Trends in prevalence of cardiovascular risk factors on the United States – Mexico border between 2005-2011

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Abstract

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Background: Cardiovascular disease is a major cause of morbidity and mortality in the United States (U.S.) and Mexico. We aimed to describe the sex-specific prevalence and time trends in five risk factors for cardiovascular disease (smoking, physical activity, obesity, diabetes mellitus and hypertension) by county or municipality that touches the U.S.-Mexico border. Then we aimed to describe the prevalence by socioeconomic status (SES).

Methods: We calculated sex-specific estimates on the county-level for diabetes mellitus, hypertension, obesity, physical activity and tobacco use. Data was obtained from surveys; for the U.S., prevalence (95% uncertainty intervals) were calculated using the Center for Disease Control's annual Behavioral Risk Factor Surveillance System (BRFSS) and the

National Health and Nutrition Examination Survey (NHANES), and for Mexico, prevalence (95% confidence intervals) were calculated from the Mexican Encuesta Nacional de Salud y Nutrición (ENSANUT) surveys in 2005-06 and in 2011-12.

Results: Prevalence estimates were available for 26 counties in 4 U.S. states and 14 municipalities in 6 Mexican states. The risk factors with the highest prevalence in the U.S. were any physical activity (68.8%), obesity (38.1%) and hypertension (35.5%). The risk factor with the lowest prevalence was diabetes mellitus (17.5%). Whereas, in Mexico the risk factors with the highest average prevalence were any smoking (51.0%), hypertension (48.9%) and obesity (35.9%). The risk factor with the lowest prevalence was diabetes mellitus (7.1%). The prevalence of any physical activity was also alarmingly low at 8.9%. Smoking had a positive association with increasing SES for females but not for males in both countries. Physical activity had a positive association with increasing SES for both sexes. Obesity and diabetes mellitus had a negative association with increasing SES. Hypertension had a negative association with increasing SES but it was stronger for females than males.

Conclusions: There is a high burden of cardiovascular risk factors along the U.S.-Mexico border region with a strong association between risk factors prevalence and a county or municipality's human development index. Public health programs should investigate regional socioeconomic status when planning intervention programs as they may have adverse effects on cardiovascular disease risk factors.

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Glossary

BMI = body mass index

BP = blood pressure

BRFSS = behavioral risk factor surveillance system

DM = diabetes mellitus

ENSANUT = Encuesta Nacional de Salud y Nutrición

GBD = global burden of disease

HAQI = healthcare access and quality index

HDI = human development index

NHANES = national health and nutrition examination and survey

QOL = quality of life

SDI = sociodemographic index

SES = socioeconomic status

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Dedication

To my husband, Seth

Chapter 1: Introduction

Despite their different geographical and political identities, the United States (U.S.) and Mexico border region has near continuous migratory flow and strong social, economic, cultural and environmental connections[1, 2]. Better understanding of the cardiovascular disease risk burden in this area is important for public health and prevention programs given the high morbidity and mortality associated with cardiovascular disease in this region, as well as the great interaction among communities on both sides of the border. We aimed to describe the sex-specific prevalence and time trends in five risk factors for cardiovascular disease (smoking, physical activity, obesity, diabetes mellitus and hypertension) by county or municipality that touches the U.S.-Mexico border. Then we aimed to describe the prevalence by socioeconomic status.

1.1 Background

Cardiovascular disease remains the leading cause of mortality for both the U.S. and Mexico border region[2-5]. In 2015, diabetes was the number 2 leading cause of mortality in Mexico and has been increasing over time; whereas, in the U.S., it is ranked much lower with decreasing mortality over time. In 2008, the crude mortality rates due to heart disease in the Mexican border states ranged from 78.0 deaths per 100,000 population in Baja California to 112.2 in Sonora and Chihuahua, compared to 86.9 for the nation. The main contributor to heart disease mortality was mortality from ischemic heart disease[1]. For the U.S. border states in 2007, the crude mortality rates due to heart disease ranged from 162.5 deaths per 100,000 population in Arizona to 168.8 in

California, lower than the 204.3 for the nation. These rates were about 15% to 18% lower than the 2003 rates.

However, hypertension, obesity and diabetes are well-recognized cross-cutting problems at the border. Mexico also has a double burden of disease with both undernutrition and infectious disease as well as emerging epidemics of chronic disease as they are in the late epidemiologic transition. The U.S.-Mexico Border Health Commission was established in 2000 and proposed strategic framework to optimized the health and quality of life along the U.S.-Mexico border, specifically to the two over-arching goals of the binational Healthy Border 2010/2020 framework were to eliminate health disparities and increase quality of life and increase number of years of healthy life[2, 6]. The Healthy Border 2010 objectives number 4 and 5 were specific to diabetes, with goals to reduce deaths due to diabetes by 10% in both countries and to reduce hospitalizations for diabetes by 25% in the US and keep hospitalization rate stable in Mexico[2]. In 2015, the Binational Technical Workgroup subsequently identified additional causes of chronic and degenerative diseases through root cause analysis. The top 6 determinants were physical inactivity, poor diet, poverty, genetic, lack of breastfeeding and education. The objectives and strategies developed included improving health promotion and promote healthy lifestyles. Specific objectives include increased fruit and vegetable intake, increased physical activity, body mass index recording, improved screening for diabetes by 10% with at least 50% of patients receive diabetes treatment control, reduce proportion of diabetics with A1C>9%, and improve blood pressure management via medication with at least 50% able to control to <140/90mmHg[2].

The U.S.-Mexico border region is important to public health because it is a unique geographical space that requires the joint efforts of local, state and federal governments, as well as non-governmental organizations to come together. This region symbolized similarities and differences that exist between these two nations where economic, social and political factors and access to health care are important determinants of health[1, 2]. The population in this region has grown over 10% between 2006-2011[1]. There are surveillance systems in both countries that rely largely on state and national level data with limited data on the communities in the border region. There is no ongoing surveillance system that has been established to monitor the health of this unique population. Prior subnational estimates on the burden of disease are available on the state level in Mexico and the U.S., with recent publications on the prevalence of risk factors by U.S county[7-12]. While differences at the states level are important to understanding disparities, the smaller administrative level of counties and municipalities is more granular and can help us understand the risk profile in a smaller geographical area. Unlike the geographical boundaries, which are relatively fixed, the political, social, economic and demographic factors that contribute to health are more fluid and dynamic[2]. Despite different policies, customs, and laws, there is near continuous migratory flow and strong social, economic, cultural and environmental connections in this region. Better understanding of the risk burden in this area is important for public health and prevention programs given the great interaction among communities on both sides of the border. Preventative strategies need to be in collaboration with both country governments to improved cardiovascular health in this region. Therefore, we aimed to describe the prevalence and trends in risk factors for cardiovascular disease by county and municipality that touches the U.S.-Mexico border. Furthermore, we aim to describe the prevalence of risk factors by different measures of socioeconomic status.

1.2 Objectives

The rationale for this thesis is that the cardiovascular disease is a leading cause of morbidity and mortality in the United States and in Mexico. However, understanding trends in cardiovascular disease mortality can be difficult and often comes too late in the disease process. Understanding risk factors for cardiovascular disease is important for future planning. The border is particularly difficult to study due to different geographical, political, education and healthcare systems. We hypothesized that reporting risk factor prevalence using a smaller geographical unit than what has been published previously in the Global Burden of Disease study[13-15], the county and municipality level, we could identify trends in cardiovascular disease risk factors on a local level. Furthermore, we could describe trends and associations with socioeconomic status of each county or municipality.

Based on this hypothesis, the primary objective was:

To describe the age-standardized prevalence of 5 major risk factors for cardiovascular disease on the U.S.-Mexico border by county or municipality. The risk factors are prevalence of self-reported diabetes mellitus, obesity, any physical activity, total hypertension and any tobacco use by sex in 2005 and 2011.

The secondary objective was:

To describe the time trend in age-standardized prevalence of 5 risk factors (diabetes, obesity, physical activity, hypertension and tobacco use) between 2005 to 2011 by sex.

Using this information, the third objective was:

To determine the association between the prevalence of each risk factor (diabetes, obesity, physical activity, hypertension and tobacco use) and socioeconomic status of the county or municipality using Border Human Development Index (HDI) and Border Quality of Life Index.

Chapter 2: Methods

Data

United States Counties

Using validated small area estimation models, data from the Center for Disease Control's annual Behavioral Risk Factor Surveillance System (BRFSS)[16] and the National Health and Nutrition Examination Survey (NHANES) were used to make county-level estimates of 21 causes of death and 6 risk factors: alcohol, diabetes, hypertension, obesity, physical activity and tobacco use [8, 17, 18]. Published data was available from the U.S. County Profiles project, available on the Institute for Health Metrics and Evaluation website [19]. Briefly, the BRFSS collects data on many of the behaviors and conditions that place adults (aged ≥18 years) at risk for chronic disease. Trained interviewers collect data monthly, using an independent probability sample of households with telephones among the non-institutionalized U.S. adult population. All BRFSS methodology, questionnaires, and data are available at http://www.cdc.gov/brfss [20]. The NHANES is a nationally representative cross-sectional survey that collects data on self-reported health and also includes an examination component that collects an extensive array of biomarkers and anthropometric measures. We used data from the examination portion of the NHANES in the years 1999 to 2010, which produces national-level estimates every two years. NHANES data and questionnaires are available at http://www.cdc.gov/nchs/nhanes.htm. Additional information on the NHANES survey design is well documented [21].

Risk factors data, including age-standardized prevalence (with 95% confidence intervals) by sex, was obtained for diabetes mellitus (total and diagnosed), hypertension (total and diagnosed), obesity, physical activity, and daily smoking for the years 2005 and 2011. Time trends were calculated by subtracting the prevalence in 2011 from 2005. Data for hypertension was only available for the years 2001 and 2009 and so time trends were calculated for this 8-year period rather than 5 years.

Mexican Municipalities

For the Mexico municipality data, we used the Mexican Survey on National Health and Nutrition (Encuesta Nacional de Salud y Nutrición-ENSANUT), which was conducted between 2005-06 and in 2011-12 in all Mexican states and is available in Spanish on the Mexican Ministry of Health website (https://www.insp.mx/paspe/83-insp/recomendaciones/829-ensanut-2006-602.html)[22] and on IHME's GHDx (http://www.healthdata.org/). Using stratified cluster sampling, households were chosen for the survey. The selection of individuals was made by simple random sampling, with one adult, one adolescent and one child who were selected in each household to participate, constituting a final sample in the year 2006 of 94,710 individuals in 48,304 households. The survey is representative at the state level and therefore not all the municipalities in each state are represented. In 2012, there were 94,197 individuals included in the survey. This included a household survey and clinical examination including systolic and diastolic blood pressure, height, and weight measurements. We took into account the survey sampling design and used the sample weights to calculate the population prevalence of diabetes, hypertension, obesity, physical activity, and daily smoking by sex.

Definition of variables

In order to make comparisons between the U.S.-Mexico border, we used the following definitions:

1. Diabetes mellitus: Self -diagnosed diabetes – proportion of adults age 20+ who report a previous diabetes diagnosis or who report taking insulin or other glucose-lowering medication.
2. Hypertension: total hypertension - prevalence (among all respondents, percentage of those who reported systolic BP of at least 140mmHg and/or self-reported taking medication and/or percentage of respondents who reported being told by a doctor or other healthcare professional that they had hypertension.
3. Smoking: Total smoking – prevalence of people who report currently smoke (as a percentage of the population).
4. Obesity: Participants were classified as obese if their BMI ≥30 kg/m2. In BRFSS, self-reported weight and height were assessed by asking respondents, “About how much do you weigh without shoes?” and “About how tall are you without shoes?” In NHANES, data on actual height and weight were collected every two years. The U.S. County data corrected for reporting bias by and pooling two years of BRFSS data with NHANES data to calculate the mean BMI by sex and age (20–34, 35–44, 45–54, 55–64, 65–74, and 75+ years). They then regressed measured mean BMI from NHANES on reported mean BMI from BRFSS separately for males and females and used the fitted coefficients from these models to calculate the corrected BMI for each individual represented in the BRFSS dataset and used this corrected BMI to assess whether or not each individual was obese. In the

2006 ENSANUT, height and weight here measured in a standard manner. In adults over 20 years of age, waist circumference was also measured, using trained personnel using conventional protocols. The size was measured with Dynatop brand stadimeters with a capacity of 2 m and with a precision of 1 mm. The body weight was measured using Tanita electronic scales, with a precision of 100 g, and the waist circumference with rigid metric tapes (Gulick, Foto Arte, Mexico) with a capacity of up to 1.5 m and a precision of 1 mm. Participants were classified as obese if their BMI ≥30 kg/m2.

5. Physical activity: To assess the prevalence of any leisure time physical activity, the BRFSS asked respondents, "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?" In the 2006 ENSANUT, respondents were asked about formal and informal physical activity, "In the past 7 days, have you participated in vigorous physical activity? One day, two days, three days, four days, five days, six days, seven days?" "In the past 7 days, have you participated in moderate physical activity? One day, two days, three days, four days, five days, six days, seven days?" Followed by, "The time you spent doing this activity was?" Any activity was defined as at least 1 day of week or vigorous or moderate physical activity.

Socioeconomic status variables

1. Border human development index (Border HDI) (Supplementary table 1): We used data previously developed and publicly available by Anderson et al. [23, 24], which is a modified version of the United Nations Development Program's

(UNDP's) index and includes equally weighted components of per capita income, education, and health. In order to compare the development levels of the U.S. counties and Mexican municipalities that touch the U.S.-Mexico Border, a modified Border HDI was created for 1990, 2000 and 2010.

2. For per capita income, the data used for income are gross regional product (GRP), at the county (U.S.) and municipality (Mexico) levels, converted to U.S. dollars using purchasing power parity exchange rates, and divided by population to put them into per capita terms.
3. The educational component is composed of two data series: the proportion of school-aged population that are enrolled in school and the proportion of population 25 and older who have graduated from high school (i.e. completed 12 years of schooling).
4. For the health component, life expectancy data was only available at the national and state levels for both the U.S. and Mexico, but not at the county or municipality level for either country. Therefore, infant mortality rate was substituted for life expectancy. The general formula for calculating each sub-index is:

   (1) $$\text{Index} = \frac{\text{Actual xi value} - \text{minimum xi value}}{\text{Maximum xi value} - \text{minimum xi value}}$$

5. Quality of life index (supplementary table 1): Developed by Wilson et al.[25], the Quality of life index was measured and evaluated using accepted indicators and procedures, relying on data from publicly available sources in Mexico and the U.S. (figure 1).

Geography

The U.S.-Mexico border is a well-described geographical region extending from the Gulf of Mexico to the Pacific Ocean. The U.S.-Mexico Border Health Commission includes 44 US counties and 80 Mexican municipalities that have most of their population within 100km of the border. Prior studies evaluating the HDI and other health studies have only included those counties or municipalities that touch the border, which includes 26 counties in 4 U.S. states (Texas, New Mexico, Arizona, and California) and 39 municipalities in 6 Mexican states (Tamaulipas, Nuevo León, Coahuila, Chihuahua, Sonora, and Baja California); and 15 sister cities/regions (Brownsville-Matamoros; McAllen-Reynosa; Starr County-Miguel Alemán-Camargo; Laredo-Nuevo Laredo; Eagle Pass-Piedras Negras; Del Rio-Ciudad Acuña; Presidio-Ojinaga; El Paso-Las Cruces-Ciudad Juárez; Columbus-Palomas; Douglas-Agua Prieta; Nogales-Nogales; Tohono O'odham Nation-Caborca-Puerto Peñasco-Sonoyta; San Luis-Somerton-Yuma-San Luis Rio Colorado; Calexico-Mexicali; and San Diego-Tijuana). This border region has a population of approximately 15 million inhabitants on both sides of the border[1].

Analysis

Sex-specific prevalence was calculated for each risk factor using age-standardized mean prevalence with 95% uncertainty intervals for the U.S. county data and age-standardized mean prevalence with 95% confidence intervals by sex and municipality in Mexico. The time trend was calculated using the difference in sex-specific prevalence from 2005 to 2011 (for hypertension in the U.S., the time trend was between 2001 to 2009)[12].

Supplementary table 1 shows the U.S. county and Mexican municipality HDI in the years 1990, 2000, and 2010 and a Quality of Life index in the years 2000 and 2010[23, 25].

Scatter plots of the sex-specific prevalence of each risk factor by socioeconomic status in 2006 were created. A scatterplot for smoking was creating using prevalence of smoking in 2006 with HDI in 2000 and smoking prevalence in 2011 with HDI in 2010. A linear regression best-fit line with 95% confidence interval was calculated for each graph.

Chapter 3: Results

Using small area estimate data from the U.S. County Profile Project, prevalence estimates were available for all 26 of the 26 counties in 4 U.S. states along the U.S.-Mexico border region for 2005 and 2011[8, 10, 17, 18, 26]. The hypertension data was obtained for the years 2001 and 2009. There were 2825 participants (45.7% female) in the ENSANUT 2006 survey, average age 42.0 (±15.9 years). In the 2011 ENSANUT survey, there were 2869 participants (54% female) in the ENSANUT 2011 survey, average age 42.1 (±15.6 years). There was data represented for all 6 Mexican states and included 18 of the 39 total border municipalities in 2006 and 20 municipalities in 2011. However, only 14 of the municipalities were the same in both years to allow for time trends in risk factor prevalence. The municipalities that were missing data were more likely to be of lower SES based on HDI and none of the missing municipalities were part of border towns with major cities in the US. Furthermore, due to changes in the questionnaire between 2006 and 2011, and lack of clinical exam data in the 2011 ENSANUT database, the only risk factor that was available for comparison to the 2006 dataset was smoking prevalence. Therefore, smoking was the only variable with both 2006 and 2011 data for Mexico.

Prevalence of risk factors in the United States

The risk factors with the highest average prevalence in the U.S. were any physical activity (68.8%), obesity (38.1%) and hypertension (35.5%). The risk factor with the lowest prevalence in the U.S. was diabetes mellitus (17.5%). The U.S. counties with the lowest burden of risk factors (excluding physical activity) were San Diego (both males and females) and Pima County (females). Starr (both males and females) and Maverick (males) counties in Texas had the highest burden of risk factors. However, even the highest burden county in the U.S. was lower overall than the lowest municipality in Mexico.

Prevalence of Risk Factors in Mexico

For Mexico, the risk factor prevalence was higher than in the U.S.. The risk factors with the highest average prevalence were any smoking (51.0%), hypertension (48.9%) and obesity (35.9%). The risk factor with the lowest prevalence was diabetes mellitus (7.1%). The prevalence of any physical activity was low at 8.9%. The Mexican municipalities with the highest burden of risk factors (excluding physical activity) were Rio Bravo (both males and females) and Reynosa (males). The municipalities with the lowest burden of risk factors (excluding physical activity) was Puerto Penas (females) and Acuna (females).

Time trends in risk factor prevalence

Smoking prevalence was estimated by sex and county/municipality for 2006 and 2011 and is shown in table 2. While smoking prevalence was decreasing in all counties for females and but one counties for males in the U.S., only 10 of the 14 municipalities for females and in 4 of the 14municipalities for males in Mexico saw decreasing trends (table 2). The confidence intervals were wide due to small sample size in the Mexican survey but the scatterplots (figure 7) show clearly the trend between the geographical areas. Data was only available for time trends for diabetes, obesity, hypertension and physical activity in the U.S. and is shown in the heat map in table 3. Diabetes and obesity were increasing for both males and females in all counties and municipalities. Hypertension was increasing in most counties in the U.S.

Socioeconomic status and risk factor prevalence

Figure 3 show the scatterplot of the prevalence of diabetes and hypertension in 2006 and HDI. Obesity and diabetes mellitus had a negative association with increasing SES in the U.S. Hypertension had a negative association with increasing SES but it was stronger for females than males in the U.S. Hypertension did not show a significant trend with increasing SES in Mexico.

Figure 4 shows the scatterplot of the prevalence of physical activity and obesity in 2006 and HDI. Physical activity had a positive association with increasing SES for both sexes in the U.S. but did not have the same trend in Mexico. In Mexico obesity had a decreasing association for both males and females with increasing HDI.

Figures 6 and 7 shows the scatterplot of the prevalence of smoking and HDI. In 2006 and 2011 by sex and HDI in 2000 and HDI in 2010. In the U.S., smoking had a positive association with increasing SES for females but not for males. In Mexico (orange dots and blue diamonds), baseline smoking was higher than in the U.S. and for both males and females, smoking had an increasing association with increasing SES. Loess and quadratic lines were also estimated for all scatterplots but performed similarly to linear regression for most scatterplots.

Chapter 4: Discussion

We describe the prevalence of smoking, physical activity, obesity, diabetes mellitus and hypertension by sex and year for 40 counties and municipalities along the U.S.-Mexico border. We found that the prevalence of cardiovascular risk factors is higher on the Mexican side of the border than in the U.S. Furthermore, the U.S. county with the lowest

HDI score was higher than the highest Mexican municipality. We saw a similar relationship with cardiovascular risk factors in that the highest burden of risk factors in the U.S. county was lower than the lowest municipality risk factor burden in Mexico. While cardiovascular disease is well recognized as a major cause of morbidity and mortality in the U.S., the high risk factor burden in Mexico is concerning for future development of cardiovascular disease.

The most concerning risk factor in Mexico is very low physical activity, with a prevalence of any physical activity of only 68% in the U.S. and 8.9% in Mexico. The other risk factors with the highest burden are obesity and hypertension. Given the new 2017 American College of Cardiology/American Heart Association hypertension guidelines with lower thresholds for diagnosing hypertension of 130/80 mmHg rather than 140/90 mmHg, the prevalence of hypertension is likely to increase significantly and surpass obesity as the number one risk factor in this population.

Smoking is extremely common and time trends between 2006 and 2011 suggest that it is increasing in most municipalities while overall decreasing in prevalence in the U.S. over time. However it remains a largely preventable cause of cardiovascular disease with 1 in 5 Americans and 1 in 2 Mexicans, particularly among those ages 20-44 years, reporting smoking use. Smoking is a major preventable cause of cardiovascular disease and requires comprehensive public health interventions, education and health policy along both sides of the border.

No prior studies have looked at risk factors along the U.S.-Mexico border. However, the U.S. Counties Profiles Project in the U.S. aimed to describe the prevalence of 6 risk factors, the 5 outlined here and alcohol use, in all U.S. counties[8, 12, 17, 18, 27]. For males in 2011, the county with the lowest prevalence varied for each risk factor. The lowest and highest prevalence for each risk factor were: smoking 10.1% to 42.5%, physical activity 54.7% to 89.9%, obesity 18.4% to 46.9%, diagnosed diabetes mellitus 5.6% to 18.7% and hypertension 26.53% to 54.43%. The prevalence in the U.S. and Mexican counties in this study are higher than the average for the U.S. alone.

For females in 2011, the county with the lowest prevalence varied for each risk factor. The lowest and highest prevalence for each risk factor were: smoking 5.84% to 41.59%, physical activity 50.9% to 89.51%, obesity 17.62% to 59.26%, diagnosed diabetes mellitus 4.85% to 20.46% and hypertension 28.52% to 57.88%. The prevalence of the risk factors in this study were higher than the average risk factors in the U.S. alone. Data does not exist on this level for the Mexican municipalities at this time, only on the state level. Prior population-based studies in Mexico have reported a prevalence of smoking in males of 31.9%, whereas in women, it was obesity (26.6%) and central obesity (49.7%). A similar high age-adjusted prevalence was observed in women and men for hypertension (29.7% and 28.8%), diabetes (12.94% and 12.66%), and hypercholesterolemia (13.81% and 12.36%)[28]. Understanding the risk factor burden is important because the Hispanic/Latino population is the fastest growing ethnic minority in the U.S.

Limitations:

The limitations to this paper include the limited data source from the Mexican ENSANUT survey that was not representative of all the Mexican municipalities. Future studies using small area estimation models, similar to the U.S. County Profile project, to estimate prevalence based on state-level data would be helpful. Furthermore, the

ENSANUT survey did not include the same questionnaire in 2005 and 2011 and the clinical exam data was not available in 2011 for accurate calculation of prevalence and time trends. Future studies that stratify by ethnicity in the U.S. using individual level data would be able to tell if Latin Americans have a similar risk profile to those of Mexicans. Furthermore, calculating risk scores based on individual level data would be interesting but was not available for the U.S. for this study.

Chapter 5: Conclusion

There is a high burden of cardiovascular risk factors along the U.S.-Mexico border region with an increasing burden on the counties and municipalities with lower socioeconomic status. Smoking prevalence is higher in Mexico than in the U.S. and is increasing over time. Public health programs should investigate regional socioeconomic status when planning intervention programs.

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Appendix A

Tables and Figures

Figure 1. Domain and indicators of quality of life along the United States and Mexico transborder region[25]

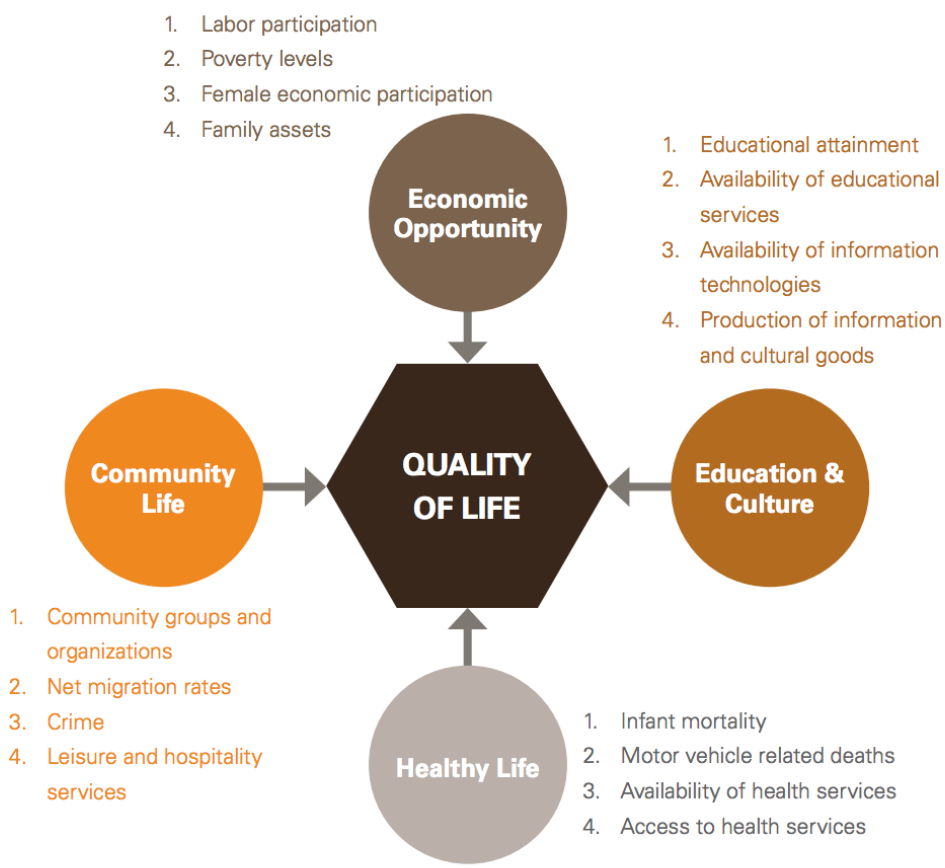

Figure 2. Map of the US-Mexico border by Human Development Index [24]

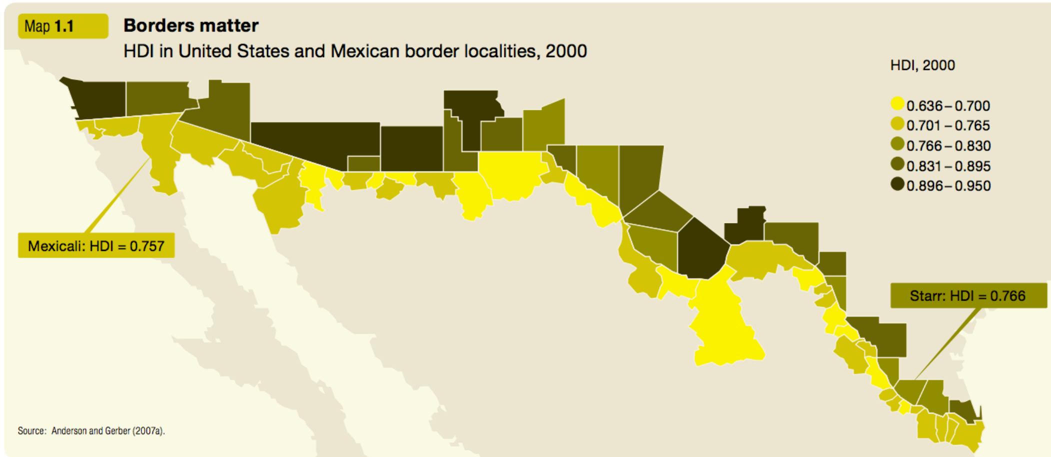

Figure 3. Diabetes mellitus and hypertension prevalence in 2006 by human development index in 2000.

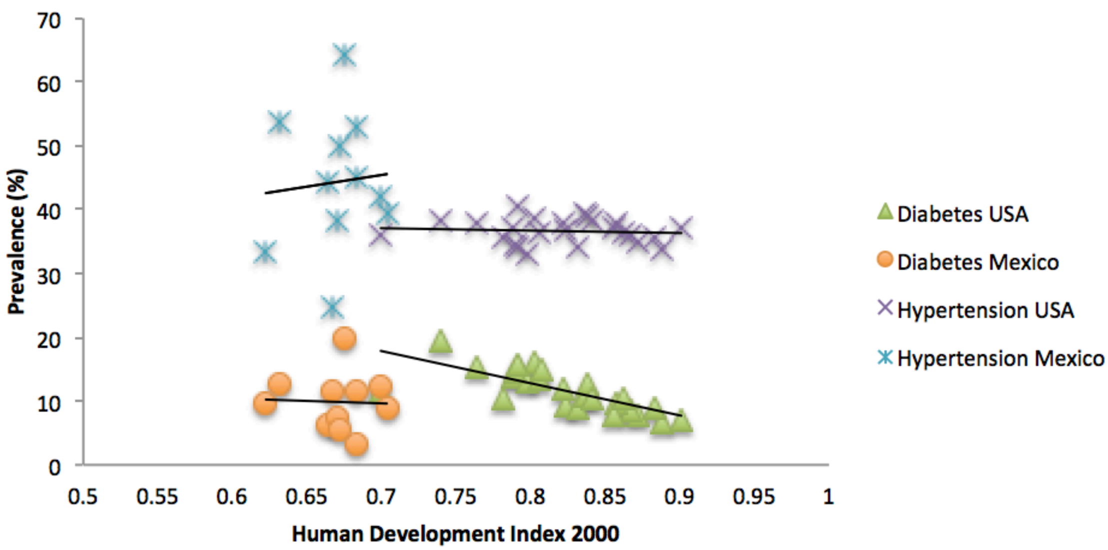

Figure 4. Obesity and physical activity prevalence by human development index in 2000.

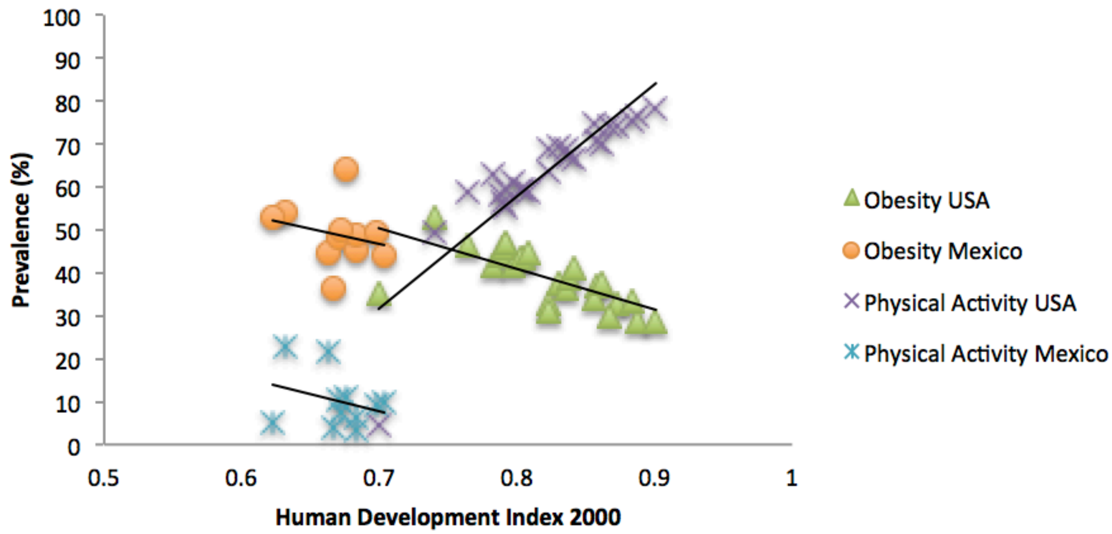

Figure 5. Smoking and physical activity prevalence by human development index in 2000.

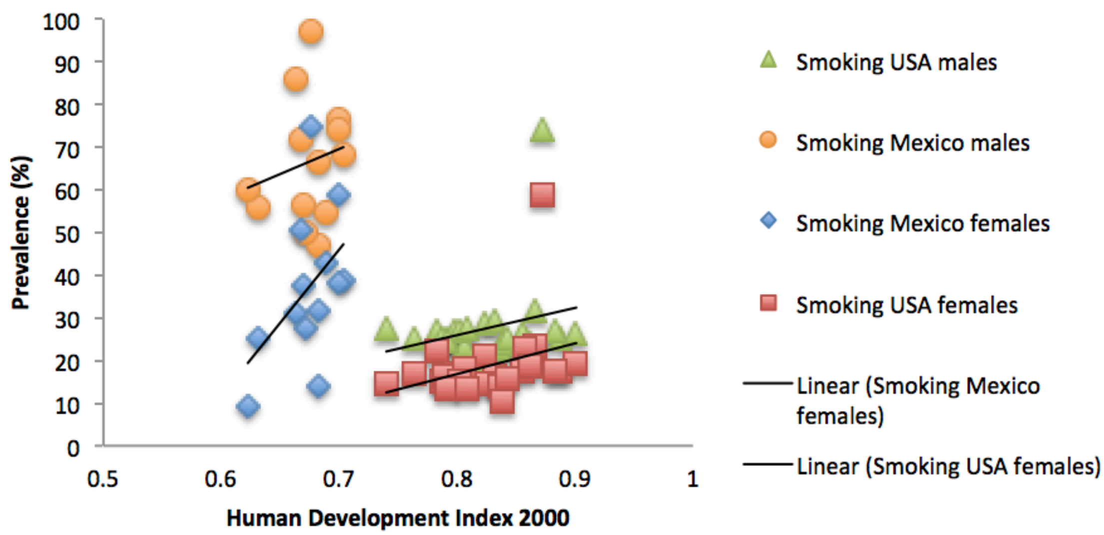

Figure 6. Smoking prevalence by sex for both United States and Mexico in 2006 and 2011 by human development index in 2000 and 2010.

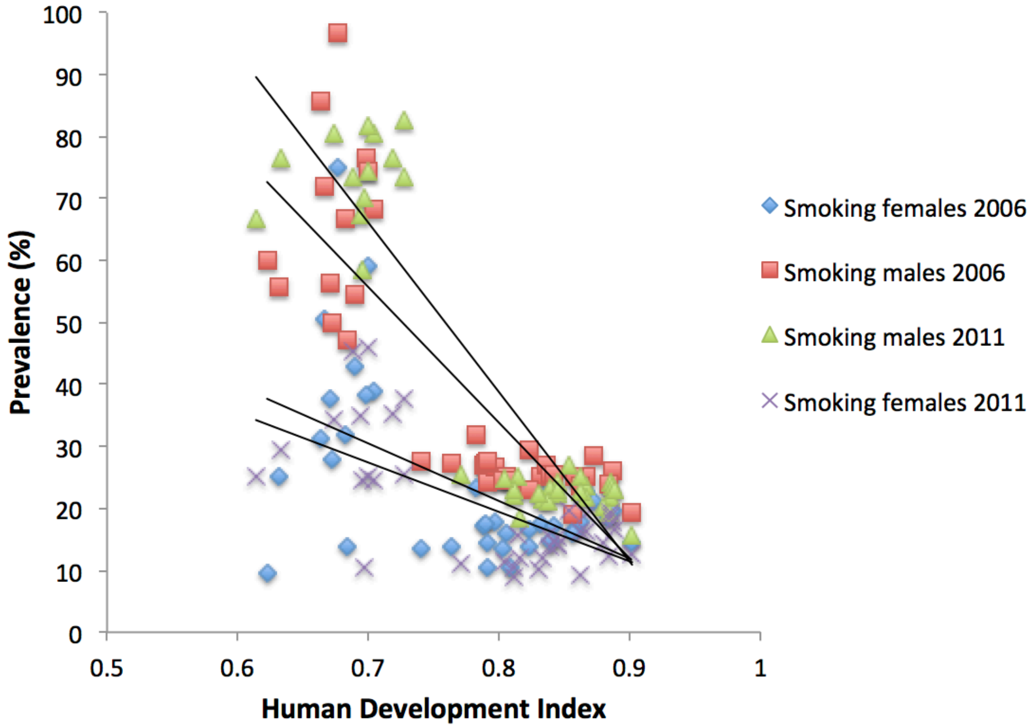

Table 1. Baseline prevalence of smoking, physical activity, obesity, diabetes mellitus and hypertension in 2006 in the United States-Mexico Border by sex.

Country	State	County/Municipality	Sex	Smoking Prevalence (%)	Physical Activity Prevalence (%)	Obesity Prevalence (%)	Diabetes - diagnosed Prevalence (%)	Hypertension - total Prevalence (%)
Mexico	Baja California	Tijuana	Males	71.95	7.7	20.7	5.7	36.5
Mexico	Baja California	Tijuana	Females	50.47	4.2	36.6	11.4	24.7
Mexico	Baja California	Tecate	Males	54.5	29.4	16.7	0	33.3
Mexico	Baja California	Tecate	Females	42.9	6.7	39.1	8.6	21.7
Mexico	Baja California	Mexicali	Males	72.2	2.6	32.3	7.5	48.5
Mexico	Baja California	Mexicali	Females	40.9	4.7	40.9	11	47.8
Mexico	Baja California	Rosarito	Males	90.5	5.6	16	2.4	40
Mexico	Baja California	Rosarito	Females	33.3	4.9	51.4	4.4	25.7
Mexico	Sonora	San Luis Rio Colorado	Males	60	11.1	20	0	80
Mexico	Sonora	San Luis Rio Colorado	Females	36.8	5.9	50	10.5	61.5

Mexico	Sonora	Puerto Penasco	Males	78.6	16.7	0	0	60
Mexico	Sonora	Puerto Penasco	Females	7.7	0	36.4	0	58.3
Mexico	Sonora	Caborca	Males	50.4	7.3	34.3	4.2	56.3
Mexico	Sonora	Caborca	Females	20.5	10	47.1	6.8	45.9
Mexico	Sonora	Agua Prieta	Males	85.7	0	33.3	0	33.3
Mexico	Sonora	Agua Prieta	Females	31.2	21.4	44.4	6.3	44.4
Mexico	Chihuahua	Ascension	Males	55.6	13.3	21.4	0	71.4
Mexico	Chihuahua	Ascension	Females	25	23.1	53.8	12.5	53.8
Mexico	Chihuahua	Juarez	Males	56.5	10.1	28.6	8.8	48.3
Mexico	Chihuahua	Juarez	Females	37.7	10.2	48.3	7.4	38.1
Mexico	Coahuila de Zaragoza	Acuna	Males	47.2	12.9	35.7	5.6	46.4
Mexico	Coahuila de Zaragoza	Acuna	Females	13.8	3.6	45	3.4	45
Mexico	Coahuila de Zaragoza	Jimenez	Males	60	0	0	6.7	80
Mexico	Coahuila de Zaragoza	Jimenez	Females	9.5	5	52.9	9.5	33.3
Mexico	Coahuila de Zaragoza	Piedras Negras	Males	66.7	8.7	20	11.1	73.3
Mexico	Coahuila de Zaragoza	Piedras Negras	Females	31.8	6.3	48.5	11.4	52.9

Mexico	Nuevo Leon	Anahuac	Males	50	33.3	40	0	60
Mexico	Nuevo Leon	Anahuac	Females	27.8	7.7	50	5.6	50
Mexico	Tamaulipas	Nuevo Laredo	Males	68.4	4.5	34.4	7	48.4
Mexico	Tamaulipas	Nuevo Laredo	Females	38.8	9.8	44	8.8	39.3
Mexico	Tamaulipas	Reynosa	Males	76.6	4.9	40.4	9.1	59.3
Mexico	Tamaulipas	Reynosa	Females	38.3	9	49.2	12.3	41.9
Mexico	Tamaulipas	Rio Bravo	Males	96.9	0	33.3	9.1	66.7
Mexico	Tamaulipas	Rio Bravo	Females	75	11.1	64.3	20	64.3
Mexico	Tamaulipas	Matamoros	Males	74.4	4.1	30.5	17.4	41
Mexico	Tamaulipas	Matamoros	Females	59	4.5	35.4	11.5	27.3
United States	Arizona	Cochise County	Males	28.55	79.51	30.62	8.81	31.95%
United States	Arizona	Cochise County	Females	21.24	74.3	33	7.95	35.84%
United States	Arizona	Santa Cruz County	Males	29.36	77.43	29.24	9.76	30.44%
United States	Arizona	Santa Cruz County	Females	16.5	69.07	33.11	9.34	34.77%
United States	Arizona	Yuma County	Males	25	73	32.6	10.19	32.77%

United States	Arizona	Yuma County	Females	17.39	69.29	37.34	9.05	36.87 %
United States	Arizona	Pima County	Males	26.12	81.2	26.09	7.91	30.62 %
United States	Arizona	Pima County	Females	19.55	76.72	28.7	6.79	34.07 %
United States	California	San Diego County	Males	19.4	82.55	26.93	7.98	28.52 %
United States	California	San Diego County	Females	14.42	78.36	28.61	7.06	33.68 %
United States	California	Imperial County	Males	22.88	68.5	41.84	11.87	31.91 %
United States	California	Imperial County	Females	13.81	63.79	31.35	11.8	37.01 %
United States	New Mexico	Hidalgo County	Males	26.84	73.23	30.29	9.32	32.47 %
United States	New Mexico	Hidalgo County	Females	22.06	68.65	36.45	10.94	37.92 %
United States	New Mexico	Luna County	Males	31.89	66.58	32.36	9.3	33.87 %
United States	New Mexico	Luna County	Females	23.37	62.93	41.98	10.46	39.36 %
United States	New Mexico	Grant	Males	25.11	78.05	27.68	7.51	29.97 %
United States	New Mexico	Grant	Females	22.63	73.87	30.15	8.68	35.63 %

United States	New Mexico	Dona Ana County	Males	25.13	75.43	27.35	8.53	30.28 %
United States	New Mexico	Dona Ana County	Females	16.51	70.81	36.71	9.75	35.92 %
United States	Texas	Hidalgo County	Males	24.21	65.68	38.46	14.36	31.43 %
United States	Texas	Hidalgo County	Females	10.57	59.48	46.51	15.39	37.74 %
United States	Texas	El Paso County	Males	25.44	75.65	30.16	11.71	30.84 %
United States	Texas	El Paso County	Females	14.88	67.07	38.55	12.65	34.07 %
United States	Texas	Hudspeth County	Males	26.87	58.89	32.78	12	33.18 %
United States	Texas	Hudspeth County	Females	17.16	58.1	44.04	13.84	38.98 %
United States	Texas	Culberson County	Males	26.64	60.45	32.35	11.36	31.46 %
United States	Texas	Culberson County	Females	17.69	61.33	41.56	13.09	37.26 %
United States	Texas	Jeff Davis County	Males	19	71.99	29.58	8	28.30 %
United States	Texas	Jeff Davis County	Females	16.1	74.99	34.11	7.9	32.89 %

United States	Texas	Presidio County	Males	27.18	58.28	33.17	12.02	31.31%
United States	Texas	Presidio County	Females	17.57	56.32	45.58	14.51	37.33%
United States	Texas	Brewster County	Males	24	73.71	29.24	8.83	29.14%
United States	Texas	Brewster County	Females	18.41	75.12	33.41	8.92	34.42%
United States	Texas	Terrell County	Males	23.65	68.01	31.47	10.15	30.58%
United States	Texas	Terrell County	Females	17.86	69.86	37.33	10.53	35.69%
United States	Texas	Val Verde County	Males	25.29	66.88	32.37	13.74	30.87%
United States	Texas	Val Verde County	Females	15.98	59.56	43.27	13.44	36.41%
United States	Texas	Kinney County	Males	25.36	69.29	33.61	11.56	31.24%
United States	Texas	Kinney County	Females	17.19	66.39	41.11	10.55	36.41%
United States	Texas	Maverick County	Males	27.23	62.02	37.66	16.04	31.85%
United States	Texas	Maverick County	Females	13.92	58.76	46.6	15.31	38.18%
United States	Texas	Dimmit County	Males	26.98	63.71	35.25	14.06	31.64%

United States	Texas	Dimmit County	Females	15.07	59.95	44.81	14.59	37.93 %
United States	Texas	Webb County	Males	24.6	67.35	34.39	15.94	30.25 %
United States	Texas	Webb County	Females	13.46	59.51	43.69	16.17	37.89 %
United States	Texas	Zapata County	Males	27.58	61.28	36.19	14.13	31.56 %
United States	Texas	Zapata County	Females	14.31	55.39	47.06	15.56	38.59 %
United States	Texas	Starr County	Males	27.68	54.84	39.63	16.9	32.89 %
United States	Texas	Starr County	Females	13.64	49.65	52.76	19.34	40.50 %
United States	Texas	Cameron County	Males	24.44	65.17	36.1	14.51	31.20 %
United States	Texas	Cameron County	Females	10.55	59.06	44.38	15.02	38.31 %

Table 2. Smoking prevalence by sex in 2006 and 2011 and time trends by county and municipality

Country	State	County/Municipality	Smoking males 2006 Prevalence (%)	Smoking females 2006 Prevalence (%)	Smoking males 2011 Prevalence (%)	Smoking females 2011 Prevalence (%)	Trend males	Trend females
Mexico	Baja	Tijuana	71.95	50.47	74.4	46	2.45	-4.47

	California							
Mexico	Baja California	Tecate	54.5	42.9	67.5	35	13	-7.9
Mexico	Baja California	Mexicali	72.2	40.9	74.5	33.7	2.3	-7.2
Mexico	Baja California	Rosarito	90.5	33.3	70	12.5	-20.5	-20.8
Mexico	Sonora	Caborca	50.4	20.5	71.4	32.7	21	12.2
Mexico	Sonora	Agua Prieta	85.7	31.2	58.6	24.4	-27.1	-6.8
Mexico	Chihuahua	Ascension	55.6	25	66.7	25	11.1	0
Mexico	Chihuahua	Juarez	56.5	37.7	73.5	45.3	17	7.6
Mexico	Coahuila de Zaragoza	Acuna	47.2	13.8	80.4	24.5	33.2	10.7
Mexico	Coahuila de Zaragoza	Jimenez	60	9.5	76.5	29.4	16.5	19.9
Mexico	Coahuila de Zaragoza	Piedras Negras	66.7	31.8	82.6	37.8	15.9	6
Mexico	Nuevo Leon	Anahuac	50	27.8	70	10.5	20	-17.3
Mexico	Tamaulipas	Nuevo Laredo	68.4	38.8	76.5	35.4	8.1	-3.4
Mexico	Tamaulipas	Reynosa	76.6	38.3	73.4	25.5	-3.2	-12.8
Mexico	Tamaulipas	Rio Bravo	96.9	75	81.8	25	-15.1	-50
Mexico	Tamaulipas	Matamoros	74.4	59	80.6	34.2	6.2	-24.8
United States	Arizona	Cochise County	28.55	21.24	24.09	19.36	-4.46	-1.88
United States	Arizona	Santa Cruz County	29.36	16.5	22.35	14.25	-7.01	-2.25
United States	Arizona	Yuma	25	17.39	24.31	15.29	-0.69	-2.1

		County						
United States	Arizona	Pima County	26.12	19.55	21.86	18.65	-4.26	-0.9
United States	California	San Diego County	19.4	14.42	15.75	12.54	-3.65	-1.88
United States	California	Imperial County	22.88	13.81	21.62	12.1	-1.26	-1.71
United States	New Mexico	Hidalgo County	26.84	22.06	23.62	18.95	-3.22	-3.11
United States	New Mexico	Luna County	31.89	23.37	26.94	19.51	-4.95	-3.86
United States	New Mexico	Grant	25.11	22.63	23.69	17.87	-1.42	-4.76
United States	New Mexico	Dona Ana County	25.13	16.51	21.85	16.16	-3.28	-0.35
United States	Texas	Hidalgo County	24.21	10.57	22.04	8.81	-2.17	-1.76
United States	Texas	El Paso County	25.44	14.88	23.18	13.69	-2.26	-1.19
United States	Texas	Hudspeth County	26.87	17.16	25.27	15.65	-1.6	-1.51
United States	Texas	Culberson County	26.64	17.69	21.19	15.51	-5.45	-2.18
United States	Texas	Jeff Davis County	19	16.1	20.28	14.48	1.28	-1.62
United States	Texas	Presidio County	27.18	17.57	18.48	11.97	-8.7	-5.6
United States	Texas	Brewster County	24	18.41	19.2	12.3	-4.8	-6.11

United States	Texas	Terrell County	23.65	17.86	23.11	16.65	-0.54	-1.21
United States	Texas	Val Verde County	25.29	15.98	22.97	14	-2.32	-1.98
United States	Texas	Kinney County	25.36	17.19	25.04	16.41	-0.32	-0.78
United States	Texas	Maverick County	27.23	13.92	23.03	10.39	-4.2	-3.53
United States	Texas	Dimmit County	26.98	15.07	24.47	12.58	-2.51	-2.49
United States	Texas	Webb County	24.6	13.46	22.25	10.19	-2.35	-3.27
United States	Texas	Zapata County	27.58	14.31	24.98	11.45	-2.6	-2.86
United States	Texas	Starr County	27.68	13.64	25.52	11.09	-2.16	-2.55
United States	Texas	Cameron County	24.44	10.55	22.56	9.1	-1.88	-1.45

Table 3. Heat map of the trends in prevalence of smoking, physical activity, obesity, diabetes mellitus and hypertension between 2006 and 2011 among the United States counties on the Mexican border by sex

State	County/ Municipality	Sex	trend in smoking	trend in physical activity	trend in obesity	trend in diabetes	trend in hypertension
Arizona	Cochise County	Male	4.46	3.49	-0.42	-1.61	-4.82
Arizona	Cochise County	Female	1.88	1.08	-3.13	-0.7	-2.46
Arizona	Santa Cruz County	Male	7.01	-1.34	-3.01	-1.67	-4.63
Arizona	Santa Cruz County	Female	2.25	-3.05	-3.89	-0.94	-2.79
Arizona	Yuma County	Male	0.69	-0.74	-6.44	-2.73	-3.67
Arizona	Yuma County	Female	2.1	-2.14	-4.05	-1.64	-2.46
Arizona	Pima County	Male	4.26	-0.93	-5.27	-1.5	-4.42
Arizona	Pima County	Female	0.9	0.03	-4.74	-1.36	-2.83
California	San Diego County	Male	3.65	-0.98	-2.68	-1.58	-3.47
California	San Diego County	Female	1.88	-2.58	-2.01	-1.63	-2.23
California	Imperial County	Male	1.26	-4.33	-1.06	-3.03	-3.48
California	Imperial County	Female	1.71	0.22	-3.2	-1.87	-2.14
New Mexico	Hidalgo	Male	3.22	-0.13	-2.68	-1.4	-3.63

New Mexico	County Hidalgo County	Female	3.11	-0.57	-3.62	-0.71	-2.43
New Mexico	Luna County	Male	4.95	-6.09	-4.42	-1.66	-4.21
New Mexico	Luna County	Female	3.86	-6.93	-0.72	-1.64	-2.98
New Mexico	Grant	Male	1.42	-1.48	-3.85	-1.72	-3.95
New Mexico	Grant	Female	4.76	1.47	-5.33	-1.32	-2.55
New Mexico	Dona Ana County	Male	3.28	-3.68	-8.86	-2.21	-3.96
New Mexico	Dona Ana County	Female	0.35	-2.61	-2.98	-1.86	-3.07
Texas	Hidalgo County	Male	2.17	-3.21	-5.69	-2.65	-4.36
Texas	Hidalgo County	Female	1.76	-2.51	-2.91	-1.31	-3.01
Texas	El Paso County	Male	2.26	-1.6	-5.77	-2.51	0.22
Texas	El Paso County	Female	1.19	-3.32	-1.86	-2.56	-2.26
Texas	Hudspeth County	Male	1.6	-1.61	-6.31	-2.27	-3.9
Texas	Hudspeth County	Female	1.51	0.01	-5.09	-2.7	-2.4
Texas	Culberson County	Male	5.45	-3.39	-4.86	-2.31	-4.38
Texas	Culberson County	Female	2.18	-2.85	-4.44	-1.64	-3.27
Texas	Jeff Davis County	Male	-1.28	-2.61	-4.4	-2.17	-3.15

Texas	Jeff Davis County	Female	1.62	-1.04	-2.93	-2.27	-1.73
Texas	Presidio County	Male	8.7	-4.89	-5.11	-1.68	-4.17
Texas	Presidio County	Female	5.6	-7.45	-1.02	-1.35	-2.82
Texas	Brewster County	Male	4.8	0.04	-5.58	-1.22	-3.76
Texas	Brewster County	Female	6.11	-0.26	-3.28	-0.88	-2.46
Texas	Terrell County	Male	0.54	-4.99	-5.12	-1.31	-3.76
Texas	Terrell County	Female	1.21	-4.39	-1.17	-1.81	-1.91
Texas	Val Verde County	Male	2.32	-4.9	-6.95	-1.24	-4
Texas	Val Verde County	Female	1.98	-4.74	-2.97	-1.08	-2.62
Texas	Kinney County	Male	0.32	-4.64	-6.01	-2.06	-4.15
Texas	Kinney County	Female	0.78	-1.63	-4.27	-1.79	-2.81
Texas	Maverick County	Male	4.2	-6.05	-5.22	-2.36	-3.92
Texas	Maverick County	Female	3.53	-0.86	-1.82	-1.53	-2.71
Texas	Dimmit County	Male	2.51	-0.69	-7.99	-1.97	-3.98
Texas	Dimmit County	Female	2.49	1.59	-3.34	-1.52	-2.63
Texas	Webb County	Male	2.35	-5	-9.95	-2.43	-4.45

Texas	Webb County	Female	3.27	0.35	-2.02	-2.07	-3.41
Texas	Zapata County	Male	2.6	-3.35	-9	-2.52	-3.34
Texas	Zapata County	Female	2.86	-2.47	-4.28	-2.14	-2.41
Texas	Starr County	Male	2.16	-3.98	-6.58	-1.78	-4.01
Texas	Starr County	Female	2.55	-5.47	-2.91	-0.92	-2.78
Texas	Cameron County	Male	1.88	-5.89	-5.81	-2.29	-4.34
Texas	Cameron County	Female	1.45	-7.27	-2.31	-0.67	-3.1

Supplementary Table 1. Human Development Index in 1990, 2000 and 2010 and Quality of Life Index in 2000 and 2010 in the United States and Mexico Border counties and municipalities.

	Human development Index			**Quality of Life Index**	
Location	1990	2000	2010	2000	2010
BAJA	0.65	0.69	0.71		
TIJUANA	0.64	0.67	0.70	0.37	0.51
TECATE	0.63	0.69	0.69	0.35	0.47
MEXICALI	0.65	0.70	0.70	0.31	0.45
PLAYAS DE ROSARITA		0.65	0.72	0.28	0.42
Total Baja	0.65	0.69	0.68		
SONORA	0.68	0.70	0.72		

SAN LUIS RIO COL	0.64	0.66	0.69	0.28	0.41
PUERTO PENASCO	0.61	0.65	0.71	0.24	0.40
GNRL PLUTARCO ELIAS CALLES	0.56	0.61	0.66	0.25	0.31
CABORCA	0.63	0.67	0.69	0.25	0.37
ALTAR	0.61	0.63	0.66	0.17	0.25
SARIC	0.56	0.60	0.63	0.08	0.17
NOGALES	0.65	0.70	0.72	0.29	0.45
SANTA CRUZ	0.62	0.61	0.64	0.14	0.15
CANANEA	0.63	0.70	0.71		
NACO	0.66	0.63	0.69	0.24	0.36
AGUA PRIETA	0.63	0.66	0.69	0.27	0.38
Total Sonora	0.63	0.67	0.70		
CHIHUAHUA	0.65	0.67	0.69		
JANOS	0.60	0.61	0.57	0.14	0.18
ASCENCION	0.56	0.63	0.61	0.16	0.25
JUAREZ	0.63	0.67	0.69	0.35	0.44
GUADALUPE	0.59	0.61	0.63	0.18	0.22
P.G. GUERRERO	0.60	0.63	0.63		
OJINAGA	0.59	0.66	0.65	0.22	0.30
MANUEL BENAVIDES	0.59	0.60	0.59	0.11	0.13
Total Chihuhahua	0.62	0.67	0.69		
COAHUILA	0.70	0.66	0.73		

OCAMPO	0.61	0.65	0.67	0.14	0.14
ACUNA	0.64	0.68	0.70	0.24	0.39
JIMENEZ	0.59	0.62	0.63	0.12	0.13
PIEDRAS NEGRAS	0.67	0.68	0.73	0.30	0.45
GUERRERO	0.56	0.62	0.66	0.12	0.19
HIDALGO	0.57	0.61	0.67	0.09	0.25
NAVA	0.64	0.68	0.70	0.21	0.30
Total Coahuila	0.65	0.68	0.71		
NUEVO LEON	0.73	0.73	0.75		
ANAHUAC	0.63	0.67	0.70	0.16	0.30
Total Nuevo Leon	0.63	0.67	0.70		
TAMAULIPAS	0.68	0.70	0.71		
NUEVO LAREDO	0.66	0.70	0.72	0.29	0.40
GUERRERO	0.61	0.65	0.46	0.21	0.23
MIER	0.61	0.68	0.66	0.26	0.37
MIGUEL ALEMAN	0.65	0.68	0.69	0.31	0.39
CAMARGO	0.63	0.65	0.73	0.22	0.29
GUSTAVO DIAZ ORDAZ	0.66	0.66	0.68	0.24	0.33
REYNOSA	0.65	0.70	0.73	0.31	0.44
RIO BRAVO	0.64	0.68	0.70	0.21	0.31
VALLE HERMOSO	0.64	0.69	0.71	0.20	0.31
MATAMOROS	0.66	0.70	0.67	0.28	0.40
Total Tamaulipas	0.65	0.70	0.69		

UNITED STATES	0.86	0.89	0.90		
Border States	0.86	0.88	0.89		
Border Region	0.83	0.86	0.87		
CALIFORNIA	0.54	0.56	0.57		
SAN DIEGO	0.87	0.90	0.90	0.91	0.85
IMPERIAL	0.80	0.82	0.83	0.49	0.60
CA Border Region	0.87	0.90	0.90		
ARIZONA	0.86	0.89	0.89		
YUMA	0.82	0.83	0.84	0.57	0.69
PIMA	0.86	0.89	0.89	0.84	0.81
SANTA CRUZ	0.79	0.82	0.84	0.55	0.63
COCHISE	0.85	0.87	0.89	0.67	0.69
AZ Border Region	0.85	0.88	0.88		
NEW MEXICO	0.85	0.87	0.88		
HIDALGO	0.84	0.84	0.87	0.53	0.57
GRANT	0.84	0.87	0.89		
LUNA	0.81	0.78	0.85	0.51	0.54
DONA ANA	0.83	0.86	0.87	0.63	0.68
NM Border Region	0.83	0.84	0.87		
TEXAS	0.85	0.88	0.89		
EL PASO	0.82	0.84	0.84	0.71	0.67
HUDSPETH	0.77	0.79	0.81	0.45	0.47
CULBERSON	0.79	0.80	0.84	0.52	0.59

JEFF DAVIS	0.84	0.86	0.88	0.69	0.73
PRESIDIO	0.77	0.79	0.82	0.45	0.62
BREWSTER	0.84	0.88	0.88	0.74	0.74
TERRELL	0.84	0.86	0.89	0.42	0.58
VAL VERDE	0.79	0.81	0.84	0.58	0.68
KINNEY	0.80	0.84	0.86	0.47	0.59
MAVERICK	0.73	0.76	0.81	0.44	0.65
WEBB	0.79	0.80	0.83	0.51	0.61
ZAPATA	0.77	0.79	0.80	0.38	0.50
STARR	0.73	0.74	0.77	0.39	0.57
HIDALGO	0.78	0.79	0.81	0.53	0.61
CAMERON	0.79	0.81	0.86	0.61	0.62