

# **AIDS, diabetes, and lung cancer mortality at the northern Mexican border: 1979-1997<sup>1</sup>**

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## **Resumen**

Se están comparando las tasas de mortalidad de tres enfermedades entre siete ciudades de la frontera Norte de México y siete ciudades no fronterizas para analizar si el mayor desarrollo económico en las zonas fronterizas afectó positivamente la salud en el periodo entre 1979 y 1997.

## **Abstract**

A comparison of mortality rates associated with three diseases in three cities on the northern border of Mexico in order to determine whether increasing economic development activities have positively affected health outcomes between 1979 and 1997.

## **Background**

In 1965 the Mexican government announced the creation of the Border Industrialization Program (BIP) that permitted U.S. firms to import into Mexico equipment and materials to be processed as duty free finished products for re-export by the Mexican factories known as maquiladoras. The primarily foreign-owned maquiladoras employ semi-skilled or unskilled labor and are mostly concentrated in a few manufacturing sectors. Behind BIP lay the hope that the historically isolated northern border would become an economic growth pole for the region, if not the whole country, further integrate the border into the Mexican economy, and provide a balance to the primacy of Mexico City.

Geographic limits were imposed upon maquiladoras during the early years of BIP (Barry, 1994), but by the end of 1972 the Mexican government permitted maquiladoras to be established essentially nationwide. While the concept has become functional, the reality has remained largely territorial. Even after the 1994 implementation of the North Atlantic Free Trade Agreement (NAFTA) most maquiladoras continued to be concentrated along the border between Tijuana and Matamoros during the 1990s (CIEMEX-WEFA, 1998).

Because of the largely state-led economic development policies behind BIP it could be expected that there would be greater cohesive coordination between the process of industrialization, urbanization, and health improvement at the northern Mexican border than in a more market driven process (Easterlin, 1996). Links between economic development, social and physical infrastructure and those factors that influence disease transmission and prevention have long been assessed (Roemer, 1978; Leisinger, 1984). Research shows that the most important health profile indicator has been income (Hunter, 1990), though, the effect of rising income tends to plateau at higher per capita income levels (Preston, 1976). After a certain threshold is reached, health profile improvement must be fine-tuned through other sociocultural factors. Most debates on the linkages between economic development and health have centered on which is the primary driving force and which is the by-product (Mandelbaum, 1945; Nurkse, 1953; Rostow, 1960; Mushkin, 1968; Wheeler, 1980; Malenbaum, 1983). Many current theorists have come to realize that these two elusive concepts are interdependent and have parallel courses.

Like most other economically transitioning countries Mexico has faced what many researchers call the double burden of disease; the traditional set of health problems (communicable diseases, reproductive diseases, respiratory diseases, and environmental sanitation), and the burden of diseases associated with developed countries, especially cardiovascular diseases, malignant neoplasms, and diseases associated with lifestyle choices. Diseases associated with lifestyle choices have impacted the northern Mexican border as highly mobile, marginalized populations experienced the erosion of traditional values as part of the

border's rapid urbanization (Stehney, 1994). Whether urbanization equates with better health is debatable since many aspects of development theory have held the assumption that development and urbanization will be associated with improved health, yet, many examples have disproved this (Phillips et al., 1994).

To examine some of these debates, in this study I examine mortality data for seven border cities against seven non-border cities for three diseases. The diseases examined include: AIDS (the late stage of HIV infection); diabetes; and lung cancer. This is to distinguish if mortality for these three diseases has varied between these two sets of sites and whether different variables account for any differences in levels.

In a strongly Catholic, patriarchal culture such as that found in Mexico, sexual promiscuity among women is censured and homosexuality is highly stigmatized (Carrier, 1995); however, in areas where a large percentage of the population is transitory and the social infrastructure is weaker, the normally restrictive social norms may be relaxed. AIDS, therefore, may be able to serve as a proxy of the social infrastructure of a given area. Because diabetes prevalence in Mexico is higher among women and the obese (Guerrero-Romero, 1997; Castro-Sanchez, 1997), diabetes can serve as a proxy for socioeconomic status (i.e. nutrition and status of women based on education). Finally, studies of lung cancer in Mexico have shown that an important portion of lung cancer patients were not smokers and, thus, other factors such as second-hand smoke influenced by crowded living conditions need to be investigated (Medina, 1996). Additionally, Hispanic women typically have relatively low rates of smoking (Winkleby, 1995; Haynes, 1990), thus, a high level of mortality among women could indicate weaknesses in the social infrastructure. Given these possible risk factors, lung cancer mortality can serve as a proxy for the level of both social and physical infrastructure.

## **Methods**

### *Data*

Data for this research is from three broad categories: census data, health data and maquiladora data. The Mexican census which is performed every ten years provides socioeconomic data at the municipio level. The municipios, a Mexican political unit, in this study are geographically similar in size to metropolitan areas. Mortality data were obtained from the *Instituto Nacional de Salud Pública* (National Institute of Public Health) (INSP) for 1979-1997 – a total of 82,941 records. AIDS data were only available starting in 1988. In the file were year and month of death, cause of death, sex, age, and location. A total of 1682 records were deleted because of uncertainties in the data.

Mortality data for Tijuana and Mexicali were presented as one geographic unit, which necessitated combining the other data for the two municipios. This reduced the total number of study sites from 14 to 13. The calculation of other variables for Tijuana and Mexicali was based on the ratio of the populations of these two municipios in 1980 and 1990. In 1980 the ratio was 53:47 for Mexicali and Tijuana respectively. In 1990 this ratio had become 45:55.

Health care data for 1994 were obtained from the "*Boletín de información estadística*," (Bulleting of Statistical Information) a publication issued by the *Secretaría de Salud* (Secretary of Health) of Mexico. Data regarding maquiladora employment and total number of factories by location were obtained from three different sources (Lorey-USMBS, 1993; INEGI, 1998; CIEMEX-WEFA, 1998). This included for the border municipios the years from 1975-1998 and for the interior municipios the figures covering the years from 1987-1998.

### *Variables*

Seven border municipios (Juárez, Matamoros, Nogales, Nuevo Laredo, Reynosa, Tijuana and Mexicali) were chosen for analysis because they have contained the vast majority of maquiladoras that employ a great number of persons (Lorey-USMBS, 1993). While each of these cities does have characteristics peculiar to its own locale they all share the distinction of being the prime beneficiaries of BIP and are often referred to as one epidemiological unit (Soberon, 1989; Ellis 1997).

Seven non-border municipios (Guadalajara, León, Mérida, Puebla, San Luis Potosí, Torreón and Veracruz) were chosen for contrast based on their population size and growth, and sizable economic bases. However, these economies have developed without any one particular policy being implemented such as BIP.

Independent variables from the 1980 and 1990 censuses included the following (INEGI 1980, INEGI 1990; CONAP, 1993):

**Demographic:** total population; age and sex structure; percentage of population born in and outside the municipio; marital status; population growth; changes in the age and sex structure; and population density;

**Housing:** percentage of population living in housing without electricity; percentage of persons living in housing considered “crowded”; literacy indicators;

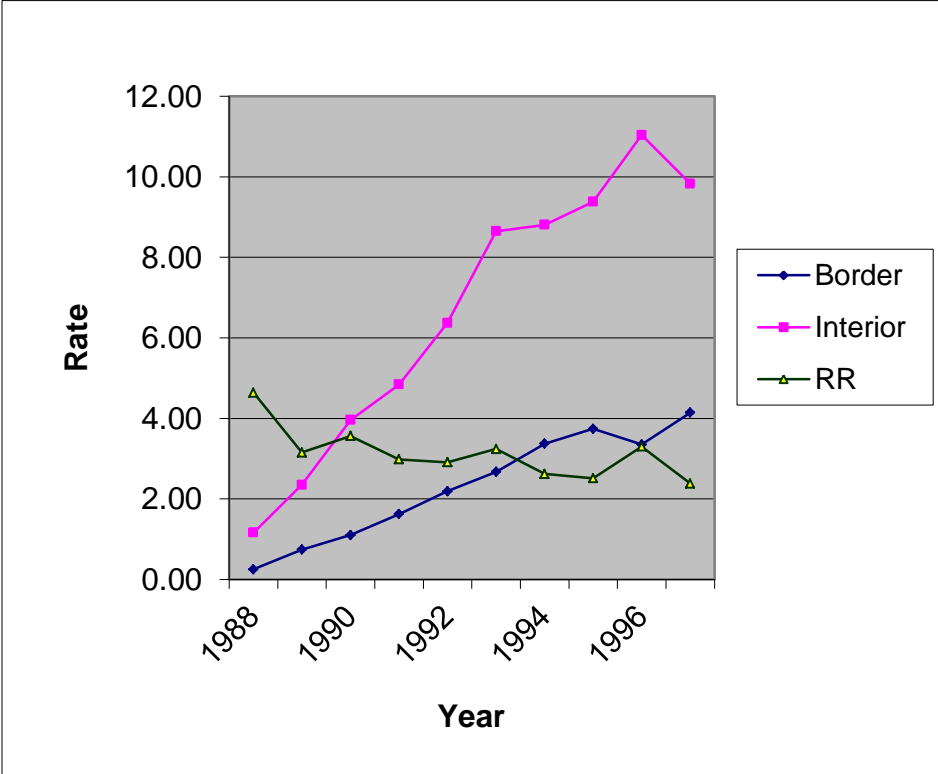
**Economic:** percentage of population by sex that is economically active; percentage of the population living on wages unable to meet their basic needs.

The available health care data for the time period at a specific enough geographic level was limited and, thus, the relevant variables were limited to: number of physicians per 100,000; percent of physicians that were general practitioners per 100,000 and; number of general consultations during the year per 100,000. It was also necessary to differentiate between migration-related secondary transmission and a more simple geographic relocation of disease. Migration data was limited in only presenting levels of migration along with state of origin. A crude proxy measure of migration for the municipios was calculated based on the number of persons migrating to the state and then dividing that number by the proportion of the municipio’s population to the total state population.

Two other variables were used in the analysis; “Year” which was treated as a continuous variable and used to control for variations over time and; a dummy variable was included to indicate border or interior location.

*Variables for Diseases Specific Analysis*

**Figure 1. Standardized mortality rates for AIDS per 100,000 interior versus border, 1988-1997**



RR= risk ratio (interior/border), t-test = 6.37 (p=.0001)

Studies of HIV/AIDS in Mexico have shown that it is overwhelmingly a disease afflicting homosexual or bisexual men (Mohar, 1995; Valdespino-Gomez, 1995; Izazola-Licea, 1995) and areas with high rates of internal and international migration (del Rio-Zolezzi, 1995; Magis-Rodriguez, 1995). Included in the analysis are indicators for marital status based on the assumption that unmarried men (and women) are more likely to have more sexual partners. Other variables included are proxies for educational status, economic status, percentage of the population that is male, health care availability, and population density as a proxy for social interaction.

Because diabetes has been shown to disproportionately affect Hispanic females and to be related to obesity, proxies for both were included in the analysis. Thus, the percentage of population that was female, the percentage of females that were economically active, the percentage of housing without electricity, and the percentage of households unable to meet its basic needs were used. For lung cancer the general variables of education, economic status, and health care accessibility were included. Since in Mexico a much larger percent of men smoke than women the percentage of the population that was male was used. Finally, a proxy for second-hand smoke (crowded living conditions) was included.

#### *Statistical Analysis*

Yearly mortality rates were calculated for each disease for each study site and then standardized to the 1990 Mexican population age distribution to control for age at death or illness. Some AIDS mortality rates were equal to zero. Based on previous similar research (Scribner, 1998) observations with zero values were assigned a value equal to one half of the lowest observation for inclusion in the analysis. Disease rates were then collapsed into two regional categories (border and interior) and tested for significance. Risk ratios were then calculated for these two regions.

Three series of bivariate correlations were performed. First, death rates for individual border cities were correlated with maquiladora employment. Second, maquiladora employment was correlated with death rates for the two regional categories. Third, death rates were correlated with each other for all sites to see if there was a possibility of mutual influence and interaction.

Variables of interest for regression were then tested for correlation to reduce later chances of multicollinearity. All variables included in the analysis (except year) were transformed to their base 10 logarithm to adjust for skew and to permit analysis as a percent change in the dependent variable associated with a 1% increase in the predictor variable (Pindyck, 1989).

Using a priori knowledge, hierarchical regression models for both mortality and morbidity as dependent variables were built and run in several different combinations. The regional grouping was later tested using analysis of covariance for its between-group significance. For some disease rates some cities deemed outliers (i.e. consistently exceeding the next highest value by two-fold over time) were excluded in a second computation of the regression model. Residuals were tested for time-series autocorrelation using the Durbin-Watson statistic.

## **Results**

### *Descriptive socioeconomic variables*

Given that the border had better levels of literacy and economic participation (Table 1) it could be reasonably expected that this region would either have comparable or better living conditions than the interior municipios. That does not appear to be the case. As Table 1 also

shows nearly 11% of the border population was in housing without electricity compared to only slightly more than 4% of the interior municipios. Additionally, Table 1 shows further evidence of the disparities between the physical infrastructure at border and the interior for the time period in question. While interior municipios had on average a greater percentage of persons unable to meet their basic needs (55.02%) they still managed to have fewer persons living in housing that was considered crowded (44.63 versus 48.53 for the border). The percent of persons living in crowded housing may be related to the overall density which for the border was approximately 4.7 times higher than the interior region.

**Table 1. Selected literacy and economic indicators for the border and interior, 1990**

	Percent of 15+ population that was illiterate	Percent of 12+ population that was economically active	Percent of occupants in housing without electricity	Percent of occupants living in housing considered crowded	Percentage of population unable to meet their basic needs
Border average	4.48	34.04	10.86	48.53	48.86
Interior average	6.05	32.10	4.03	44.63	55.02

Source: INEGI (1990); CONAPO (1993).



Additionally, the interior municipios appear to have been better served by health care. In all the measures, except one (percent of physicians as general practitioners), the interior municipios ranked higher than the border municipios. This may indicate that, even though health care was more available in terms of the number of physicians in the interior, there may have been more accessibility to health care at the border. Finally, the percentage change of persons born outside the various municipios in 1980 and 1990 was consistently higher at the border. Indeed, in ranking the percentage change born outside the municipios between 1980 and 1990 three border municipios occupied the top three spots (Nogales, Juárez and Tijuana at 4.3%, 3.5%, and 2.4% respectively).

*Correlation analysis*

Table 2 shows that the mortality rates for AIDS and diabetes were correlated with growth in maquiladoras and maquiladora employment. Only at the border did lung cancer mortality correlate with maquiladora growth and employment. Additionally, though not shown, AIDS and diabetes mortality were associated with each other. In nine of the thirteen study sites AIDS and diabetes mortality were correlated at .50 and above.

**Table 2. Number of maquiladoras and maquiladora employment correlation with mortality rates by border and interior location**

Location	Maquilas/ AIDS	Maquilas/ DM	Maquilas/ LC	Employ/ AIDS	Employ/ DM	Employ/ LC
Border	.87	.61	.54	.91	.67	.65
Interior	.95	.68	.12	.95	.79	.09

DM = diabetes mellitus; LC = lung cancer; Maquilas = number of maquiladoras;  
Employ = number of maquiladora employees

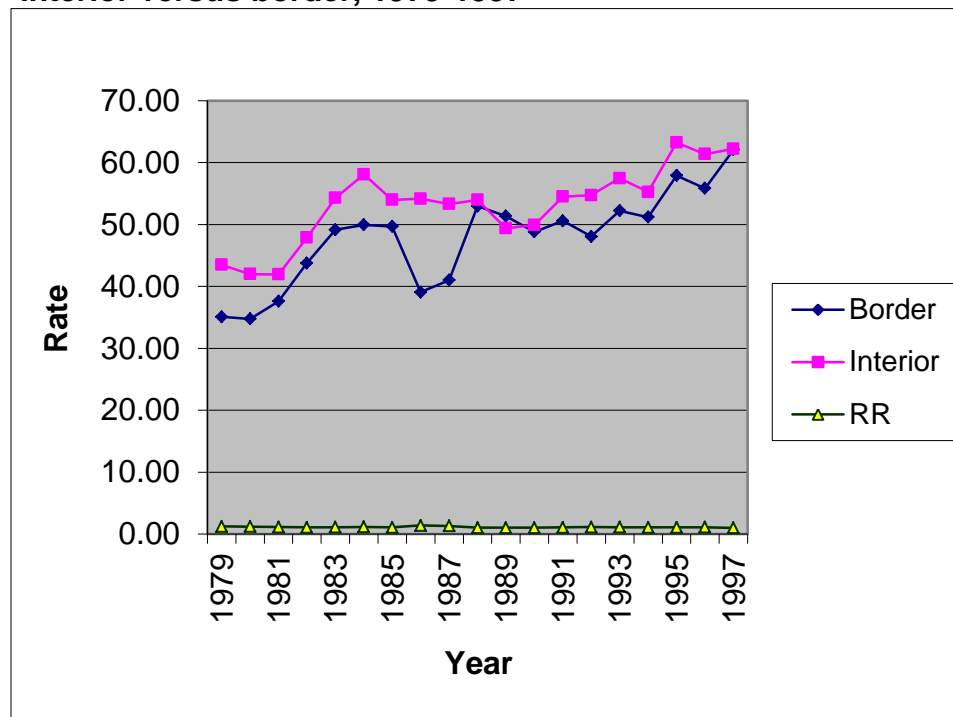
### *Statistical analysis of specific diseases: the border and the interior*

The risk from dying from AIDS, as presented in Figure 1, was consistently higher in the interior (risk ratio ranged from 2.38-4.64), but appears to be diminishing. Indeed, the highest risk was at the beginning of the time period and the lowest at the end due to the very low initial death rates at the border. However, it is important to note that for both the border and the interior municipios the trend is upward with the interior municipios showing a greater increase.

Consistently higher rates for AIDS mortality were found in four interior municipios (Veracruz, Guadalajara, Mérida, and Puebla) while some municipios, notably Nogales, Nuevo Laredo and León, reported no cases for several early years. Since the time period began in 1988 and the HIV/AIDS epidemic was first noted in North America as early as 1984, it is highly unlikely that these three urban centers had no cases as late as 1988.

The regression and covariance analysis for all three diseases shows that most of the variables believed to influence AIDS mortality were significant and to be in the direction of their supposed influence. However, the amount of influence that percentage of 1990 female population 15+ and illiterate and the percentage of female population 12+ and economically active were surprising. Total percentage of the population that is single and population density show a negative correspondence. However, this influence is comparatively small requiring nearly a 19% decrease to change AIDS mortality by 1%. Like the crude risk ratio the coefficient for being at the border shows a negative relationship affirming the significant greater risk of dying from AIDS if living in an interior municipio.

**Figure 2. Standardized mortality rates for diabetes per 100,000 interior versus border, 1979-1997**



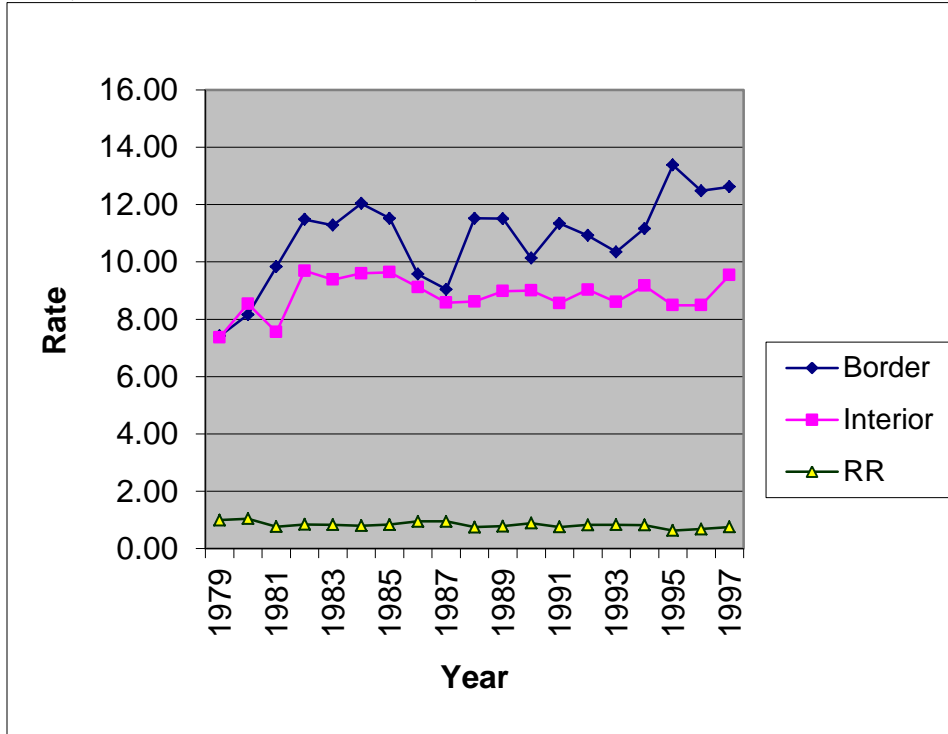
RR= Risk ratio (interior/border), t-test = 5.71 (p<.0001)

The mortality rates for diabetes for the interior and border are fairly close together giving a limited range of risk ratios (1.002-1.39) and only in 1989 did the risk for the border population exceed the risk for the interior population (Figure 2). In both cases the trend is upward. Prior to 1988 the highest rates of diabetes mortality were usually in the interior municipios. However, after 1988 the highest rates were at the border.

In Table 3 it can be seen that all of the factors thought to influence diabetes mortality did, indeed, have an effect. After adjusting for possible confounders it can be seen that living at the border slightly increases the risk of dying from diabetes. This corresponds with what was previously hypothesized; namely that the border population translated their increased incomes into more Western lifestyles, including dietary habits.

While most of the variables entered into the model followed their expected patterns (higher income but lower education lead to greater risk for diabetes) the amount of female economic activity does not. Also important to note is that the female percentage of the population had less of an influence on diabetes mortality than socioeconomic indicators. The diabetes model may not apply as well to the two sub-groupings as demonstrated by the ANCOVA results and there may be some serial autocorrelation in the data given the Durbin-Watson statistic (.96). However, since the time period analyzed was over 18 years the serial autocorrelation may be an artifact of the data.

**Figure 3. Standardized mortality rates for lung cancer per 100,000 interior versus border, 1979-1997**



**RR= Risk ratio (interior/border), t-test = -6.65 (p<.0001)**

The border municipios had consistently higher levels of lung cancer mortality than the interior municipios and in 1994 those rates began to diverge further (Figure 3); a border municipio had the highest rate of mortality from lung cancer for 18 of the 19 years of study. In some years (1979 & 1989) the rates for the border municipios were much higher than the interior. For example, in 1989 Nogales' rate of 25.99/100,000 was more than double that of the highest interior municipio (Guadalajara at 11.56/100,000).

All of the variables thought to influence lung cancer mortality were significant and their influence was in the direction hypothesized. The percentage of the population that was male shows a small positive influence. The percentage of the females who were economically active shows a positive influence and the percentage of persons living in crowded housing showed a positive influence. The two health variables showed the greatest influence in that a small increase in either of these two variables lead to an increase in lung cancer mortality. Also notable is the large ANCOVA f-value that highlights that there are significant differences between interior and border groupings.

### **Discussion**

In general, the variables for each disease were significant and their influence was in the direction presupposed. The three mortality data sets showed results that were consistent with previous studies (Mohar, 1995; Castro-Sanchez, 1997; Lazcano, 1997). That these diseases associated with a "Western" lifestyle were correlated with the growth in maquiladoras is not surprising. Given a rise in disposable income one can also expect a change in lifestyle habits, including diet, and, perhaps, more social permissiveness.

While the risk from dying from AIDS has been consistently lower at the border, this risk may be obscured by bias in the data. U.S. officials were concerned that Mexico was underreporting its AIDS cases (Hatcher, 1985), though it is unknown whether this underreporting is systematic and if it continues today. This could be due to a later arrival of the HIV epidemic in Mexico or possible misclassification bias as earlier deaths may not have been attributed to AIDS. Guadalajara, which showed an early detection of the disease and was ranked highly in all health care statistics, for example, may have had better diagnostic facilities and, therefore, an earlier and higher mortality rate.

That the percentage of the 1990 population that was male showed an influence on AIDS deaths is not surprising given that in Mexico AIDS has been primarily a disease afflicting gay and bisexual males. Nor is it surprising that the percentage of physicians who were general practitioners showed an influence or the percentage of the population born outside of the municipio. Having a greater percentage of general practitioners may provide better detection and classification of the disease while having a greater percentage of immigrants to an area might provide less social structure and more sexual permissiveness. As the percentage illiteracy increased so did the chance of dying from AIDS. Likewise, as economic activity for women increased so too did the chances of contracting HIV and, hence, dying from AIDS. That these two factors may have a larger influence on AIDS mortality than the percentage male may be an additional indicator that the HIV epidemic in Mexico transitioned in the 1990s from one that is more related to socioeconomic status than sexual orientation.

Mortality from diabetes was shown to be higher at the border. This is not surprising as it was hypothesized that rising incomes at the border would lead to greater adoption of a Western diet based on higher levels of acculturation. It was also expected that greater female economic activity would lead to higher levels of diabetes mortality because of higher incomes and further

adaptation of Western eating habits, however, it did not. This may be explained by greater female activity leading to a less sedentary lifestyle and greater dietary choices.

While the crude risk for dying from lung cancer was greater at the border, this risk was slightly reduced once other factors were controlled. This may be due to the ability of border residents to access and afford better health care and treatment, thus, shifting mortality from lung cancer into morbidity. These two variables in conjunction with the negative influence of being at the border indicate that a death from lung cancer may have more to do with available health care.

One possible risk factor for lung cancer mortality at the border might be acculturation leading to a higher propensity of in-migrants to begin smoking. Hispanic populations have been shown to be at a higher risk for smoking and acculturation has been linked to smoking in Hispanic adults and adolescents (Epstein, 1998). At the border, where a large proportion of the population have been migrants and the “culture” is a mixture of both Mexican and American, it could be expected that there would be high rates of smoking. Compounding the problem and, perhaps, having greater impact on the health of border residents has been the persistent marketing of tobacco in the region (Power, 1998).

The peculiarities of the northern Mexican border and their influence on public health must be acknowledged. This is a region where two countries with different standards and costs of living, political and health systems meet, leading to both benefits and costs accruing for the border. The governments of both the U.S. and Mexico have long recognized the need for binational cooperation on border issues. For example, the Pan American Health Organization (PAHO) and the U.S.-Mexico Border Health Association (USMBHA) have both worked to find solutions through joint action on both sides of the border. Likewise, the Border Epidemiological Center for HIV/AIDS Control worked to reduce HIV transmission (Izazola-Licea, 1991; Sepulveda, 1992).

One health benefit of residing along the U.S.-Mexico border is the possible cross-utilization of health services by Mexican nationals. While the typical percentage of Mexican border residents seeking care in the United States has been shown to be small (Guendelman, 1993; Ellis, 1996;), that option does exist. According to past National Satisfaction Surveys, 5.7% of the medical needs among border adults are not met, versus 7.9% nationwide (Ellis, 1996).

The health care offered by transnational corporations (TNCs) to their employees cannot be discounted either. However, this impact is probably minimal given that in Mexico maquiladoras only employed approximately 1% of the total population in the 1990s (USEPA/SEDUE, 1997) and even along the border that percentage has rarely exceeded 20% (Suárez y Toriello, 1996). Given the high rate of turnover in most maquiladoras and the limited health care usually offered by TNCs this benefit reduces even further. Additionally, the growth in maquiladora employment actually corresponded with the increases in the mortality rates for the three diseases.

BIP was set-up to attract migrants to the border and provide employment for them. The effect of such a large migrant community on the border would be multi-faceted. The first would be a possible weaker social structure and, therefore, a likely high rate of lifestyle and communicable diseases. But conversely, migration theory holds that it is the youngest and healthiest that most often migrate (Castles, 1993; Harris, 1995). This would lead one to believe that the overall health of this area should have improved as young migrants entered this region and the age structure changed.

*Limitations of the Study*



Mexico, like many countries, has problems with data accuracy and availability of certain variables for precise geographic analysis. This can be mitigated by relying on several data sources over long periods of time, but for some data this was not possible. Most of the independent variables were cross-sectional because of the reliance on the 1990 census data. There are periodic surveys typically performed every year, but the resultant data from those surveys are aggregated to the state level.

This research also would have been stronger had more detailed migration data been available. It is possible for a person to become ill in one region, migrate to another and then have their ill health profile be reflected in the statistics of the recipient region. Mexican migration data are typically only available for every ten years and are aggregated to the state level. In other words, it is only possible to account at a gross level the flow of migrants.

This was a mixed ecological study and, therefore, can suffer from ecological bias. However, ecological studies do have benefits. Primarily, they are efficient means of evaluating the effectiveness of intervention programs or implemented policies, and are useful in identifying certain types of “contextual” effects on individual risk (Morgenstern, 1998) or unintended effects of population interventions (Morgenstern, 1982). They can be used to test or screen new etiologic hypotheses regarding the possible effects of a specific exposure on several health outcomes. Finally, it should be noted that the geographical unit used in this study is fairly small in comparison to other studies (Grosse, 1983; Cumper, 1984; Preston, 1975) that have investigated similar health effects of policy interventions.

One of the main strengths of this research is its originality. A review of the extant literature revealed little research conducted on the impact of maquiladoras on public health in general. Previous studies focused on small subpopulations within export processing zones (EPZs), namely employees of TNCs, or have been mostly descriptive (Frumkin, 1995; Hatcher, 1995). Most previous studies have demonstrated that employees in EPZs faced numerous occupational hazards, but have not examined health status at a larger scale. By using several different study sites, including the border and interior, this research at least partially overcame this.

This research also covered a range of diseases of import and, therefore, can make broader statements about health at the border. It was first hypothesized that the lack of physical and social infrastructure at the border affected the health of the resident populations in several ways. By obtaining data on AIDS, diabetes and lung cancer a more extensive picture of the health status at the border emerges.

### **Conclusions**

The Mexico-U.S. border is a unique region of the world. Nevertheless, even with that caveat in mind, more general principles can be sought. What a country considering implementing a regionally-targeted, economic development policy cannot assume is that it will lead to better health. As an example of this, the Border Industrialization Program which was never explicitly intended to improve health at the border did not result in any significant differences in AIDS, diabetes, and lung cancer mortality for the region. What has been shown is that the main outcome is a different health profile; not necessarily a better health profile. The even larger principle is that areas with better economic conditions may not be able to translate their increases in wealth to increases in health or even bettering their standard of living. Economically advantaged areas may only be able to shift higher rates of mortality to morbidity.

The higher risks at the border, such as social permissiveness, acculturation, the marketing of harmful products, and the adoption of a Western diet, appear to be at least partially reduced by

the benefits of its unique location. The economic growth of the region, the bi-national health programs, and the accessibility of health care have dampened the more harmful aspects and have, perhaps, shifted what would have been deaths into long-term disabilities.

As was also shown by this research, despite the implementation of a policy designed to economically favor the northern Mexican border, the general living conditions there were worse in comparison to their non-border equivalents. Subsequently, the border still faces the burden of communicable and lifestyle diseases. The question then arises for other regions of what can be expected for their health status when they do not share the propinquity to a more economically developed country as the northern Mexican border does.

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