Observations on the interaction of older age and diabetes on COVID-19 mortality, and of non-pharmaceutical interventions on daily reported COVID-19 cases in El Paso, Texas, 2020

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Abstract

Introduction. In El Paso, Texas, a largely Hispanic population, a large surge of COVID-19 occurred in October 2020. Using public health surveillance data and a field survey we report on the epidemiology and control of this pandemic in 2020.

Population and Methods. We used reported COVID-19 cases to the notifiable disease reporting system to: 1) calculate morbidity and mortality rate ratios by age, gender, race/ethnicity, and poverty; and 2) to assess temporal trends using joinpoint regression. A door-to-door cluster sampling serologic survey assessed prevalence of SARS-CoV-2 infection. We calculated the relative excess risk due to interaction (RERI) of older age and diabetes on mortality from COVID-19.

Results. By the end of 2020, the reported morbidity and mortality were 0.8% and 216.8 per 100,000 population, respectively. The overall prevalence of infection reached 18.5%. Compared to those under 20 years of age, the reported morbidity was nearly twice among 65+ years of age (RR=1.6 [95% CI=1.6, 1.7]), but the mortality in this group was disproportionately large (RR=1,026 [95%

CI=329.0, 3,171.0]). Hispanics had twice the morbidity and mortality than non-Hispanics. Essential workers had an increased prevalence of SARS-CoV-2 infection compared to other occupations. Social distancing measures appeared to have contributed to decrease the morbidity by the end of 2020. Diabetes and older age jointly increased the risk of COVID-19 mortality (RERI=27.9 [95% CI = 24.0, 32.2]).

Conclusions. US Hispanics experienced excess COVID-19 morbidity and mortality. Older age and diabetes mellitus synergistically increased the risk of COVID-19 mortality.

Keywords: epidemiology, coronavirus, COVID-19, SARS-CoV-2, Hispanics, antibodies, diabetes; interaction, United States

Introduction

In October 2020, a third wave of the COVID-19 pandemic occurred in El Paso, Texas. the largest, mostly (85%), Hispanic/Latino metropolitan area in the United States of America (USA). Hispanics/Latino are disproportionately affected by obesity-related disorders, saliently diabetes [1, 2]. Although the excess COVID-19 morbidity and mortality among Hispanic/Latinx US populations has been reported [3], to our knowledge at the time of this submission, there were no previously published field epidemic investigations during the COVID-19 pandemic in mostly Hispanic USA populations (*Cfr*. Supplemental table). Furthermore, regardless of race/ethnicity, no previous study has addressed the excess mortality assessing the joint effects of older age and common morbidities such as high blood pressure and diabetes mellitus. On the contrary, previous published studies have only address the issue of confounding by age via adjustment in multivariate analysis of the estimates of effect of comorbidities by age, hindering the description of the true nature of the joint effects of these two factors.

Non-pharmaceutical interventions (NPIs) aiming to control the COVID-19 pandemic were implemented in most countries of the world and include a) personal protective measures such as masking, and

handwashing; b) surface disinfection and ventilation; c) social distancing measures such as school, workplace, and business closures; and d) travel restrictions. The impact of social distancing measures, particularly school, workplace and other business closures implemented in the US were hypothesized to work through decreasing the contact rates and therefore the effective reproductive number [4].

We examined morbidity and mortality data available to the local health department and supplemented by a random household survey of SARS-CoV-2 antibodies, with the following objectives: 1) to evaluate the possible interaction between diabetes and older age in the risk of mortality in the study population; 2) evaluate the possible effect of non- NPIs on the occurrence of reported morbidity; and 3) describe high-risk groups for COVID-19 and SARS-CoV-2 infection.

Population and Methods

Study population

The population of El Paso County, Texas, 2020 population 839,238 is served by a local health department, the City of El Paso Department of Public Health (COEPDPH), requiring reporting of COVID-19 cases according to guidelines of the US Centers for Disease Control and Prevention, in place since February 2020.

Outcomes: COVID-19 cases and deaths

We reviewed data on laboratory-confirmed cases of COVID-19 meeting the standard case definition [5]. among El Paso County, Texas, residents diagnosed during March 11–December 22, 2020, and reported to the COEPDPH. The date of specimen collection was readily available for all reported cases. In addition to data available from case records, we also reviewed death certificate data on the reported cases and available to COEPDPH from which we abstracted the underlying cause of death and conditions contributing to the death.

Outcome: SARS-CoV-2 infection

We also report on a household probability serologic survey (n=197) conducted on December 11-December 28,2020, to assess the risk of SARS-CoV-2 infection using both IgM and IgG antibodies. A recent SARS-CoV-2 infection (i.e., last three months) was as indicated by presence of IgM class antibodies. A person with likely an older infection (more than three months) had a negative IgM but positive IgG test.

Sampling

We used a standard multistage area probability sampling technique to obtain an equal probability sample of 193 housing units [6, 7]. The sample size was calculated to estimate anticipated proportions of 50% with a precision of 5% [8]. We selected 30 census tracts as primary sampling units using probability proportional to size from population estimates of 2019. Within a census tract a segment or block group was selected and within the block group, one block was selected at random. Later, a field team canvassed the selected block to enumerate the occupied households. Using a pseudo random number generator, a starting household was selected at random, and the contiguous households were visited to select as many as seven persons from the selected households. Within each selected household, consent was obtained from the responding adult available, and one person was selected using the next birthday method [9]. We used Google Earth (Google LLC, Mountain View, CA) to produce maps and locate the census blocks. To reduce cold contacts, in advance of the visits, flyers were distributed door to door in target blocks. However, there were no repeated visits to households where there was no one home. Most visits took place during working hours of weekdays. The interview and blood collection took place in the porch of the homes to limit the probability of SARS-CoV-2 transmission between survey staff and survey participants.

To measure the presence of antibodies in capillary blood samples, we used an immune lateral flow FDA emergency use approved commercial test (Premier Biotech, Hangzhou Biotest Biotech, Co., Ltd),

which was found to have a 90.9%, and 97.2%, sensitivity and specificity, respectively [10]. We obtained data from the participants of the serologic survey on usual occupation, and coded the data on occupation using National Institute of Occupations Safety and Health NIOCCS software [11], grouping occupations with two digit codes 29 to 41 (Healthcare Practitioners and Technical Occupations, Healthcare Support Occupations, Protective Service Occupations, Food Preparation and Serving Related Occupations, Building and Grounds Cleaning and Maintenance Occupations, Personal Care and Service Occupations, and Sales and Related Occupations) were grouped as 'essential workers' and the rest as 'non-essential' excluding those classified as homemakers, retired, students, military and with insufficient data. We collected data on previously diagnosed chronic conditions including diabetes.

Analysis

Proportions, rates, and ratios were calculated using methods described elsewhere [12]. Age-specific morbidity and mortality rates were calculated using estimates from the 2019 American Community Survey as denominator for analysis on age, gender, race/ethnicity, and poverty. Except for age-specific rates, all morbidity and mortality rates were age-standardized using the 2000 US Census population as standard using the direct method [12]. For spatial analyses we used zip code tabulation areas (ZCTA) to calculate crude morbidity and mortality rates by place of residence. We used grouped COVID-19 cases by ZCTAs of residence forming categories of ZCTA's according to the quartiles of the distribution of the proportion of families living below poverty level to assess the association of the occurrence of COVID-19 by poverty. The distribution of poorer areas in El Paso is well known through ACS data: it affects the South Central (ZCTAs 79901, 79905, and 79915), Southeastern (ZCTAs 79927, 79928, 79948, 79936, 79938 and 79953) as well as the Upper Northwest (ZCTAs 79911, 79921, 79935) sections of the county.

The time series consisting of COVID-19 cases by day of specimen collection from October 1-December 22, 2020 (n=88 days), was analyzed using joinpoint regression [13] using software in the public domain

(Joinpoint Version 4.7, National Cancer Institute, Bethesda, MD) to obtain a daily percent change following NPIs aiming to control the pandemic. This approach is known as an ecologic time series analysis in which “a change of exposure, such as the start of an intervention program, compare the slope in the disease trend before and after the intervention” [14]. The daily percent change was obtained from a regression analysis on the log scale [13].

Sampling weights for the serologic survey were calibrated to reflect the distribution of the population by age, gender and race/ethnicity and to obtain estimates of the proportion of persons with positive antibodies to SARS-CoV-2. We assessed the effect of misclassification from imperfect test validity on our estimates [15].

To assess the contribution of diabetes to the excess risk of mortality from COVID-19, we calculated the risk of mortality among adults with and without diabetes, using our household survey estimate of prevalence of diabetes for denominator data, and the number of COVID-19 deaths with any mention of diabetes in death certificates by two age categories (under 65 years of age, and 65+ years of age). The assessment of interaction thus used two sources, our door-to-door survey to estimate the prevalence of diabetes, and case reports including death certificate to assess presence or absence of diabetes as a contributing cause of death but with COVID-19 as underlying cause of death. The point estimate of prevalence of diabetes mellitus from our survey was applied to the ACS population estimates to obtain denominator data of persons with and without diabetes by age group. For the analysis of the interaction we used standard methods described elsewhere [16], if we call A and B, older age and diabetes mellitus, when we use relative measures of association such as the rate ratios noted RR, the excess risk is equal to RR -1, and the relative excess risk due to interaction is $RERI = RR_{AB} - RR_{A\bar{B}} - RR_{\bar{A}B} + 1$ with a null value=0. The evaluation of the interaction on the multiplicative scale was evaluated on the rate ratio of both exposures, A and B, over the product of the rate ratio on the presence of one (A) and the absence of the other (B), times the relative risk in the absence of the first one (A), and the presence

of the second one (B), the synergy factor $(SF) = \frac{RR_{AB}}{RR_{A\bar{B}} \times RR_{\bar{A}B}}$, with a null value =1 [17]. A Poisson regression model was fitted using SAS PROC GENMOD, specifying the Poisson link, to obtain RERI, estimates and their 95% CI, using the method of variance estimates recovery described elsewhere [18]. The 95% CI of the SF was obtained from normal approximation estimators [17]. All survey data used complex survey estimators. Statistical significance was set at 0.05. All analysis were carried out using the SAS software (v 9.4, SAS Institute, Cary, NC).

Protection of human subjects

All serologic survey participants provided written informed consent. The University of Arkansas for Medical Sciences Internal Review Board determined the project was a non-human subject research (protocol 262096) as it was considered part of the response to a public health emergency, case and contact investigations are public health practice, and the assessment of past infection through serology was considered a program evaluation, and yet a simplified consent process and forms in English and Spanish were signed and a copy left with the participants.

Results

Reported COVID-19 morbidity and mortality

As of December 22, 2020, a total of 90,258 COVID-19 cases had met the case definitions (5). The cumulative incidence at that date was 10,828 per 100,000 (i.e., 10.8%). A total of 1,800 deaths were recorded for a case-fatality ratio of 2.0% (i.e., 1,800/90,258). Table 1 shows the occurrence of COVID-19 morbidity and mortality by age, sex, race/ethnicity, and level of poverty of the zip code of residence. While the reported morbidity COVID-19/SARS-CoV-2 rates were higher among young and middle-aged adults, the risk of COVID-19 mortality, among the elderly, was 1,021-times that of children (0-19 years).

TABLE 1. Characteristics of cumulative laboratory-confirmed COVID-19 cases, and deaths among El Paso, Texas residents reported to the City of El Paso Department of Public Health — El Paso City, Texas, March 11–December 22, 2020

Characteristics	Cases			Deaths		
	Number	Risk†	Risk Ratio (95% CI)	Number	Risk†	Risk Ratio (95% CI)
All	90,258	10,828		1,800	216.8	
Age (years)						
0 to 19	15,176	6,074.3	1	3	1.2	1
20 to 44	40,237	13,365.2	2.2 (2.2 - 2.2)	77	25.6	21.3 (6.7 - 67.5)
45 to 64	24,600	13,430.4	2.2 (2.2 - 2.3)	430	234.8	195.5 (62.8 - 608.5)
65+	10,245	9,740.9	1.6 (1.6 - 1.7)	1,290	1,226.5	1,021 (329.0 - 3,171.0)
Sex						
Males	42,856	10,426.4	0.9 (0.9 - 0.9)	1,075	307.1	2.0 (1.9 - 2.2)
Females	47,400	11,272.1	1	725	150.2	1
Race/Ethnicity						
Hispanics	81,708	11,869.5	2.0 (2.0 - 2.1)	1,622	233.1	1.6 (1.4 - 1.9)
Non-Hispanics	8,548	5792.3	1	178	124.1	1
Neighborhood poverty						
<13.0%	16,208	8,654.6	1	480	271.6	1
13.1% to 19.2%	32,327	10,182.9	1.2 (1.1 - 1.2)	551	217.0	0.8 (0.7 - 0.9)
19.3% to 25.8%	25,977	12,523.3	1.4 (1.4 - 1.5)	525	243.9	0.9 (0.8 - 1.0)
>25.8%	15,857	14,766.0	1.7 (1.7 - 1.7)	413	300.1	1.1 (1.0 - 1.3)

† Per 100,000 population.

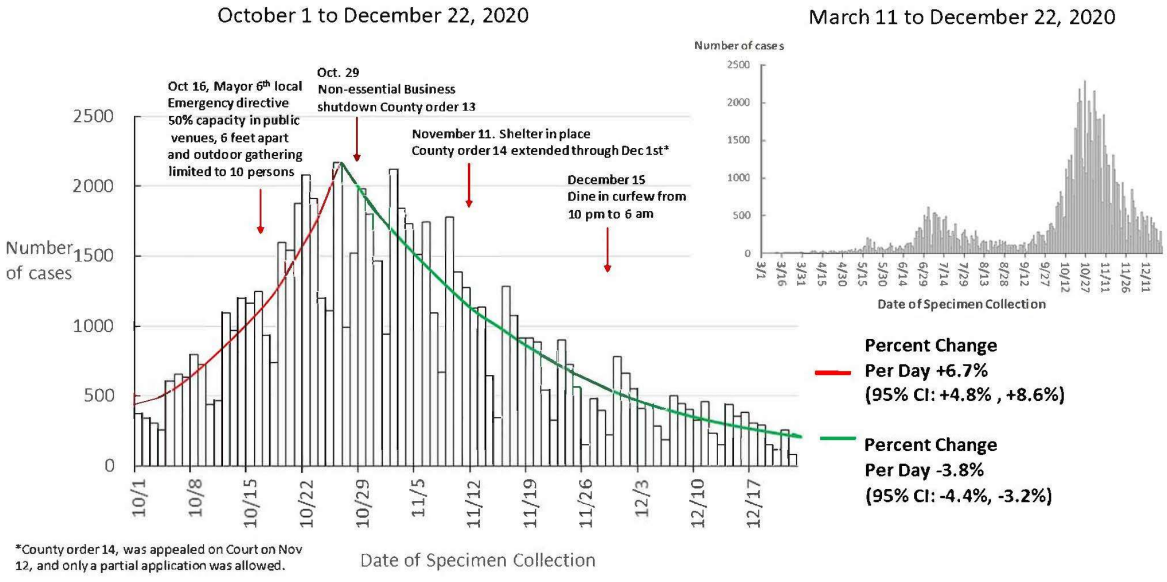
Source: City of El Paso Department of Public Health

The reported morbidity rates by gender were lower among males, but the COVID-19 mortality rates for males were twice that of women. The COVID-19 morbidity and mortality of Hispanics were significantly higher than among non-Hispanic persons.

The epidemic curve for the entire reporting period of March 11 through December 22 is shown in the

inset of Figure 1. The rate of PCR testing in the US had increased from less than 1% persons tested to in April to 35% in September of 2020, reflecting the widely availability of PCR testing for SARS-CoV-2 infection and COVID-19 surveillance [19]. The main figure shows a timeline with the dates of declaration of public health measures during the third wave, aiming to decrease the contact rate. The first public health mandate was declared in mid-October limiting the number of patrons allowed in restaurants and other public places. The second mandate was declared by the end of October, shutting down all non-essential businesses. From October 1 through October 29 there was a sustained increase at a rate of 6.7% per day, and a second segment, with a decline at a rate of -3.8% per day, starting on the first week of November after the shutdown of non-essential businesses. Other NPIs had been in place extending the restrictions to businesses, such as the hours of operations of restaurants and bars as shown in the Figure 1. Along with the NPI's depicted in the timeline of Figure 1, starting on approximately October 19, the COEPDPH scaled up a bilingual English/Spanish educational and community outreach and media campaign actions.

Figure I. Reported Cases of COVID-19/SARS-CoV-2 infections by date of specimen collection, El Paso, Texas, 2020



Source: City of El Paso Department of Public Health

Both panels of Figure 2 panel a show the age-adjusted COVID-19 morbidity and mortality rates by zip code, respectively. There was a narrow interquartile range of the reported incidence (7,926 to 11,493 per 100,000). Higher reported incidence in areas along the US-Mexico border and the northern part of the county, the ZCTAs previously described as most affected by poverty. The age-adjusted risk of mortality from COVID-19 shown in Figure 2 panel b, had a wider range of values (interquartile 76 to 235 per 100,000) but was elevated also in poor areas of the county.

Figure 2. (A) Age-adjusted reported incidence of COVID-19/SARS-CoV-2 infections per 100,000 by zip code of residence, El Paso, Texas March 11- Dec 22, 2020

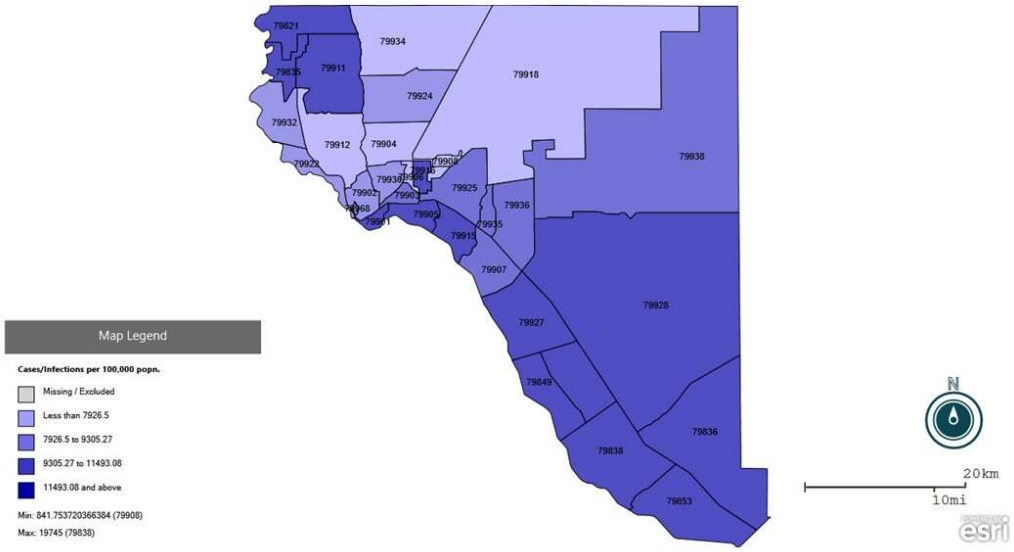
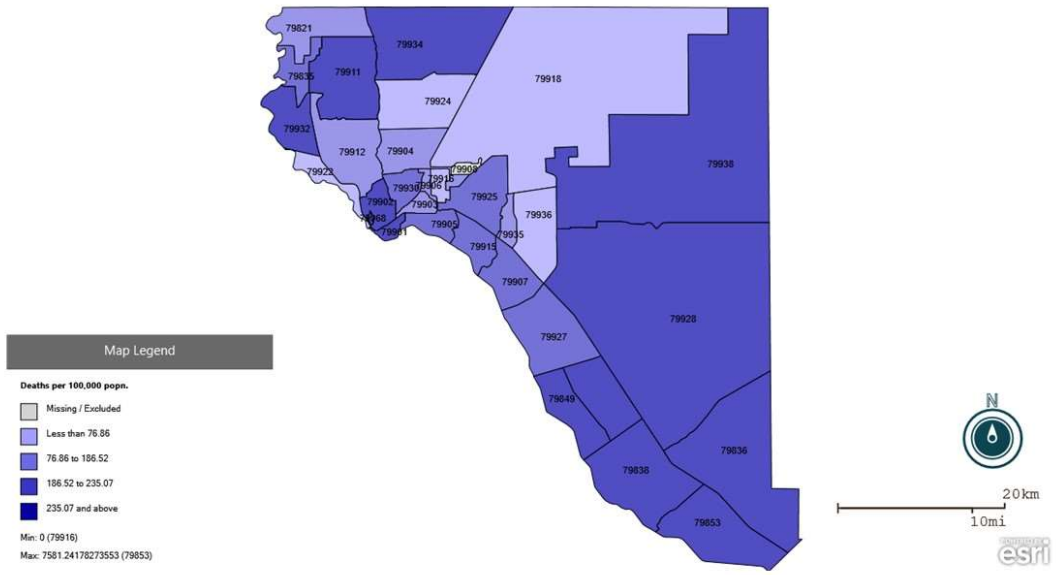


Figure 2. (B) Age-adjusted mortality from COVID-19 per 100,000 by zip code of residence, El Paso, Texas, March 11- Dec 22, 2020



Source: City of El Paso Department of Public Health

Serologic Survey

From December 11-28th, 2020 we completed a total of 197 interviews and serological tests in randomly selected individuals. The response rate was 17.7%, with 55.6% and 26.6% of visits reporting no one home and refusals, respectively.

The weighted estimate of cumulative incidence of SARS-CoV-2 infection was 18.5% (36 positive test/197 tested (95% CI=9.6% - 27.4%), we estimated a total of 155,000 persons with past SARS-CoV-2 infection. The estimate of risk of recent SARS-CoV-2 infection was 9.5% (95% CI= 2.0 - 17.0), and the proportion of persons with likely older infections was estimated at 8.9% (95% CI= 0.2 - 17.6), suggesting that 48.6% of all SARS-CoV-2 past infections occurred in the last three months. Among those with past infection, both recent and older, 29.4% had no history of symptoms resembling COVID-19. Based on the results of the survey, we estimate that the infection-fatality ratio was 0.1% (i.e.,1,800 deaths/155,000 infections), while the crude CFR was 5% based on the reported cases, or 2.0% (i.e., 1,800 deaths/90,258 reported cases). The distribution of the participants by age, sex, ethnicity, high

school education and occupation is shown in Table 2. There were some variations in SARS-CoV-2 infection by age, Hispanic ethnicity, and education in the serologic survey, but were not statistically significant. The prevalence figures were 20.6% (95% CI = 5.8% - 35.3%), 15.3% (95% CI = 4.6% - 26.0%) and 9.7% (95% CI = 2.6% - 16.8%) among children (<20 years of age), 20-64 and 65+ year-olds, respectively. Hispanics had a prevalence of 19.9% (95% CI = 8.9% - 30.8%), and non-Hispanics had a 9.8% prevalence (95% CI = 0.0% - 29.0%).

A higher prevalence was observed among those without high school (23.6%; [95% CI = 11.2% - 36.1%]) than among those with high school and higher education (13.2% [95% CI = 2.5% - 23.8%]). The infection was the same by gender: 18.3% in males, and 18.6% in females. However, we found a ten-fold increased prevalence of SARS-CoV-2 infections among ‘essential workers’ (10/33 prevalence = 33.0% 95% CI = 8.3% - 57.7%) compared with a prevalence of 4.4% (95% CI = 0.0% - 10.1%), which remained significant once adjusted for age, sex, ethnicity and education (prevalence odds ratio = 13.1; (95%CI = 1.4 -124.1). Health care workers drove in large part this association (prevalence ratio = 4.9; 95% CI =1.1 - 22.3) but the limited number of observations (9/86) prevented subgroup analysis. In the subset of the working population (i.e., 86) women had a higher risk of SARS-CoV-2 infection that men.

The overall estimates of prevalence of SARS-CoV-2 infection in El Paso would only change by 0.7%, from 18.5% to 17.8% if adjusted for imperfect sensitivity and specificity of the test.

Table 2. Distribution of SARS-CoV-2 infections in a random sample of residents by select characteristics, El Paso, Texas, December 2020

	Infections	Age-specific Risk*	Total	Multivariate** odds ratio (95% CI)
Age Group				
0-39	9	(20.6)	52	0.4 (0.0 - 5.0)
40-59	15	(15.5)	64	1.2 (0.1 - 13.2)
60+	8	(10.0)	67	1
Total	32	(15.8)	183	
Gender				
Females	23	(18.6)	111	18.9 (5.6 - 63.4)
Males	13	(18.3)	86	1
Total	36	(18.5)	197	
Race/Ethnicity				
Hispanics	33	(19.9)	171	6.6 (0.7 - 61.9)
Non-Hispanics	3	(11.8)	21	1
Total	36	(18.4)	197	
Education				
High School and less	24	(23.6)	105	1.8 (0.2 - 18.2)
More than High School	12	(13.5)	92	1
Total	36	(18.4)	197	
Occupation				
Essential workers	10	(33.0)	33	13.1 (1.4 - 124.1)
Health care	5	(48.8)	9	-
Other workers	6	(4.4)	53	1
Total	16	(13.8)	86	

*Weighted estimates

**Restricted to the working population (n=86)

Source: City of El Paso Department of Public Health

Evaluation of the interaction of older age and diabetes

The prevalence of self-reported medically diagnosed diabetes among adults (20+ year-olds) in our survey was 13.6% (95% CI = 9.3% - 18.0%), varying from 7.5% (95% CI = 4.4% - 10.6%) among persons 20-64 to 46.9% (95% CI = 20.9% - 72.9%) among those 65+ years of age. Seventy-five percent

of death certificates of COVID-19 fatalities mentioned diabetes as a comorbidity. The proportion of COVID-19 deaths with mention of diabetes increased by age from 47.6% to 86.0% among decedents 20-64 and 65+ years of age, respectively. A comparison of the double-specific mortality rates using death certificate data and estimates from our own survey, showed an excess risk of COVID-19 mortality among older persons with diabetes (mortality risk = 2,248.3 per 100,00) compared to the risk of persons 65+ without diabetes (mortality risk = 324.1 per 100,000), or the risk of death from COVID-19 among persons 20-64 years of age with diabetes (mortality risk = 669.1 per 100,000). The referent group, those less than 64 years of age and without diabetes, had a mortality risk from COVID-19 of 59.6 per 100,000 (Table 3). The RERI was more than 22 times above the null value (RERI= 22.1; 95% CI = (18.6 - 26.2). The attributable proportion due to interaction was 58.5% (95% CI = 53.1% - 63.1%), that is the proportion of the risk in those with both exposures (old and with diabetes) that was due to the interaction. The interaction was less than multiplicative: the SF was 0.6 (95% CI = 0.5 - 0.8).

Table 3. Modification of the effect of diabetes mentioned in death certificate and using estimates of diabetes from self-reports in survey by age on the rate of mortality from COVID-29, El Paso, Texas 2020

Age Groups	Diabetes			
	No		Yes	
	Deaths	Population	Deaths	Population
Age				
20-64	267	447,907	243	36,317
	59.6 per 100,000		669.1 per 100,000	
Mortality Risk Ratio (95% CI)	1		11.2 (9.4 - 13.3)	
	(Referent)		*P* <0.0000001	
65+	181	55,848	1,109	49,327
	324.1 per 100,000		2,248.3 per 100,000	
Mortality Risk Ratio (95% CI)	5.4 (4.5 - 6.6)		37.7 (33.0 - 43.1)	
	P <0.0000001		*P* <0.0000001	

Relative risk due to interaction (95% CI) For 65+ years with diabetes = 36.3 – 4.8 – 4.6 + 1 = 27.9 (95% CI = 24.0 - 32.2).
Synergy Factor (95% CI) or 65+ years with diabetes = 37.7/ (5.4*11.2) = 0.6 (0.5 - 0.8).

Source: City of El Paso Department of Public Health

The excess risk of mortality from COVID due to the interaction was more striking given that the risk of

COVID-19disease among older persons was lower (9,740 per 100,00) than among persons 20-64 years of age (13,400 per 100,000) (Table 1). Similarly older persons had a lower prevalence of /SARS-CoV-2 infection (10.0%) than those under 40 (20.6%). Older persons experienced less morbidity, yet more mortality than younger persons.

Forty-five percent of the survey respondents reported not leaving their home more than twice a week in the last month, that is consistent with the stay home orders, and 47.5% stated agreed with the statement “must have the vaccine” as the survey took place once the FDA had approved emergency authorization for use of COVID-19 vaccines, but before vaccination began.

Discussion

As of this report, to our knowledge no previous field investigations had been conducted to characterize the epidemiology and control of the COVID-19 pandemic in a mostly Hispanic population in the USA. El Paso, Texas experienced a large wave of the pandemic in October and early November of 2020, with a cumulative incidence of 10,828 per 100,000 (10.8%) as large as that of New York City [20], which may reflect increased availability of PCR testing later on in 2020, making difficult a comparison of reported figures given a diversity of factors such as testing, and access to healthcare in general.

There were more reported cases and deaths from COVID-19 per 100,000 population among Hispanics than among non-Hispanics in El Paso, Texas. Such ethnic disparity could reflect the fact that Hispanics are employed in low-pay occupations and industries that do not allow working from home or keeping a 6-feet distance. Not shown in detail in table 2, our survey found that 16.4% of non-Hispanics were essential workers, and the proportion among Hispanics working as essential workers was 35.5%.

Poverty was associated with the risk of morbidity (i.e., age-adjusted rate ratio 1.7 [95% CI = 1.7 - 1.7] for those in neighborhoods with more than 28.5% of their neighborhoods under the poverty line, versus those in neighborhoods with the least poverty). There was a weaker association with the risk of mortality

(age-adjusted mortality risk ratio 1.1 [95% CI = 1.0 - 1.3]), i.e., statistically different than the age-adjusted morbidity risk ratio of 1.7. A study in Los Angeles, California, found increased SARS-CoV-2 antibody positivity for households with income levels of <$65,000 a year with those from households with income >$110,000 per year [21].

The set of risk factors for SARS-CoV-2 infection are not necessarily the same as those affecting the risk of COVID-19 overt disease or severe disease and fatalities. The scope of the assessment of the occurrence of the pandemic using reported morbidity, seroprevalence and mortality data allows us to contrast those factors in the same study population. A higher risk of SARS-CoV-2 infection was related to factors that increase contact such as occupation. There was some increased risk of infection among females and Hispanics that could be related also to increased contact: for instance, single headed female household must work because they are sole breadwinners. Increased risk of COVID-19 disease was associated with age above 20 years, poverty, and Hispanic which could be interpreted as related to host susceptibility: increased age results in impaired immunity, and Hispanics have higher prevalence of chronic diseases and metabolic syndrome. Finally, the risk of mortality increased exponentially with age, among men, Hispanics. Hispanics experience a heavier burden of chronic disease than non-Hispanics. A recent cohort study conducted in California, USA, found that occupational and socioeconomic factors placed Hispanics at high risk of death from COVID-19 [22]. Poverty increased the risk of COVID-19 disease in our data, and not as much the risk of death from COVID-19, suggesting poverty increased the risk of acquiring the infection rather than the outcome of infection. Again, environmental factors played a role in the risk of acquiring SARS-CoV-2 infection and COVID-19 disease, while host factors were associated with severity and fatal outcomes of SARS-CoV-2 infection and COVID-19 disease.

There were no significant variations by age and gender in neither reported morbidity or prevalence of antibodies. Using reported COVID-19 cases as outcome, higher rates were found among adults 20-64

years of age and Hispanics. However, the mortality increased significantly by age, with a 1,021-fold risk in the elderly, consistent with the findings during the early pandemic wave in New York City [20]. There was a higher mortality risk among men than women as well. Using case-reporting, death certificate and survey serologic data, Hispanics were at higher risk of COVID-19 morbidity and mortality.

There was a sharp decrease two weeks after the implementation of limits to the occupancy of restaurants and other public places by mid-October, and the shutdown of non-essential businesses by the end of October, which strongly suggests the NPIs had an effect in halting transmission. The resurgence of the pandemic in 2021 is consistent with the fact that the proportion of the immune population in El Paso by the end of 2020, was only 18.5%, below the threshold level required for herd immunity [23, 24]. The findings of most household survey participants not leaving their homes, few weeks after the lockdown, is consistent with observance of stay home orders by Pasoans as confirmed in our survey. The observance of public health recommendations of social distancing, wearing mask and practicing personal hygiene may have been extremely helpful to limit the natural growth of the pandemic. The evidence provided by our observations in El Paso, Texas adds to the empirical evidence of the real-life effectiveness of interventions put in place to curve down the COVID-19 pandemic in many public health jurisdictions around the world. Time series ecological analysis are powerful tools that can provide guidance to decision-making in the absence of experimental or individual-level observational data.

The excess of COVID-19 morbidity and mortality and SARS -CoV-2 infection among Hispanics and other US minorities has been observed elsewhere but not documented using risk and risk ratios and the RERI and SF in a standard format for interaction in epidemiological research [25]. Most previous studies have used SARS-CoV-2 testing databases [26], or hospitalization record [26] which do not lend themselves to assess the prevalence of chronic conditions in the underlying cohorts. Studies of databases as Medicare are limited by the exclusion of referent population (i.e., persons under 65 years

of age [28], or ignored the assessment of interaction altogether [29-37].

We did not find an interaction on the multiplicative scale. However, the additive interaction reported is of public health importance as discussed elsewhere [16] In our context, consider the mortality by age and diabetes in Table 3. The effect of diabetes among those under 65 years of age, measure in the difference scale was 609 COVID-19 deaths per 100,000 persons, while among those 65+ was 1,924 per 100,000 persons. If we had limited supplies of vaccines, one would have saved more lives targeting those 65+ years of age. That was the age group targeted by most experts around the world. Our observations based on reported deaths in New York City in 2020-2021, indicate that the interaction between older age and chronic diseases was more than multiplicative (SF=5.0; 95% CI = 3.0 - 8.5), which may only reflect the allocation of more human resources to thoroughly ascertain the occurrence of chronic disease among COVID-19 decedents during the early phase of the pandemic [38].

Limitations

Our findings are subject to several limitations. First, case reporting likely missed an unknown proportion of infection due to the clinical spectrum of this virus and its natural history. Some infected individuals who were tested (community tested or in our own serological survey) may have not been shedding viruses or developed antibodies at the time of specimen collection. Furthermore, case reporting is likely to have also missed mild cases among persons not even seeking medical care or who dismissed mild symptoms as not COVID-19-related. Second, the upsurge of cases clearly exceeded the local capacity impacting the completeness of case reporting, and many reports missed data on key elements such as date of onset, therefore we relied on date of specimen collection. Third, there was a large amount of variability in the practice of filling out the death certificates, in particular during a fear raising pandemic, and certain comorbidities were likely missed.

Turning to the prevalence survey, it had a low participation rate, limiting the ability to make inferences.

Other surveys during the pandemic also reported low response rates [39]. The prevalence of diabetes in our survey is close to the estimates of prevalence of diabetes from medically diagnosed self-reported figures plus examination among Spanish-speaking Hispanics in the 2017-2018 National Health and Nutrition Examination Survey (NHANES) data (i.e., 22% as tabulated by one of us, data not shown). We used our own estimate of the prevalence of diabetes, given these similarities, but have to acknowledge that our sample size is small, the consistency with the findings of NHANES lends support to the use of our estimates. Also, our assessment of the role of other comorbidities is limited to diabetes, as the public at large in El Paso is more aware of this highly prevalent condition, and maybe less aware of other chronic diseases such as hypertension or the contribution of obesity to both diabetes and hypertension. Some degree of misclassification of the prevalence of diabetes and the proportion of deaths with diabetes may have affected the measurement of the interaction, introducing a bias towards the null value for RERI and SF. Therefore, without claiming that the reported proportion of COVID-19 decedents with diabetes is an accurate estimate, one can infer that at least there was a departure from the state of no interaction on the additive scale. As discussed before, a multiplicative interaction was found in the data of New York City; however, there are more human resources available to the health department in New York City, where on 126 (0.5%) of 24,358 COVID-19 deaths did not have a chronic disease or obesity. The lack of statistical difference in prevalence of antibodies by Hispanic ethnicity may reflect lack of statistical power of our serosurvey, which was powered to estimate prevalence of 50%, or differences between the age-specific prevalence of self-reported medically diagnosed diabetes (>0.9). but inadequate for prevalence ratios below 1.5. Most of the analysis of the proportion of infected persons by strata and derived from the serological survey lack adequate precision.

Conclusion

Hispanics in El Paso, Texas, experienced a disproportionate burden of COVID-19. NPIs, in particular the shutdown of non-essential business, decreased the transmission via diminished contact rates. In this US minority population, chronic diseases like diabetes mellitus, which overburden US minorities

interacted with older age to increase the risk of fatal outcomes of COVID-19.

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Contributions

All authors contributed to the conceptualization, data collection, analysis, interpretation and manuscript writing.

Publicly available data

The files for both the case data and the survey data with select fields, codes and programming samples is available in Figshare (https://doi.org/10.6084/m9.figshare.22337713).

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