Panel: Research in context

Systematic review

We searched PubMed with the terms "tobacco" OR "smoking" OR "cigarette" AND "trends" or "projections" for articles published in English before Dec 16, 2014. We identified no articles that provided a comprehensive and comparable systematic assessment of recent trends and projections ensuring consistency for four tobacco use indicators and including target achievement probabilities under the WHO global monitoring framework. We identified articles that estimated recent trends or made projections for a single country or small subsets of countries for one or two indicators.[26–30]

Interpretation

Our findings show that striking between-country disparities in tobacco use would persist in 2025, with many countries not on track towards target achievement and several low-income or middle-income countries at risk of worsening tobacco epidemics if recent trends remain unchanged. Immediate, effective, and sustained action is necessary to attain and maintain desirable trajectories for tobacco control and achieve global convergence towards elimination of tobacco use.

the timeframe of the data, all our projection estimates are subject to the standard limitations of projections based on a functional assumption, irrespective of the sophistication of the Bayesian hierarchical approach. Third, our study did not include estimates for smokeless tobacco, which is an important form of tobacco use. Unfortunately, severe limitations in availability and quality of data for smokeless tobacco compared with smoked forms[43] precluded the inclusion of smokeless tobacco in this study. Additionally, smokeless tobacco could have very different risk factors and use profiles compared with smoked tobacco, and might be better modelled in a separate study focusing on countries known to have appreciable prevalence of this form, rather than as a single indicator in a global study. Fourth, although a formal impact evaluation of the Framework Convention on Tobacco Control has not been done, there is some evidence that it accelerated adoption of some measures for tobacco control,[44] and future shifts occurring after country ratification might not be fully captured in our basis period for projection. However, varying lags in actual implementation of control measures after implementation of the framework, and existing policies for tobacco control in place before the framework, precluded use of the year of ratification as the base point for projections. Instead, we opted to use a common starting point that allowed for a straightforward comparison of projections, and provided a common reference point from which to examine country differences in actual implementation of tobacco control measures. Finally, some of the countries represented in our data had very few datapoints, and the trend estimates for these countries are likely highly affected by regional estimates. For these countries, the trend can be interpreted as their likely future trajectory of tobacco use prevalence if they adopt the tobacco control policies common in their region. Although trend estimates from our research can serve as an indicator of these countries' future tobacco trends, these countries need to improve surveillance and monitoring of tobacco use to properly understand their future risk profile of non-communicable diseases.

Patterns in target achievement probabilities, trajectories, and projected prevalence uncover areas for attention. We estimated low probabilities of target achievement and upward trends in prevalence for most countries in the WHO African region for men and in the WHO eastern Mediterranean region for both sexes. For men, both regions have several countries—six (32%) for the eastern Mediterranean region and 15 (38%) for the African region—with high (≥95%) estimated probabilities of increase, and 37% of the population covered by the African region are almost certain to experience increases in tobacco smoking by 2025 if urgent action is not taken to reverse the progress of the smoking epidemic. Global inequalities in tobacco control continue to exist, with many more high-income than low-income countries achieving reductions in tobacco smoking by 2010, and the future landscape of tobacco control starkly defined by national income: less than 1% of the population of low-income and middle-income countries live in areas with a high probability of achieving tobacco control targets, compared with 36% of the population of high-income countries. International cooperation is thus needed, consistent with evidence that country capacity is a crucial mediator in implementation of tobacco control measures.[45] In view of increasing trends in other risk factors for non-communicable diseases (eg, blood pressure[46] and high body-mass index[47]), and low resources for several countries in these regions, immediate and effective action should be taken to prevent potential epidemics of non-communicable diseases that could burden already-fragile health systems. Tobacco is the most policy-responsive risk factor for non-communicable disesases,[48] and with price the key determinant of initiation and cessation, high specific excise taxes on all brands could prevent increases and induce reductions in prevalence as well as generate revenues for health financing[10] for these countries.

Synthesis of target achievement probabilities and projected prevalence also provides impetus for stronger control strategies for tobacco, even for high-income countries. Projected target achievement should not be taken as cause for complacency; some countries, such as Japan, with greater than 50% probability of achieving the target would still belong to the third-highest quintile of current prevalence of tobacco smoking (29% to <36%) among men in 2025. Our findings lend support to those from a modelling exercise that recommended a more ambitious reduction target for tobacco use to achieve corresponding goals to reduce premature mortality from non-communicable diseases.[48] Although a 30% relative reduction is feasible on the basis of previous experience and is useful for benchmarking progress,[6] it should not hold countries back from aspiring to more challenging yet efficient pathways towards elimination of tobacco use.

Although efforts for tobacco control in the past decade have been successful in reduction of tobacco use in many countries, some countries are at risk of substantial increases in tobacco use, and tobacco control targets remain out of reach for many. If recent trends remain unchanged, we project that many countries will not achieve tobacco control targets and more than 1 billion people will remain current smokers in 2025. Stagnating trends imply that future research is needed to devise ways to accelerate progress and for innovation in tobacco control strategies. Countries in Africa and the eastern Mediterranean, with few resources and fragile health systems, are susceptible to worsening tobacco epidemics, and there is also evidence that the epidemic will persist among women in some high-income countries. Immediate, effective, and sustained action is needed to attain and maintain desirable trajectories towards a tobacco-free world.

Contributors

All authors were involved in study design, data consolidation and processing, model development, analysis, and writing and editing of the report.

Declaration of interests

We declare no competing interests.

Acknowledgments

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References

1 WHO. WHO framework convention on tobacco control. Geneva: World Health Organization, 2003.
2 WHO. Parties to the WHO framework convention on tobacco control. http://www.who.int/fctc/signatories_parties/en/ (accessed Jan 22, 2015).
3 WHO. WHO report on the global tobacco epidemic, 2013: enforcing bans on tobacco advertising, promotion and sponsorship. Geneva: World Health Organization, 2013.
4 WHO. WHO global report on mortality attributable to tobacco. Geneva: World Health Organization, 2012.
5 UN General Assembly. Political declaration of the high level meeting of the general assembly on the prevention and control of non-communicable diseases A/66/L.1. http://www.un.org/ga/search/view_doc.asp?symbol=A/66/L.1 (accessed March 10, 2014).
6 WHO. Draft comprehensive global monitoring framework and targets for the prevention and control of noncommunicable diseases A66/8. http://apps.who.int/gb/ebwha/pdf_files/WHA66/A66_8-en.pdf?ua=1 (accessed Nov 24, 2014).
7 WHO. WHO framework convention on tobacco control: outcomes of the sixth session of the conference of the parties. Moscow: 2014. http://www.who.int/fctc/cop/sessions/COP6factsheet.pdf (accessed March 2, 2015).
8 Ng M, Freeman MK, Fleming TD, et al. Smoking prevalence and cigarette consumption in 187 countries, 1980–2012. *JAMA* 2014; **311:** 183–92.
9 Edwards R. The problem of tobacco smoking. *BMJ* 2004; **328:** 217–19.
10 Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. *N Engl J Med* 2014; **370:** 60–68.
11 IARC Working Group on Methods for Evaluating Tobacco Control Policies. Methods for evaluating tobacco control policies. Lyon: International Agency for Research on Cancer, 2008.
12 WHO. Global adult tobacco survey. http://www.who.int/tobacco/surveillance/survey/gats/en/ (accessed Dec 18, 2014).
13 WHO. World health survey. http://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/whs/about (accessed Dec 18, 2014).
14 National Center for Chronic Disease Prevention and Health Promotion Division of Population Health. CDC—BRFSS—Behavioral Risk Factor Surveillance System. Atlanta, GA: Centers for Diseases Control and Prevention, 2014. http://www.cdc.gov/brfss/ (accessed Dec 18, 2014).
15 WHO. STEPwise approach to surveillance. Geneva: World Health Organization, 2014. http://www.who.int/chp/steps/en/ (accessed Dec 18, 2014).
16 Global Tobacco Surveillance System (GTSS). Global adult tobacco survey (GATS): indicator guidelines: definition and syntax. 2009. http://www.who.int/tobacco/surveillance/en_tfi_gats_indicator_guidelines.pdf (accessed Dec 18, 2014).
17 Lopez AD, Collishaw NE, Piha T, et al. A descriptive model of the cigarette epidemic in developed countries. *Tob Control* 1994; **3:** 242.
18 Perry CL, Eriksen M, Giovino G, et al. Tobacco use: a pediatric epidemic. *Tob Control* 1994; **3:** 97.
19 UN Statistics Division. Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings. http://millenniumindicators.un.org/unsd/methods/m49/m49regin.htm (accessed Dec 18, 2014).
20 van Rossum G, Drake FL, eds. Python reference manual. Virginia, VA, USA: PythonLabs, 2001. http://www.python.org (accessed March 2, 2015).
21 Flaxman A, Vos T, Murray CJL, eds. An integrative metaregression framework for descriptive epidemiology. Washington, DC: University of Washington Press, 2014 (in press).
22 Patil A, Huard D, Fonnesbeck CJ. PyMC: Bayesian stochastic modelling in Python. *J Stat Software* 2010; **35:** 1–81.
23 Ahmad OB B-PC, Lopez AD, Murray CJ, Lozano R, Inoue M. Age standardization of rates: a new who standard. http://www.who.int/healthinfo/paper31.pdf (accessed Dec 9, 2013).
24 UN Department of Economic and Social Affairs Population Division. World population prospects: the 2012 revision, methodology of the United Nations Population Estimates and Projections. ESA/P/WP.235. New York, NY: United Nations, 2014. http://esa.un.org/wpp/documentation/publications.htm (accessed March 1, 2015).
25 Kass RE, Raffery AE. Bayes factors. *J Am Statist Assoc* 1995; **90:** 773–95.
26 Mendez D, Alshanqeety O, Warner KE. The potential impact of smoking control policies on future global smoking trends. *Tob Control* 2013; **22:** 46–51.
27 Fu M, Martinez-Sanchez JM, Cleries R, et al. Opposite trends in the consumption of manufactured and roll-your-own cigarettes in Spain (1991–2020). *BMJ Open* 2014; **4:** e006552.
28 Manuel DG, Tuna M, Hennessy D, et al. Projections of preventable risks for cardiovascular disease in Canada to 2021: a microsimulation modelling approach. *CMAJ Open* 2014; **2:** E94-E101.
29 Sozmen K, Unal B, Saidi O, et al. Cardiovascular risk factor trends in the Eastern Mediterranean region: evidence from four countries is alarming. *Int J Public Health* 2015; **60** (suppl 1): S3–11.
30 van der Deen FS, Ikeda T, Cobiac L, Wilson N, Blakely T. Projecting future smoking prevalence to 2025 and beyond in New Zealand using smoking prevalence data from the 2013 Census. *N Z Med J* 2014; **127:** 71–79.
31 WHO. WHO Report on the Global Tobacco Epidemic, 2008: the MPOWER package. Geneva: World Health Organization, 2008.
32 Aaro LE LK, Vedoy TF, Overland S. Evaluering av myndighetenes samlede innsats for å forebygge tobakksrelaterte sykdommer i perioden 2003 til 2007. 3/2009. http://www.sirus.no/filestore/Import_vedlegg/sirusrap.3.09.pdf (accessed Dec 5, 2014).
33 Helsedirektoratet. Facts and figures. http://www.helsedirektoratet.no/english/topics/tobacco-control/facts-and-figures/Sider/default.aspx (accessed Dec 5, 2014).

34 Helsedirektoratet. Norway's strategy and policies for tobacco control. http://www.helsedirektoratet.no/english/topics/tobacco-control/strategy-and-policies/Sider/default.aspx (accessed Dec 5, 2014).

35 Norwegian Institute of Public Health. Health risks of Scandinavian snus consumption (English summary). 2014. http://www.fhi.no/dokumenter/a32e0bfe81.pdf (accessed Jan 25, 2015).

36 Ramstrom LM, Foulds J. Role of snus in initiation and cessation of tobacco smoking in Sweden. *Tob Control* 2006; **15:** 210–14.

37 Foulds J, Ramstrom L, Burke M, Fagerstrom K. Effect of smokeless tobacco (snus) on smoking and public health in Sweden. *Tob Control* 2003; **12:** 349–59.

38 Luo J, Ye W, Zendehdel K, et al. Oral use of Swedish moist snuff (snus) and risk for cancer of the mouth, lung, and pancreas in male construction workers: a retrospective cohort study. *Lancet* 2007; **369:** 2015–20.

39 England LJ, Levine RJ, Mills JL, Klebanoff MA, Yu KF, Cnattingius S. Adverse pregnancy outcomes in snuff users. *Am J Obstet Gynecol* 2003; **189:** 939–43.

40 Bryant J, Bonevski B, Paul C, Lecathelinais C. Assessing smoking status in disadvantaged populations: is computer administered self report an accurate and acceptable measure? *BMC Med Res Methodol* 2011; **11:** 153.

41 Wong SL, Shields M, Leatherdale S, Malaison E, Hammond D. Assessment of validity of self-reported smoking status. *Health Rep* 2012; **23:** 47–53.

42 WHO. WHO protocols and guidelines. http://www.who.int/tobacco/surveillance/guide/en/ (accessed Dec 5, 2014).

43 Mackay J, Eriksen MP, Ross H. The tobacco atlas, 4th edn. Atlanta, Ga: American Cancer Society, 2012.

44 Sanders-Jackson AN, Song AV, Hiilamo H, Glantz SA. Effect of the framework convention on tobacco control and voluntary industry health warning labels on passage of mandated cigarette warning labels from 1965 to 2012: transition probability and event history analyses. *Am J Public Health* 2013; **103:** 2041–47.

45 Hiilamo H, Glantz SA. Implementation of effective cigarette health warning labels among low and middle income countries: state capacity, path-dependency and tobacco industry activity. *Soc Sci Med* 2015; **124:** 241–45.

46 Danaei G, Finucane MM, Lin JK, et al, for the Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group (Blood Pressure). National, regional, and global trends in systolic blood pressure since 1980: systematic analysis of health examination surveys and epidemiological studies with 786 country-years and 5·4 million participants. *Lancet* 2011; **377:** 568–77.

47 Finucane MM, Stevens GA, Cowan MJ, et al, for the Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group (Body Mass Index). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *Lancet* 2011; **377:** 557–67.

48 Kontis V, Mathers CD, Rehm J, et al. Contribution of six risk factors to achieving the 25×25 non-communicable disease mortality reduction target: a modelling study. *Lancet* 2014; **384:** 427–37.

参考資料４

Estimation of the burden of disease in Japan. Presented at the Symposium on Environmental Burden of Disease in Japan. Sungkyunkwan University School of Medicine. Feb. 24th, 2015.

Estimation of the burden of disease in Japan

Stuart Gilmour, Ver Bilano, Yi Liao,
Kenji Shibuya

February 23rd, 2015

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1

Introduction and Objectives: JBD

Japanese administrative divisions:

- Prefectures
- Municipalities

Japanese geographical and cultural divisions:

- Four islands + Okinawa
- North/south variation in weather and history
- Megalopolis vs. ageing coast
- Inequality

Need to understand sub-national patterns of illness and risk

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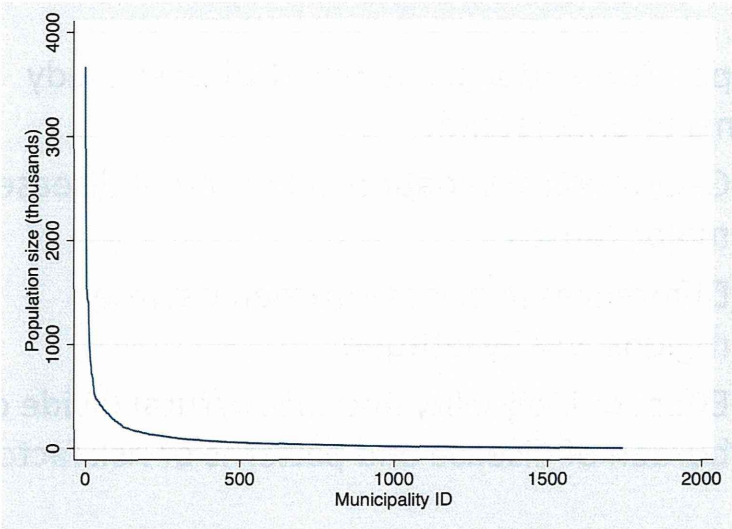
2

The megalopolis



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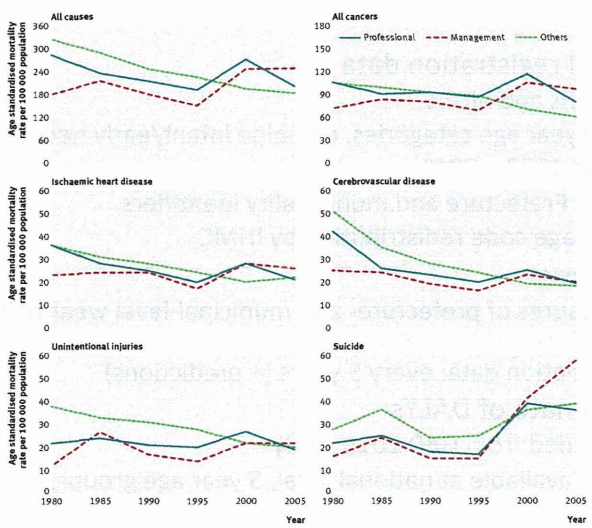
Patterns of inequality



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Objectives

Japan Sub-national Burden of Disease study aims to understand:

- Geographical variation in burden of disease by major causes
- Differences in disease burden between regions and by latitude
- Effect of inequality and urban/rural divide on burden of disease and patterns of risk factors

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Methods: Data sources

Japan vital registration data
- Deaths and births
- Five year age categories, combine infant/early neonatal/child
- From 1979 – 2011
- With Prefecture and municipality identifiers
- Garbage code redistribution by IHME

Japan census
- Measures of prefecture- and municipal-level wealth, industry, facilities and inequality
- Population data: every 5 years (+ predictions)

IHME Estimate of DALYs
- Provided from GBD 2013 study
- Only available at national level, 5 year age groups, cause

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Methods: Mortality and YLLs

Initial model at IHME Cause level 2

Semi-parametric smoothed model :

- Natural logarithm of population rates
- Separate random effects regression model by cause
- Smooth residuals
- Scale back to mortality envelope

YLLs calculated from IHME model life-table

Methods: YLDs and DALYs

Limited sub-national data in Japan

Only robust data is for cancer incidence

Estimate Indicative YLDs only

Use IHME estimate of national YLDs

- Linear model of ln(YLD rate) by cause
- Age/sex, age/year, sex/year interaction model
- Estimate predicted values at Prefecture level

DALYs calculated from this YLD estimate + YLLs

Results: Overview

Year	Deaths	YLLs	DALYs
1995	925,585	15,453,000	28,550,000
2000	965,099	14,829,000	28,579,000
2005	1,088,273	14,856,000	29,296,000
2010	1,202,309	14,352,000	29,458,000

YLL rate in 2010 (crude, per 1000): 113.17
DALY rate in 2010 (crude, per 1000): 232.30

Leading cause: Cancer, in all years

Variation from IHME Estimates:
- Deaths: Underestimate by 2%
- YLLs: Underestimate by 8%

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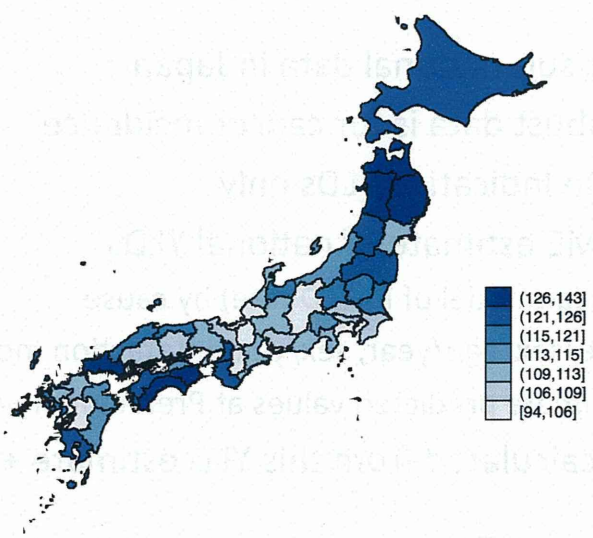
9

Results: YLLs per 1000 population (crude)



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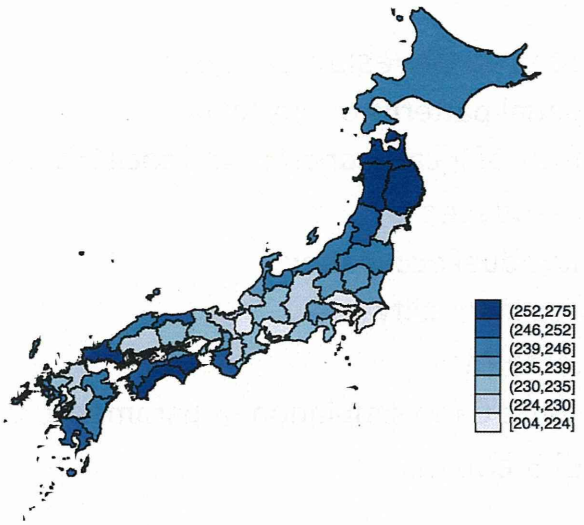
Results: DALYs per 1000 population (crude)



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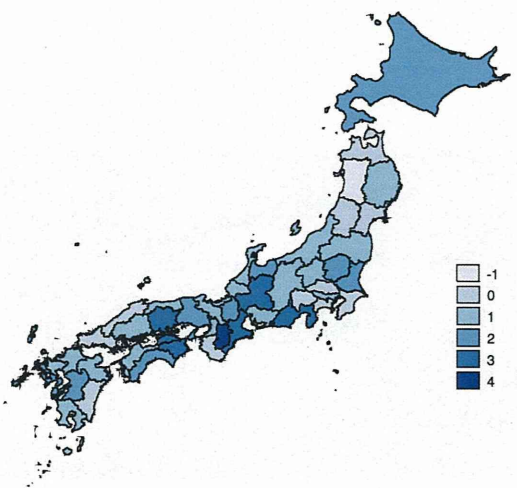
11

Results: Change in cause ranking for suicide, 1995-2010



Largest increase in:
- Nara
- Tokushima
- Okayama
- Gifu
- Shizuoka
- Kagawa
- Mie

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12

Further research

- Small area Bayesian analysis
  - Spatial patterns of mortality
  - Effect of local economic and social factors
- Sub-analyses
  - Individual occupation
  - Area inequality
- Uncertainty
  - Monte Carlo simulation or parametric models?
- Level 3 causes

Estimating the burden of disease from the Great East Japan Tsunami and nuclear accident

Introduction

Disasters have effects on different time frames

- Acute: initial mortality
- Short term: Evacuation and resettlement
- Medium term: Instability and stress
- Long term: Effects of disruption and loss

Can we quantify them?

2011 Great East Japan Earthquake, Tsunami and Nuclear Accident: triple disaster with effects across all time frames

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The 3.11 Disaster: Acute effects

- Deaths: 18,894
- Missing: 3,305
- YLLs: 472,981
- Homes lost: 127,531

Standard modeling underestimates mortality and YLLs from "forces of nature" in Japan

Are there indirect effects and can we calculate them?

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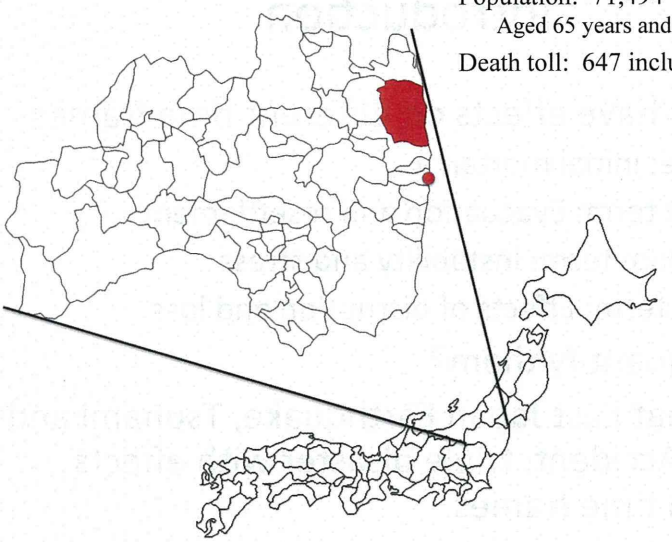
16

Minamisoma City

Population: 71,494
Aged 65 years and over: 18,536 (25.9%)
Death toll: 647 including missing



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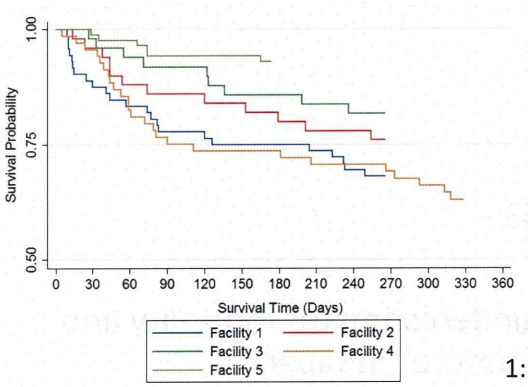
17

Results:
Facility-specific hazard ratio after the earthquake



1: 2.88 (1.74, 4.76) – significant
2: 2.40 (1.24, 4.67) – significant
3: 1.39 (0.69, 2.81)
4: 2.36 (1.49, 3.76) – significant
5: 0.77 (0.34, 1.76)

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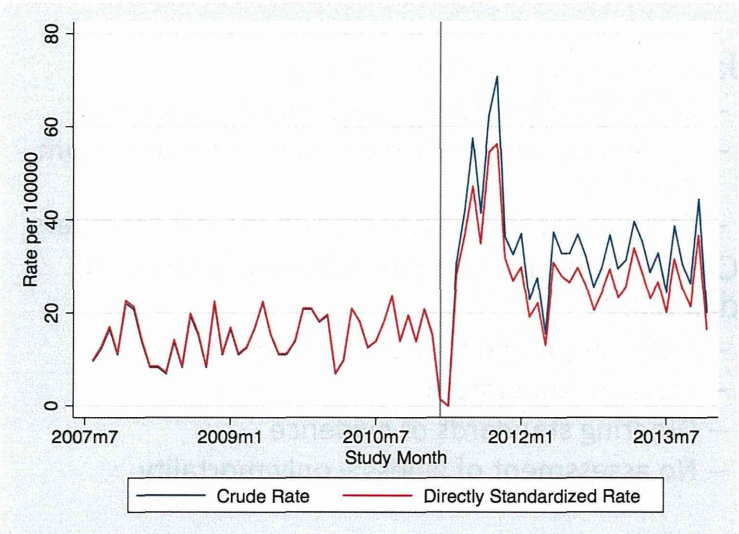
18

Results: Stroke hospitalization rates, 2008 - 2013



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19

Disaster-related deaths

- Deaths arising due to disasters but not directly caused by them
- Examples:
  - Diabetes and heart disease mortality due to medication disruption (Katrina)
  - Increased stroke and myocardial infarction due to stress (Hanshin earthquake)
  - Infectious disease due to disruption of civil society (Haiti)
  - Suicide arising from stress

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20

Disaster-related deaths in Japan

- Japanese government policy
  - 災害関連死弔慰金 (*saigai kanrenshi choikin*)
  - System of compensation for deaths arising from disasters
  - Families receive compensation for lost members
- Can we use this data to identify burden of disease?
  - Judgment made by a committee
  - Inconsistent system
  - Differing standards of evidence
  - No assessment of illness – only mortality

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Possible disaster-related morbidity in Minamisoma

- Direct effects from disruption:
  - Depression, stress, other mental disorders
  - Radiation-related cancers
  - Long-term sequela of injury (largely unmeasured)
- Indirect effects:
  - Behavioral disorders in the elderly
  - Secondary sequela of suicide and mortality
  - Increased risk factors (hypertension, physical inactivity)

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Conclusion

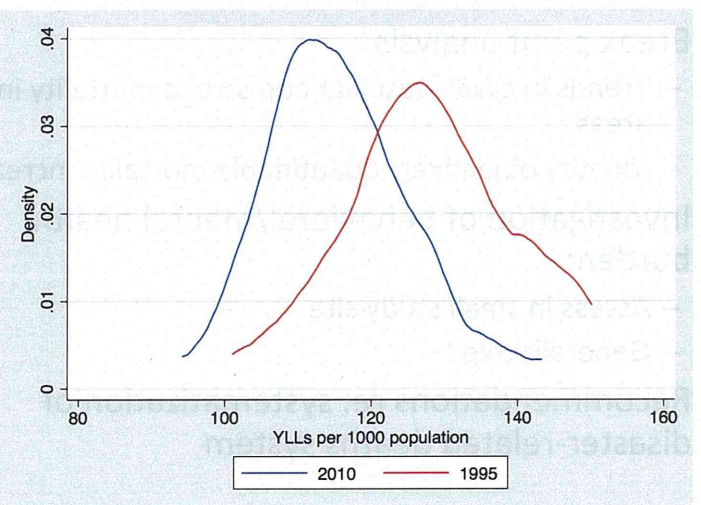
- Direct mortality and YLLs easily quantifiable
- Direct YLDs not yet understood
  - Need comprehensive survey of survivors
  - Evacuation->Population redistribution-> Unidentifiable
- Indirect YLLs and YLDs probably unmeasurable
- Compensation schemes may enable quantification of some indirect burden
  - Not operating in many settings
  - Often poorly documented and arbitrary
  - Welfare focused
- Quantification of the complete burden due to disasters is still largely impossible

Future research

- Break point analysis
  - Trends in cardiovascular and stroke mortality in small areas
  - Identify objectively quantifiable mortality increase
- Investigation of behavioral/mental health burden:
  - Assess in small study site
  - Generalizable?
- Recommendations re: systematization of disaster-related deaths system

Appendices

Density of YLLs by Prefecture (rate): 1995 and 2010



参考資料 5

GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 385(9963):117-171

Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013

*GBD 2013 Mortality and Causes of Death Collaborators**

Summary

Background Up-to-date evidence on levels and trends for age-sex-specific all-cause and cause-specific mortality is essential for the formation of global, regional, and national health policies. In the Global Burden of Disease Study 2013 (GBD 2013) we estimated yearly deaths for 188 countries between 1990, and 2013. We used the results to assess whether there is epidemiological convergence across countries.

Methods We estimated age-sex-specific all-cause mortality using the GBD 2010 methods with some refinements to improve accuracy applied to an updated database of vital registration, survey, and census data. We generally estimated cause of death as in the GBD 2010. Key improvements included the addition of more recent vital registration data for 72 countries, an updated verbal autopsy literature review, two new and detailed data systems for China, and more detail for Mexico, UK, Turkey, and Russia. We improved statistical models for garbage code redistribution. We used six different modelling strategies across the 240 causes; cause of death ensemble modelling (CODEm) was the dominant strategy for causes with sufficient information. Trends for Alzheimer's disease and other dementias were informed by meta-regression of prevalence studies. For pathogen-specific causes of diarrhoea and lower respiratory infections we used a counterfactual approach. We computed two measures of convergence (inequality) across countries: the average relative difference across all pairs of countries (Gini coefficient) and the average absolute difference across countries. To summarise broad findings, we used multiple decrement life-tables to decompose probabilities of death from birth to exact age 15 years, from exact age 15 years to exact age 50 years, and from exact age 50 years to exact age 75 years, and life expectancy at birth into major causes. For all quantities reported, we computed 95% uncertainty intervals (UIs). We constrained cause-specific fractions within each age-sex-country-year group to sum to all-cause mortality based on draws from the uncertainty distributions.

Findings Global life expectancy for both sexes increased from 65·3 years (UI 65·0–65·6) in 1990, to 71·5 years (UI 71·0–71·9) in 2013, while the number of deaths increased from 47·5 million (UI 46·8–48·2) to 54·9 million (UI 53·6–56·3) over the same interval. Global progress masked variation by age and sex: for children, average absolute differences between countries decreased but relative differences increased. For women aged 25–39 years and older than 75 years and for men aged 20–49 years and 65 years and older, both absolute and relative differences increased. Decomposition of global and regional life expectancy showed the prominent role of reductions in age-standardised death rates for cardiovascular diseases and cancers in high-income regions, and reductions in child deaths from diarrhoea, lower respiratory infections, and neonatal causes in low-income regions. HIV/AIDS reduced life expectancy in southern sub-Saharan Africa. For most communicable causes of death both numbers of deaths and age-standardised death rates fell whereas for most non-communicable causes, demographic shifts have increased numbers of deaths but decreased age-standardised death rates. Global deaths from injury increased by 10·7%, from 4·3 million deaths in 1990 to 4·8 million in 2013; but age-standardised rates declined over the same period by 21%. For some causes of more than 100 000 deaths per year in 2013, age-standardised death rates increased between 1990 and 2013, including HIV/AIDS, pancreatic cancer, atrial fibrillation and flutter, drug use disorders, diabetes, chronic kidney disease, and sickle-cell anaemias. Diarrhoeal diseases, lower respiratory infections, neonatal causes, and malaria are still in the top five causes of death in children younger than 5 years. The most important pathogens are rotavirus for diarrhoea and pneumococcus for lower respiratory infections. Country-specific probabilities of death over three phases of life were substantially varied between and within regions.

Interpretation For most countries, the general pattern of reductions in age-sex specific mortality has been associated with a progressive shift towards a larger share of the remaining deaths caused by non-communicable disease and injuries. Assessing epidemiological convergence across countries depends on whether an absolute or relative measure of inequality is used. Nevertheless, age-standardised death rates for seven substantial causes are increasing, suggesting the potential for reversals in some countries. Important gaps exist in the empirical data for cause of death estimates for some countries; for example, no national data for India are available for the past decade.

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See Comment page 92

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For interactive versions of figure 7 and figure appendices 1–3, visit http://vizhub.healthdata.org/le

Introduction

The Global Burden of Disease (GBD) study provides a unique comprehensive framework to systematically assess national trends in age-specific and sex-specific all-cause and cause-specific mortality. Up-to-date and comprehensive evidence for levels and trends for each country is critical for informed priority setting. Trends quantify progress against explicit health targets, whether local, national, or global, and help to evaluate where programmes are working or not. Quantification across populations and over time using comparable definitions and methods can also enable benchmarking. Regular comprehensive updates about causes of death will identify emerging public health challenges. The GBD 2013 study provides the first GBD study to use a continuously updated approach to global health surveillance.[1]

The GBD 2010 study, a collaboration of 488 investigators, showed important global and regional trends for all-cause and cause-specific mortality.[2–8] The GBD 2010 reported substantial decreases in child mortality driven by reductions in diarrhoea, lower respiratory infections, and more recently, malaria. The lowest income regions had progressed in combating maternal mortality, HIV/AIDS, tuberculosis, and malaria. Nevertheless, much work remains to be done for these Millennium Development Goal-related diseases. Outside sub-Saharan Africa, 1990–2010 saw rapid shifts towards a larger share of death from non-communicable diseases and injuries and a rising mean age of death. Country analyses using the GBD 2010 database have been reported for China, Iran, Mexico, UK, and USA, taking advantage of the comparable methods and definitions of the GBD to benchmark these countries against their peers.[9–16]

See Online for appendix

Much debate surrounds what should follow the Millennium Development Goals; objective, timely, and comprehensive evidence for the levels and trends in causes of death can be a useful input. Ambitious goals have been discussed,[16] such as the elimination of preventable child and maternal mortality in a generation. Targets of zero disease have been formulated for HIV/AIDS, tuberculosis, and malaria by various groups.[17–23] *The Lancet* Commission on *Global health 2035: a world converging within a generation*[24] suggested that a grand convergence in health can be achieved between poor and rich countries by 2035. Advocates for non-communicable disease programmes argue[25] that rapid epidemiological transitions in many regions of the world require broader health goals for the development community. Movements to focus on universal health coverage in the post-2015 health agenda emphasise the consequences of failure to meet basic health-care needs.[24–27]

Broad interest in the GBD 2010 has led to the expansion of the GBD collaboration to include more than 1000 investigators in 106 countries. The GBD 2013 not only incorporates newly published or released datasets, particularly from the past 5 years, but also expands the analysis in other ways. We included subnational assessments for provinces of China, states of Mexico, and regions of the UK. These subnational assessments will help national decision makers to identify inequalities and local variation in leading diseases, injuries, and risk factors. The list of causes has been expanded and many new and more detailed data sources incorporated. We report the new findings for the first time at the country-level for 1990–2013.

Methods

Study design

The GBD approach to estimating all-cause mortality and cause-specific mortality has been previously described.[2,3] Here, we describe several refinements.[28] Figure 1 shows the general analysis of all-cause mortality and cause-specific mortality and their interactions. GBD 2010 included 291 causes of death or disability, of which 235 were causes of death; we have expanded the list to include 306 causes of death or disability, of which 240 are causes of death. The extra causes were added on the basis of three considerations: (1) causes that were for epidemiological reasons already modelled separately but reported combined with other causes in GBD 2010—for example, silicosis, asbestosis, anorexia nervosa, and typhoid and paratyphoid fever; (2) the category of other unintentional injuries was large and heterogeneous so we broke it down further to include pulmonary aspiration and foreign body in trachea or lung, foreign body in other part of body, and unintentional suffocation; and (3) new datasets became available to enable estimation of mesothelioma, new maternal sub-causes, neonatal haemolytic anaemia, and chronic kidney disease caused by glomerulonephritis. Appendix pp 245–251 provides the International Classification of Diseases codes for the GBD 2013 cause list. After broad consultation, we have removed from the cause list the pathogen-specific causes of diarrhoeal diseases and lower respiratory infections. Instead, we analysed these causes with a counterfactual approach.

We assessed 21 regions and seven super-regions as defined in the GBD 2010. The GBD 2013 also included an assessment of subnational populations in three countries: provinces for China, states for Mexico, and the UK broken down into Scotland, Wales, Northern Ireland, and nine regions of England. We analysed these countries subnationally because of the interest from national collaborators and because sufficient data were made available by the teams in each country. In future iterations of the GBD, we hope to include further subnational breakdowns. In addition, we separately analysed data sources for rural and urban regions in India. This approach improved our estimation of mortality and causes of death and enabled us to analyse causes of death that were specific to urban or rural regions alone.