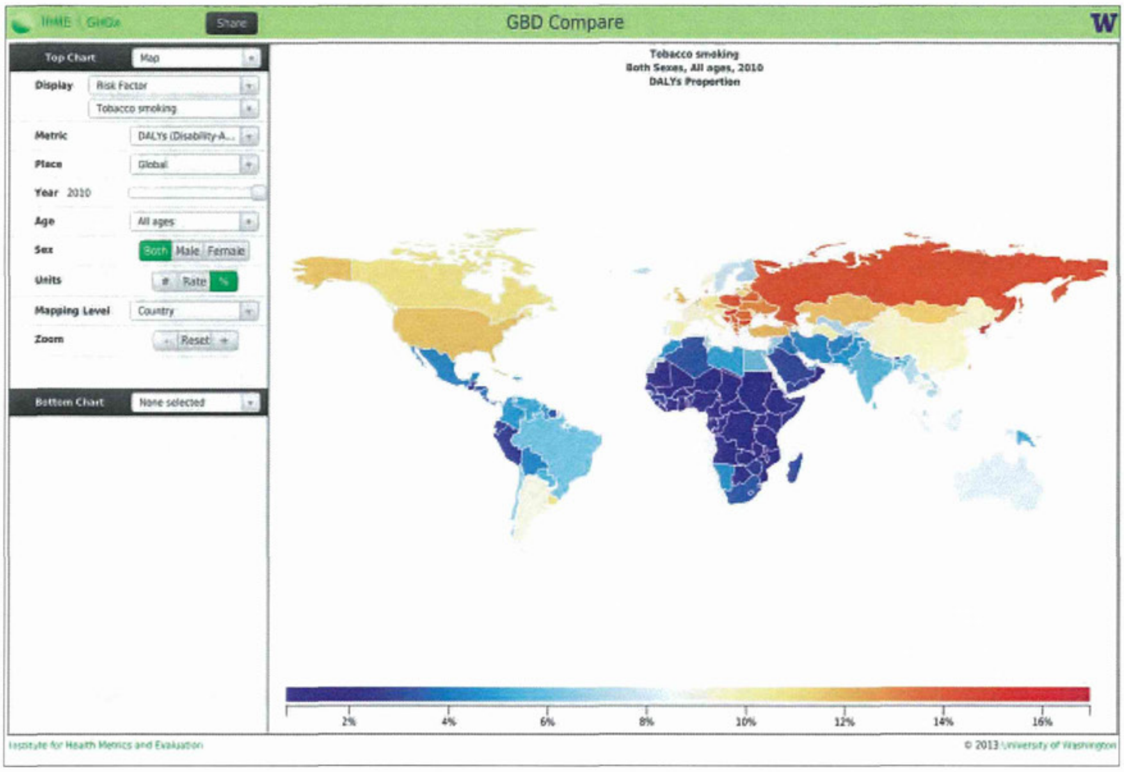

Figure 2: **Screenshot of an output of GBD Compare showing the percentage of DALYs attributable to tobacco by country in 2010 for both sexes combined**
DALYs=disability-adjusted life-years.

the causes. They can adjust the level of disaggregation of the cause list—eg, three broad causes or 21 second-level causes. GBD Compare can also show results for risk factors. Stacked bar charts show the number of deaths, YLLs, YLDs, and DALYs attributable to that risk factor, disaggregated by cause.

Users can produce maps for any disease, injury, or risk factor showing rates, numbers, or proportions of deaths, YLLs, YLDs, and DALYs to enable comparisons between countries (figure 2). Maps can be used to display the rank for a specific cause or risk factor within a country, effectively visualising their relative importance within each country. Because some countries are small in area, a user can zoom in or out on the map to examine specific areas such as the Caribbean, the Pacific, or Central America. Two other views show estimates for a quantity of interest over time with uncertainty or across age groups with uncertainty. In GBD Compare, users can display two views at once (figure 3). They can explore results by navigating between the top and bottom panels: clicking on a disease or injury on the treemap will display that cause on the map, and clicking a country on the map will switch the treemap to this country.

Four different visualisations provide supplemental views: GBD Arrow Diagrams, GBD Cause Patterns, GBD Uncertainty Visualization, and a healthy life expectancy and life expectancy visualisation (HALE/LE Visualization). GBD Arrow Diagrams allow the user to see—for a specific country, age group, and sex—the rank order of disease and injury causes or risk factors in terms of deaths, YLLs, YLDs, or DALYs, and how the rankings have changed between 1990 and 2010 (figure 4). The arrow diagrams change dynamically if a different age, sex, country, year, or metric is selected.

GBD Cause Patterns uses stacked column charts for 21 broad cause groups to show the selected burden metric, such as number, rate, or percentage, and allows comparisons between regions, any set of countries, age groups, both sexes, and years. It is a powerful way to understand how the age and broad cause composition of burden has changed from 1990 to 2010 for each metric. It is also a powerful

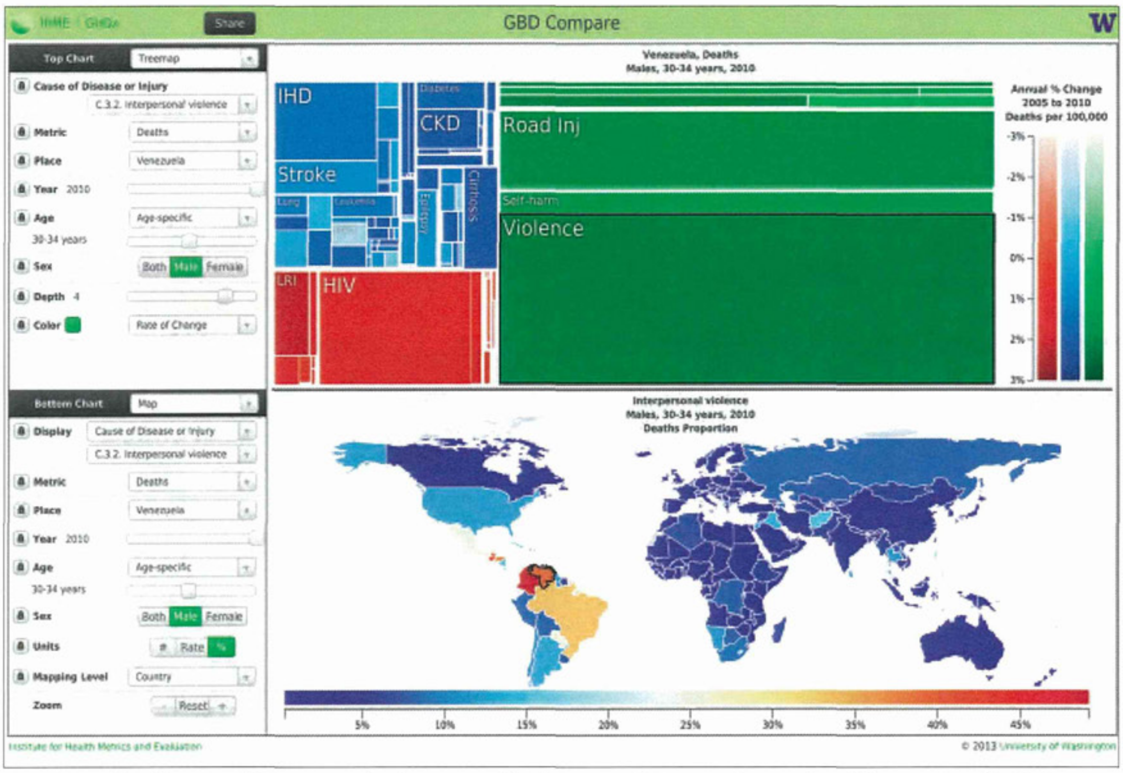

Figure 3: Screenshot of an output of GBD Compare showing treemap of deaths in men aged 30–34 years in Venezuela and the proportion of deaths due to violence in this age group worldwide

way to visualise the differences in numbers, rates, or proportions between any set of countries. Country-level results, and comparisons between them, are potentially subject to greater uncertainties than are regional and global ones, so the clear presentation of those uncertainties is particularly important. The GBD Uncertainty Visualization displays the 95% uncertainty intervals for both numbers and ranks associated with each cause or risk for any combination of age groups, sexes, and region. HALE/LE Visualization allows users to compare life expectancy with healthy life lost (the difference between life expectancy and healthy life expectancy) for 1990 and 2010; results are displayed for all 187 countries and can be viewed by age group and sex. This visualisation was released in December, 2012.

Comparisons of outcomes have often been limited by a lack of comparability of measurements between countries. GBD 2010 invested substantial effort in a detailed endeavour to enhance the comparability of cause of death data both over time and across countries.[2,11] Similarly, the analysis of prevalence of the 1160 sequelae by different experts included substantial emphasis on controlling for variation in case definitions, recall periods, instrument design, and biomarker assays across studies. Residual issues of comparability and data quality undoubtedly remain; nonetheless, GBD 2010 provides a unique and comparable platform to examine differences in levels and trends in diseases, injuries, and risk factors across countries. In our experience, different users might want to select a customised set of countries to serve as relevant comparators. We are releasing a ranking instrument on March 5, for this purpose, and are developing others. In GBD Leading Cause, any set of countries can be examined using a heat map to look at differences in the leading causes of burden due to disease, injuries, or risk factors. These heat maps are analogous to those reported for DALYs at the regional level.[3]

Two visualisations explore the mortality and causes of death input data: Mortality Visualization and COD Visualization. Some researchers and analysts wish to understand what data were available to feed into the analysis of age-specific mortality or causes of death.

Figure 4: **Screenshot of an output of GBD Arrow Diagrams showing ranks of diseases and injuries as causes of DALYs in women of reproductive age in Ethiopia in 1990 and 2010**
DALYs=disability-adjusted life-years.

Mortality Visualization gives them access to country-specific estimates and the underlying data used for mortality of children younger than 5 years and adults aged between 15 and 60 years. These measures are the two critical summary measures of mortality experience used as inputs of developing life tables; for each country, the user can examine what studies are available and meta-data describing the provenance of that measurement. The visualisation also shows the various steps in development of estimates of the levels and trends in both adult and child mortality. COD Visualization provides access to the curated cause of death database that has been developed at IHME for GBD 2010. Users can view numbers, cause fractions, and rates for each age group and all ages combined. Each datapoint has metadata attached that are revealed by hovering over the datapoint. Some data points cannot be shown because data use agreements from the data holders restrict access.

Overall, these visualisations offer a unique opportunity to explore a number of results that, if displayed in a spreadsheet, would be displayed in millions of rows and be largely unusable. Allowing users to explore the data visually by key dimensions—country, age, sex, cause, year—will reduce barriers to access and vastly increase the number of potential users, thereby leading to greater data democratisation. To enhance the value and effect of GBD 2010 and to encourage greater use of these visualisations, further training and dissemination will be essential. Short videos on how to use them will be available online. Detailed training workshops on GBD methods will be held, beginning in May, 2013. Planned future revisions of the GBD will hopefully draw on a much more extensive network of scientists. This extended network will not only improve the quality of assessment, but will also provide a forum for continuing reflection, learning, interpretation, and action based on GBD 2010 results and future revisions. A broader understanding of GBD methods and access to national results will enable the growing number of countries with an expressed interest to undertake subnational burden of disease assessments.

For **videos** see http://www.healthmetricsandevaluation.org

For more on **training workshops** see http://www.healthmetricsandevaluation.org/gbd/training

See Online for appendix

Global and regional descriptions of leading causes of mortality and disease burden, and how they are changing, serve an important policy need, particularly for donors and policy makers looking to accelerate progress with key global health and development goals. Local policy will be much better served by, and will probably be much more responsive to, local evidence about major causes of health loss in populations. For this reason, the release of the national burden of disease estimates is expected to encourage and focus national policy responses to address leading health challenges in each country. We now have the evidence base to identify these challenges by age group, for males and females separately, for 291 causes of death and disability, and for most leading health risks. The challenge for national policy dialogue will be to make the most of this evidence to improve the health of individuals and populations. Plans that are underway to continuously update the GBD results will also enhance their usefulness by making it possible to track the links between resources, programme initiatives, and changes in health.

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For members and their conflicts of interest see appendix.

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Health in the UK: could do even better?

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Countries are political entities; to analyse by country is a political act. So Christopher Murray and colleagues' report in *The Lancet*,[1] which compares health outcomes in the UK with those in other countries, is political. It is a political analysis and requires a political response—from UK politicians and from the body politic of the health professions.

The Global Burden of Disease (GBD) project assembled a stellar cast, and the UK authorship of Murray and colleagues' report[1] reads like an invite list for the public health hall of fame. Unquestionably, this report has the best possible science behind it. Key strengths include comprehensive coverage, a strong effort to ensure international comparability, and attention to disability not just mortality. Even so, there are points of methodology that merit comment before examination of substantive issues.

The report pits the UK against comparators in Europe and Australia, Canada, and the USA, and adopts a league table approach based on two timepoints—1990 and 2010. League tables are problematic for two reasons. First, rankings are notoriously unstable statistically,[2] especially if only two timepoints are compared. More

Mortality Risk amongst Nursing Home Residents Evacuated after the Fukushima Nuclear Accident: A Retrospective Cohort Study

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Abstract

Background: Safety of evacuation is of paramount importance in disaster planning for elderly people; however, little effort has been made to investigate evacuation-related mortality risks. After the Fukushima Daiichi Nuclear Plant accident we conducted a retrospective cohort survival survey of elderly evacuees.

Methods: A total of 715 residents admitted to five nursing homes in Minamisoma city, Fukushima Prefecture in the five years before 11th March 2011 joined this retrospective cohort study. Demographic and clinical characteristics were drawn from facility medical records. Evacuation histories were tracked until the end of 2011. The evacuation's impact on mortality was assessed using mortality incidence density and hazard ratios in Cox proportional hazards regression.

Results: Overall relative mortality risk before and after the earthquake was 2.68 (95% CI: 2.04–3.49). There was a substantial variation in mortality risks across the facilities ranging from 0.77 (95% CI: 0.34–1.76) to 2.88 (95% CI: 1.74–4.76). No meaningful influence of evacuation distance on mortality was observed although the first evacuation from the original facility caused significantly higher mortality than subsequent evacuations, with a hazard ratio of 1.94 (95% CI: 1.07–3.49).

Conclusion: High mortality, due to initial evacuation, suggests that evacuation of the elderly was not the best life-saving strategy for the Fukushima nuclear disaster. Careful consideration of the relative risks of radiation exposure and the risks and benefits of evacuation is essential. Facility-specific disaster response strategies, including in-site relief and care, may have a strong influence on survival. Where evacuation is necessary, careful planning and coordination with other nursing homes, evacuation sites and government disaster agencies is essential to reduce the risk of mortality.

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Introduction

Following the Great East Japan Earthquake and subsequent tsunami on 11th March 2011[1,2], a level seven nuclear accident at Fukushima Dai-ichi nuclear power plant caused extensive social disruption and fear in Fukushima prefecture. On the 12th March, shortly after this accident, the Japanese government issued a mandatory evacuation order for those living within a 20 km radius of the nuclear plant and indoor shelter and voluntary evacuation instructions for residents of the 20 to 30 km zone, both of which caused dysfunction in hospitals, clinics, and welfare facilities, and loss of medical supplies[3].

Although all eight nursing home facilities in Minamisoma were located outside the compulsory 20 km evacuation zone, they were all within the 20 to 30 km indoor shelter and voluntary evacuation zone, and all elderly residents of all the homes were voluntarily evacuated irrespective of their individual state of health or care needs, because of the increasing fear of radiation and/or disruption of food, gasoline and medical supplies to this area. Questions about the safety of evacuation of elderly residents are of paramount importance to residents[4–7], medical and welfare institutions[4,8] and, of course, the Japanese government, whose emergency response to the radiation accident is controversial[9]; however, although initial reports suggested a chaotic evacuation with high overall mortality risk[10], there is no detailed understanding of mortality risks associated with the evacuation process[6].

Research on hurricane preparedness in the USA has suggested that evacuation can be associated with an approximately two-fold mortality risk[11,12]. US nursing homes are required to maintain evacuation plans, though compliance with these plans is not