Transitions of cardio-metabolic risk factors in the Americas between 1980 and 2014

NCD Risk Factor Collaboration (NCD-RisC) – Americas Working Group*

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Abstract

Background: Describing the levels and trends of cardio-metabolic risk factors associated with non-communicable diseases (NCDs) is vital for monitoring progress, planning prevention and provide evidence to support policy efforts. We aimed to analyse the transition in body-mass index (BMI), obesity, blood pressure, raised blood pressure (RBP) and diabetes in the Americas, 1980-2014.

Methods: Pooled analysis of population-based studies with data on anthropometric measurements, biomarkers for diabetes, and blood pressure from adults aged 18+ years. A Bayesian model was used to estimate trends in BMI, RBP (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg) and diabetes (fasting plasma glucose ≥7.0 mmol/l, history of diabetes, or diabetes treatment) from 1980 to 2014 in 37 countries and 6 sub-regions of the Americas.

Findings: 389 population-based surveys from the Americas were available. Comparing the 2014 with the 1980 prevalence estimates, the obesity ratio was the largest in the non-English-speaking Caribbean sub-region (4.71 in men and 2.50 in women) showing that the prevalence in 2014 for men is almost five times larger than it was in 1980. The English-speaking Caribbean sub-region had the largest ratio regarding diabetes (2.14 in men and 2.13 in women). Conversely, the ratio for RBP signals that the frequency of this condition has diminished across the region; the largest decrease was found in North America (0.56 in men and 0.54 in women).

Interpretation: Despite the generally high prevalence of cardio-metabolic risk factors across the Americas region, estimates also show a high level of heterogeneity in the transition between countries.

Funding: Wellcome Trust.

Research in context

Evidence before this study

We searched Medline (through PudMed) using the terms ((hypertension[Title] OR “blood pressure”[Title]) OR (diabetes[Title] OR “type 2 diabetes”[Title]) OR (BMI[Title] OR “body mass index”[Title])) AND ("Americas"[Mesh]).

National estimates covering all indicators reported in this study were not found, i.e., studies were largely conducted in limited regions/sites. The search yielded two reviews of diabetes and obesity prevalence in Latin American countries, published in 2002, indicating that an update of this evidence is warranted. Overall, the available evidence seems to be limited to country-based research on the epidemiology of cardio-metabolic risk factors. Comparable metrics between countries in the Americas region covering a large study period have not been published.

Added value of this study

This work provides the most comprehensive analysis of trends in cardio-metabolic risk factors, namely body mass index, blood pressure and diabetes, in the Americas region. This research covers a substantially longer period (1980-2014) than any previous work and provides estimates for 37 countries and territories in the Americas. This work informs that the frequency of high body mass index and diabetes has increased throughout the region and, conversely, the prevalence of raised blood pressure appears to have decreased over time. The findings suggest that countries with high prevalence of a risk factor do not necessarily have also high frequency of another risk factor. The results signal different patterns of convergence and divergence between risk factors within sub-regions.

Implications of all the available evidence

Despite a significant improvement observed in the prevalence of raised blood pressure across the region, much work is still needed to curtail the increasing burden of high body mass index and diabetes. Cardio-metabolic risk factors are rising on the public health agenda of governments in the Americas region, particularly among LMICs in the region, and the 2019 United Nations General Assembly high-level meeting on universal health coverage is also encouraging. This momentum can benefit from the use of regional trends from this study, which will inform policy and action in the Americas region.

Introduction

With over 41 million annual deaths, non-communicable diseases (NCDs) and their associated risk factors pose significant challenges for global health.[1,2] In the region of the Americas almost 6 of the 7 million deaths occurred in 2017 were due to NCDs, 14% of the total global NCDs deaths.[3] Although countries in some sub-regions of the Americas share many cultural, economic and developmental similarities, yet differences in urbanisation, pace and timing of the demographic, nutritional, and epidemiological transitions, have led to high levels of heterogeneity in the burden of NCDs across countries in the region. In 2017 the age-standardised mortality rate for NCDs in the region ranged from below 350 deaths per 100,000 people in Peru, Colombia and Canada to over 890 deaths per 100,000 people in Haiti, a level above the one observed in any other country in the region in 1990.[2]

As part of the challenges posed by the increasing burden of NCDs in the region, the plan of action of the Pan American Health Organization strategy for the prevention and control 2021-2025 was set with the aim to reduce avoidable mortality and morbidity associated with NCDs as well as to minimize the exposure to risk factors through a series of actions at the regional and national levels; this initiative aligned with the World Health Organization NCD Global Monitoring Framework and Global Action Plan 2013-2020.[4,5]

Describing the levels and trends of cardio-metabolic risk factors associated with NCDs is vital for monitoring progress, planning prevention and provide evidence to support policy efforts.[5,6] Previous analyses have either focused on trends and burden of single risk factors in the region,[7–10] or on cross-sectional analyses without exploring change over time.[11] Given the relevance of these risk factors for health policy and decision-making, and focusing exclusively on the Americas, we analysed national and sub-regional trends from 1980 to 2014 in mean body-mass index (BMI), obesity, mean systolic blood pressure, raised blood pressure (RBP) and diabetes in adults.

Methods

Study design and data sources

Data used in this analysis were pooled and analysed by the NCD Risk Factor Collaboration (www.ncdrisc.org) and have been described in detail elsewhere (**Appendix 1**).[7–9] Here, we analysed national and regional trends in mean BMI, prevalence of obesity, mean systolic and diastolic blood pressure, prevalence of RBP (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg), and prevalence of diabetes (fasting plasma glucose ≥7.0 mmol/l, history of diabetes, or diabetes treatment) in adults aged 18 years and older, in the 37 countries of the Americas. For mean BMI and prevalence of obesity, results are reported for ages 20 years and above. While the NCD Risk Factor Collaboration has released estimates for BMI, prevalence of obesity, mean systolic and diastolic blood pressure, prevalence of RBP up to 2016, estimates for diabetes are only available up to 2014. To keep consistency in the analysis across the three risk factors the study period has been limited to 1980-2014. In addition, while estimates for BMI prevalence were available for seven different categories (<18·5 kg/m², 18·5 kg/m² to <20 kg/m², 20 kg/m² to <25 kg/m², 25 kg/m² to <30 kg/m², 30 kg/m² to <35 kg/m², 35 kg/m² to <40 kg/m², and ≥40 kg/m²) here we report only the prevalence of obesity (BMI≥ 30 kg/m²), which is of key public health concern in the Americas.

Estimates were obtained using population-based data sources representative of national, sub-national (i.e. covering ≥1 sub-national regions, or >3 communities) or community (≤3 communities) levels, with measured height or weight, systolic or diastolic blood pressure, or at least one of the following diabetes biomarkers: fasting plasma glucose (FPG), oral glucose tolerance (OGTT) or glycated haemoglobin (HbA1c). Conversion of diabetes biomarkers to a common definition is described elsewhere.[9]

Statistical analysis

Analyses were done separately for men and women, using a Bayesian model to obtain estimates by age group, country and year. The model used here has been described and validated previously (**Appendix 1**);[7–9,12] the model had a hierarchical structure in which estimates for each country and year were informed by its own data, data from other years in the same country and data in other countries in the same region.[13] The hierarchical structure shared information to a greater degree when data were non-existent or weakly informative (e.g., a study with a small sample size is less informative than a

study in the same country and year with a larger sample), and to a lesser extent for data-rich countries and sub-regions.The model incorporated non-linear time trends and age patterns, allowing the age pattern to vary across countries. The model accounted for the possibility that the risk factors in subnational and community samples might systematically differ from nationally representative ones, and have larger variation than in national studies. These features were implemented by including data-driven fixed-effect and random-effect terms for subnational and community data. The fixed effects adjusted for systematic differences between subnational or community studies and national studies. The random effects allowed national data to have larger influence on the estimates than subnational or community data with similar sample sizes. The model also accounted for rural–urban differences in risk factors, through the use of data-driven fixed effects for rural only and urban-only studies. These rural and urban effects were weighted by the difference between study-level and country-level urbanisation in the year when the study was done. The statistical model included a country level-covariates specific to each of the risk factors - proportion of national population living in urban areas for BMI; average number of years of education, proportion of national population living in urban areas, a summary measure of availability of different food types for human consumption for DM and BP, and age-standardised adult mean BMI for DM. We fitted this Bayesian model with the Markov chain Monte Carlo (MCMC) algorithm. We ran 55,000 iterations, monitoring convergence, and discarded 5,000 to give 50,000 iterations. We then thinned the chains, to give 5,000 iterations for each chain. The 20 chains were then combined, and further thinning was carried out to give the final 5,000 samples from the posterior distribution of model parameters, which were then used to obtain the posterior distributions. The reported credible intervals (CrIs) represent the 2.5^{th}-97.5^{th} percentiles of the posterior distributions. Reported estimates were age-standardised using the World Health Organization standard population.[14] Results are presented at sub-regional and country level. Classification of countries into sub-regions (using posterior estimates) is described in **Appendix Table S1** and classification of the countries is based on geographical, cultural and epidemiological similarities among countries. To evaluate the correlation between risk factors, the Spearman's correlation rank test for risk factor prevalence was used. Probabilities of increases or decreases in risk factors were calculated using the proportion of MCMC draws in which increases or decreases were observed.

Results

Number of data sources

The analysis used 389 population-based surveys from the region, of which 236 had information on BMI (1,783,267 participants), 223 surveys on blood pressure (1,042,131 participants), and 108 surveys on diabetes (284,555 participants). Among the 37 countries included, only Antigua and Barbuda, Bahamas, Bermuda, and Saint Vincent and the Grenadines had no studies available (**Figure 1**; see **Appendix Table S1** for information on the number of data sources by country, sub-region and risk factor).

Risk factors levels and trends across sub-regions

Over the period from 1980 to 2014, the age-standardised mean BMI, age-standardised prevalence of obesity and diabetes increased in both sexes in all sub-regions in the Americas, whereas the age-standardised prevalence of RBP and the age-standardised mean systolic blood pressure declined in some sub-regions and did not change in others (**Figures 2A** and **2B** for prevalences; see **Appendix Figure S1** and **S2** for means, and **Appendix Table S2 and S3**).

Obesity, and similarly mean BMI, increased everywhere in the region with the fastest increase observed in the non-English-speaking Caribbean sub-region with prevalence of obesity going from 3.9% (95% CrI: 2.2%-6.3%) in 1980 to 18.6% (14.3%-23.3%) in 2014 among men, and from 12.2% (8.2%-17.0%) in 1980 to 30.5% (25.7%-35.5%) in 2014 among women. The English-speaking Caribbean sub-region ranked first for prevalence of diabetes, 11.1% (6.4%-17.3%) in men and 13.6% (8.2%-21.0%) in women in 2014, with prevalence levels being 2.1 times larger (for men and women) in 2014 when compared to 1980 levels. A decrease in RBP is observed in all the sub-region regardless of the levels observed in 1980, with the largest fall being in North America from 27.6% (22.3%-33.2%) and 19.9% (15.8%-24.4%), respectively among men and women in 1980, to 15.5% (11.1%-20.9%) and 10.7% (7.7%-14.5%) in 2014 (**Appendix Table S2, S3 and S4)**.

Although there had been a decline in mean systolic blood pressure, since early 2000s this trend appears to have stopped or reverted, particularly in North America, Central Latin America, Andean Latin America and Southern Latin America for men and in North America and Central Latin America for women

(**Appendix Figure S1** (men) and **S2** (women)). On the other hand, mean BMI has been increasing almost linearly until early 2000s, when this pace seems to have slowed down in North America for both men and women and in Central America and Andean Latin America for women.

The consistent risk factor trends observed in the region hid non-uniform sub-regional trends (**Figure 3**). A regional convergence for both men and women is observed in the prevalence of RBP over time (**Figure 3B**), with North America (i.e., USA and Canada) showing a convergence towards much lower levels when compared to the other sub-regions. A more complex pattern is observed in the prevalence of obesity (**Figure 3A**) and diabetes (**Figure 3C**) with a combination of sub-regional divergences, such as the variation of prevalence of obesity in all the sub-regions for men or diabetes in women.

Risk factors levels and trends within sub-regions

The age-standardised prevalence of obesity, RBP and diabetes for each country in 2014 are shown in the heatmap (**Figure 4A** and **4B**, and **Appendix Table S5**), while corresponding estimates for 1980 are provided in **Appendix Figure S3.** Country-specific trends are available at www.ncdrisc.org.

The age-standardised prevalence of obesity in men increased from 1980 to 2014 in every country, with a range of 2.1 to 2.5-fold in Bermuda, Argentina and Chile (probability of an increase = 0.999, >0.999 and >0.999, respectively), to 8.3-fold in Haiti (p>0.999) (**Figure 4A**). In women, the age-standardised prevalence of obesity increased by 1.4 to 1.8-fold in Bermuda, Bahamas, Uruguay and Venezuela (p=0.99,>0.999,>0.999 and 0.999, respectively) to 4.4-fold in Haiti (p>0.999) (**Figure 4B**). Yet, for men in 2014 the prevalence of obesity was above 20% in almost a third of the countries with the USA ranking first with 35% (30%-40%); whereas for women, all countries had a prevalence of obesity above 20%, with 16 out of 37 of them above 30%.

Changes in prevalence of RBP between 1980 and 2014 ranged from a 50% reduction in Canada among men (p>0.999) and a 60% reduction in Bermuda (p=0.999) among women. Most countries showed declines in the prevalence of RBP, and the only two countries where increases were noted were in Saint Lucia (10%, p=0.75 for men and p=0.63 for women) and in Trinidad and Tobago (20%, p=0.72 for men and p=0.74 for women) for both sexes (**Figure 4A** and **4B**). In 2014 the higher proportions of RBP in men, with prevalences from 28%-30%, were concentrated in the countries within the English-speaking Caribbean and Southern Latin America sub-regions (Saint Lucia, Paraguay, Saint Kitts and

Nevis, and Argentina), whereas for women it was in the countries in both Caribbean sub-regions with the highest prevalences in the range of 23%-24%.

Relative to 1980, all countries showed increases in diabetes in both sexes: diabetes in men increased from 1.2-fold in Canada and Uruguay (p=0.75 and p=0.69 respectively) to 4.1-fold in Saint Lucia (p=0.99) (**Figure 4A**), whilst diabetes in women increased in the range from 1.2-fold in Canada (p=0.70) to 3.1-fold in Saint Lucia (p=0.98) (**Figure 4B**). Similarly, to the previous risk factors the highest estimates for prevalence of diabetes, up to 15%, were concentrated in the English-speaking Caribbean countries in men and women.

Finally, compared with men, in 2014 women showed a higher prevalence of obesity and diabetes, but lower prevalence of RBP (Figure 5B), except for USA, Canada, Argentina, and Venezuela where the prevalence of RBP and diabetes was higher in men than women (Figure 5B). The difference between men and women in 2014 is larger when compared to 1980 (Figure 5A).

Correlation between risk factors

The comparison using Spearman's correlation rank test of risk factor prevalence revealed a positive correlation between obesity and RBP (r=0.75 for men and r=0.67 for women), between obesity and diabetes (r=0.88 for men and r=0.80 for women) and between diabetes and RBP (r=0.74 for both men and women) only in 1980, but not in 2014 (r=-0.25, r=0.053, and r=0.51 for obesity-RBP, obesity-diabetes and diabetes-RBP respectively for men, r=-0.22, r=0.51, and r=0.49 for women) (**Appendix Figure S4**).

Discussion

This study provides a comprehensive assessment of obesity, RBP and diabetes prevalence in the Americas over the last 35-year period and enhances our understanding of transitions in cardio-metabolic risk factors in the region. Our estimates show that countries with the highest prevalence of a given cardio-metabolic risk factor do not necessarily have the highest prevalence of another risk factor. The Americas is experiencing an obesity crisis accompanied by heterogeneous patterns of diabetes and RBP. These findings are important to scope and prioritize adequate NCD responses.

The increasing levels in obesity and diabetes prevalence observed in the region over time require appropriate measures to deal with these public health challenges. The reasons behind the disparity in the associations between obesity and diabetes or between obesity and RBP between sub-regions and in the same sub-region at different times are multiple. Traditionally, the term “diabesity” has denoted the epidemiologic parallelism between obesity and diabetes, which is understandable considering the shared pathophysiological mechanisms.[15] In terms of human capital, many countries in the Americas region are also transitioning from major burdens faced during childhood, particularly undernutrition.[16,17] With this, the long-lasting effects of early undernutrition, direct cause of nutritional stunting, could play a role in developing NCDs later in life.[18]

Our study expands the current regional literature as we have included consistently all countries with data covering over three decades, a time period that has witnessed important socio-economic changes in the Latin America and the Caribbean region. Our analysis showed that cardio-metabolic risk factors, with the exception of RBP, have steadily increased, and that the tendency is to keep on the rise. Whilst previous studies have mostly focused on South America,[19–22] we have expanded to include all countries from Central America and the Caribbean region, as well as the USA and Canada. The evidence provided highlights how the heterogeneity in risk factor prevalences requires multi-sectorial and locally adapted responses to improve prevention and treatment.

Given the high level of heterogeneity observed in the region, the results would support a diversification of health interventions across sub-regions and countries. While the main focus in North America should be on reducing the level of obesity, maintaining the trend in the other risk factors, countries in the other sub-regions are experiencing a real emergency with interventions needed not only to reduce the prevalence of obesity but also to prevent diabetes and RBP. Meanwhile, countries such as Peru, Bolivia,

and Ecuador with relatively low levels of cardio-metabolic risk factors should focus on how to reverse their increasing trends, continue with good profiles and implement new policies.[23] For example, compared to other countries in Africa (South Africa) and Asia (China, India and Pakistan), some countries in South America (Argentina, Chile, Peru and Uruguay) seem to have relative better rates of awareness, treatment and control of hypertension.[24] However, inequalities within countries (and between countries) should be addressed to secure that all population groups have these adequate patterns of awareness, treatment and control of hypertension. This is exemplified by the USA where Hispanic and Black population are characterised by different risk profiles when compared to the white population.[25,26] Such heterogeneity is further exemplified by the INTERHEART study where the population attributable risk for acute myocardial infarction due to diabetes ranged from 7.4 in Colombia to 17.0 in Brazil.[20]

Our estimates focused on RBP instead of hypertension, which in epidemiological studies is a composite variable including measured blood pressure and/or diagnosis of hypertension and/or currently under treatment for hypertension. The results herein presented should be interpreted in this context. Nevertheless, the analysis of trends in RBP is key for the World Health Organization NCD Global Monitoring Framework, as one of the 9 voluntary global targets is “a 25% reduction in the prevalence of raised blood pressure.”[5] The falling trends in the prevalence of raised blood pressure could signal improvements in awareness, treatment and control of hypertension. This seems to be the case in Canada[27] and the USA,[26] though we are unaware of similar trends for other countries and sub regions in the region.

Our findings also show that the highest levels of the three cardio-metabolic risk factors are observed in the small countries in the Caribbean sub-region. While countries in this sub-region differ in terms of economic level, the absolute population size may contribute to their relative health under-performance.[28,29] With high prevalence and very poor morbidity outcomes, this area is characterised by high levels of vulnerability with very limited ability to respond to the health needs of the population, including NCDs and chronic health issues, paired by limited healthcare funding.

Tackling NCDs in the Americas will require individual-based high-risk approaches with population-based strategies.[30,31] This regional analysis of trends of multiple cardio-metabolic risk factors provides sufficient data-driven insights for decision-making today and serves as a baseline to monitor and

evaluate further the impact of initiatives to be implemented in the region.[32] The dissection of the information of the Americas from the NCD-RisC database offers a broader scoping and easier visualisation of the particular features of the region in terms of major cardio-metabolic risks. However, limitations should also be acknowledged. First, due to data availability, we did not include other important cardio-metabolic risk factors such as waist circumference, smoking or lipid profile. We presented results for established cardio-metabolic risk factors, accounting for their availability in rural and resource-limited settings. Second, we did not include data from children or adolescents, and future efforts should include these populations because it is most likely that cardio-metabolic risk factors have also increased among them.[33,34] Third, good quality nationally representative data on cardio-metabolic risk factors are still lacking in some of the countries, especially in the Caribbean. We recognise that estimates from pooled analyses may differ slightly from national surveys, especially in those data-poor countries and the intention of this exercise is not to supersede local efforts but to maximize available resources and to support local endeavours to produce current comprehensive data.

This region-wide analysis is the result of a collective approach, maximising the existing data available with a common goal for the public good. To overcome some of the limitations discussed here, and to support effective cardio-metabolic prevention interventions, national and international support should be provided to improve the surveillance system with cross-sectional and cohort studies aimed at monitoring cardio-metabolic risk factors, especially in those data-poor countries which would benefit the most from more reliable estimates.

Conclusions

This paper addresses some of the most important risk factors for NCDs closing the gap in the lack of information on the past and current levels of cardio-metabolic risk factors in the whole Americas region, a region that is important to our global world. Despite the high prevalence of cardio-metabolic risk factors across the Americas, estimates show significant variation between countries and sub-regions. Countries with the highest figures for one risk factor do not necessarily also stand out in another risk factor, and men's profiles do not necessarily resemble women's. Time trends show that, except for RBP, the risk factors have steadily increased since 1980. In addition, the within region divergence in trends observed suggests that the levels of risk factors are not increasing or decreasing at the same pace in all countries. This detailed information on the burden in the region can signal opportunities given

the interconnectedness in cultural, social, demographic, ethnic, and economic and political aspects of the countries in the Americas.

Acknowledgment

We thank WHO country and regional offices and World Heart Federation for support in data identification and access.

Funding

The study was supported by the Wellcome Trust. JJM acknowledges having received support from the Alliance for Health Policy and Systems Research (HQHSR1206660), the Bernard Lown Scholars in Cardiovascular Health Program at Harvard T.H. Chan School of Public Health (BLSCHP-1902), Bloomberg Philanthropies, FONDECYT via CIENCIACTIVA/CONCYTEC, British Council, British Embassy and the Newton-Paulet Fund (223-2018, 224-2018), DFID/MRC/Wellcome Global Health Trials (MR/M007405/1), Fogarty International Center (R21TW009982, D71TW010877), Grand Challenges Canada (0335-04), International Development Research Center Canada (IDRC 106887, 108167), Inter-American Institute for Global Change Research (IAI CRN3036), Medical Research Council (MR/P008984/1, MR/P024408/1, MR/P02386X/1), National Cancer Institute (1P20CA217231), National Heart, Lung and Blood Institute (HHSN268200900033C, 5U01HL114180, 1UM1HL134590), National Institute of Mental Health (1U19MH098780), Swiss National Science Foundation (40P740-160366), Wellcome (074833/Z/04/Z, 093541/Z/10/Z, 107435/Z/15/Z, 103994/Z/14/Z, 205177/Z/16/Z, 214185/Z/18/Z) and the World Diabetes Foundation (WDF15-1224). MDC is supported by an Academy of Medical Sciences Springboard Award, and JB by a Royal Society Research grant.

Conflict of interest

ME reported a charitable grant from the AstraZeneca Young Health Programme, and personal fees from Prudential, Scor, and Third Bridge, outside the submitted work. All other authors declare no competing interests.

Contributors

JJM, MDC and ME initiated the study. All authors contributed to data collection, pooling analysis and/or preparation of the results. JJM, RMCL and MDC wrote the first draft with input from CF, IRH, PAL, RENM, BZ, JB and DG. All other authors commented on the paper and contributed to the revision.

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Figures

Figure 1 - Number of data sources available for (A) body mass index, (B) blood pressure and (C) diabetes by sub-region and year.

Figure 2 – Trends in age-standardised prevalence of obesity, raised blood pressure, and diabetes by sub-region in (A) men and (B) women.

The lines show the posterior mean estimates and the shaded areas show the 95% CrI.

Figure 3 – Boxplot of prevalence of (A) obesity, (B) raised blood pressure and (C) diabetes, overall and by sub-region.

Figure 4 – Heatmap of age-standardised prevalence of obesity, raised blood pressure (RBP), and diabetes (DM) by country in (A) men and (B) women in 2014. Countries ranked by prevalence of obesity. Ratio of prevalence for each risk factor are calculated for current (2014) values relative to 1980 estimates.

Note: for the first three columns red indicates the highest level in the prevalence of that specific risk factor and white the lowest; for the last three columns purple indicates the highest ratio of prevalence and white the lowest.

Figure 5 – Male vs. female age-standardised prevalence of obesity, raised blood pressure and diabetes in (A) 1980 and (B) 2014.

Appendix - Figures and tables

Figure S4 – Age standardised prevalence of obesity vs. age standardised prevalence of raised blood pressure and age standardised prevalence of diabetes by sex, (A) 1980 and (B) 2014