Calculating Expected Years of Life Lost to Rank the Leading Causes of Premature Death in San Francisco

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Abstract **Introduction**: A core function of local health departments is to conduct health assessments. The analysis of death certificates provides information on diseases, conditions, and injuries that are likely to cause death—an important outcome indicator of population health. The expected years of life lost (*YLL*) measure is a valid, stand-alone measure for identifying and ranking the underlying causes of premature death. The purpose of this study was to rank the leading causes of premature death among San Francisco residents, and to share detailed methods so that these analyses can be used in other local health jurisdications.

Methods: Using death registry data and population estimates for San Francisco deaths in 2003–2004, we calculated the number of deaths, *YLL*, and age-standardized *YLL* rates (*ASYR*s). The results were stratified by sex, ethnicity, and underlying cause of death. The *YLL* values were used to rank the leading causes of premature death for men and women, and by ethnicity.

Results: In the years 2003–2004, 6312 men died (73,627 years of life lost), and 5726 women died (51,194 years of life lost). The *ASYR* for men was 65% higher compared to the *ASYR* for women (8971.1 vs. 5438.6 per 100,000 persons per year). Several of the leading causes of premature deaths in men and women were largely preventable: HIV/AIDS, lung cancer, hypertensive heart disease, suicide, accidental drug overdose, homicide, chronic obstructive pulmonary disease, and alcohol use disorders. A large health disparity exists between African Americans and other ethnic groups: African American age-adjusted overall and cause-specific *YLL* rates were remarkably higher, especially for homicide among men. Except for homicide among Latino men, Latinos and Asians have comparable or lower *YLL* rates among the leading causes of premature death compared to whites.

Conclusions: Local death registry data can be used to measure, rank, and monitor the leading causes of premature death, and to measure and monitor ethnic health disparities.

1 Introduction

A core function of local health departments is to conduct public health surveillance, including population health assessments [1, 2]. Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health [3]. Primary data collection, such as representative telephone or household surveys, can be expensive and difficult to sustain on an ongoing basis. Therefore, local health jurisdications need to analyze existing health data that is population-based, comprehensive, readily available, and locally relevant. Analysis and interpretation of such data provide objective evidence for public health policymakers, partners, and stakeholders to inform and guide the setting of local public health priorities. This is especially important because of the geographic variation in health outcomes, major risk factors, and health disparities [4,5].

The analysis of death certificates provides information on diseases, conditions, and injuries that are likely to cause death—an important outcome indicator of population health. However, registered causes of death are only part of the story; they are not representative of conditions that adversely impact health but do not cause death (or are underclassified as the cause of death). To address these limitations, the Global Burden of Disease Study investigators developed methods and measures to incorporate both fatal and nonfatal health outcomes into a summary measure of population health called *disability-adjusted life years* ($DALY$s) [6]. For a specific condition, $DALY$s are comprised of two components: the years lived with disability (YLD) due to that condition, and the expected years of life lost (YLL) due to death from that condition. The YLD is weighted from 0 (no disability) up to, but not including, 1. (A YLD weight of 1 would be equivalent to death.) Based on the age at death, the YLLs are the expected years of life remaining based on a chosen standard life expectancy. Therefore, $DALY$s are the years of life lost to disability (YLD) and premature death (YLL).

For a specific condition, YLDs are based on age-specific incidence rates, average duration (until recovery or death), and level of disability. Population-based, representative data for measuring YLD are generally not available for many conditions or events; it would require conducting studies and analyses to estimate and integrate these three components. Unfortunately, for a comprehensive list of conditions that impact population health, directly measuring YLDs is cost prohibitive and not practical for most local health jurisdictions. Fortunately, using the Tenth Revision of the International Classification of Diseases (ICD-10) coding of death certificates, YLLs are measureable for a comprehensive set of conditions. The YLL is a valid, stand-alone measure for identifying and ranking the causes of premature death for a region [7,8,9]. YLLs, as opposed to more traditional mortality measures (counts, rates, etc.), highlight premature deaths. These deaths are particularly important from a public health and public policy perspective because they represent preventable loss of life.

The purpose of this study is to rank the leading causes of premature death in the City and County of San Francisco using YLLs, and to provide the methodological details (see Appendix) so that other local health jurisdictions can conduct similar analyses to guide public health priority setting.

2 Methods

For the years 2003–2004, registered deaths for San Francisco were obtained from the State of California, Department of Health Services, Center for Health Statistics [10]. The data file contained the deaths of San Francisco residents (whether or not they died in San Francisco), and the deaths of non-residents that died in San Francisco. For this analysis only San Francisco resident deaths were used. Population estimates were obtained from the State of California, Department of Finance, Demographic Research Unit [11]. Standard life expectancies for men and women are from the Coale-Demeny Model Life Tables West: Levels 25 for men, and Level 26 for women (Appendix A, Table 8). For calculating age-standardized rates we used the Year 2000 United States standard million population (Appendix A, Table 9).

For this study, we calculated the number of deaths, *YLL*s, *YLL* means, *YLL* percents, and age-standardized *YLL* rates (*ASYR*s). Because rates based on fewer than 20 deaths may not be reliable, these rates were not always reported. The results were stratified by sex, ethnicity, and underlying cause of death. The *YLL* values were used to rank the 15 leading causes of premature death for men and women, and by ethnicity. For a specific underlying cause of death (stratified by sex $\pm$ ethnicity), the *YLL* percent represents what proportion of total *YLL*s can be attributed to that specific cause of death. The *YLL* mean represents the average *YLL* for those deaths from a specific cause. A larger *YLL* mean indicates that the deaths occurred to younger persons. Smaller *YLL* means are associated with dying at an older age. *YLL*s reported here are discounted but are not age weighted. Methodological details are available in the Technical Notes (Appendix A).

3 Results

In the years 2003–2004, 6312 men died with 73,627 years of life lost, and 5726 women died with 51,194 years of life lost (Table 1). The *ASYR* for men was 65% higher compared to the *ASYR* for women (8971.1 per 100,000 persons per year vs. 5438.6 per 100,000 persons per year) (Table 1).

Stratified by sex and ethnicity, displayed in Table 1, are the *YLL*, number of deaths, *YLL* mean, age-standardized *YLL* rates, and *ASYR* ratios. While whites and Asians account for the largest number of deaths (as expected based on population estimates), African American men and women have the highest age-standardized *YLL* rates (Figure 1). For all causes of death, the *ASYR* for African American men is 2.44 times higher compared to white men, and the *ASYR* for African American women is 2.31 times higher compared to white women.

The leading causes of premature death for San Francisco residents, ranked by *YLL*s, are displayed in Table 2. Also included for each cause of death is the percent of total *YLL*, number of deaths, *YLL* means, and *ASYR*s. In San Francisco, ischemic heart disease is the leading cause of premature death among men and women. Among men, HIV/AIDS is the second leading cause, and among women, it is the fifteenth. Lung cancer is the third leading cause of death for both men and women. Cerebrovascular disease (stroke) is the second leading cause among women, and the fourth leading cause among men. Breast cancer is the fourth leading cause of death among women, and hypertensive heart disease is the fifth leading cause among men and women. Among men, suicide, unintentional drug overdose, and homicide are the 6th, 7th and 8th causes

Table 1: Expected years of life lost (YLL) and age-standardized YLL rates, By ethnicity, San Francisco, 2003–2004

Sex	Ethnicity	*YLL*	Deaths	*YLL mean*[a]	*ASYR*[b]	*ASYR* Ratio[c]
Male						
	African American	13,536.2	927	14.6	23,116.0	2.44
	American Indian	336.8	18	18.7	*	*
	Asian/Pacific Islander	14,846.4	1,594	9.3	5,589.0	0.59
	Latino/Hispanic	7,565.8	513	14.7	7,742.2	0.82
	White (reference)	36,442.8	3,201	11.4	9,459.0	1.00
	Multirace	705.8	46	15.3	5,031.1	0.53
	Other	56.2	4	14.0	*	*
	Missing	135.9	12	11.3	*	*
	Total	73,626.8	6,312		8971.1	
Female						
	African American	8,544.9	770	11.1	13,576.4	2.31
	American Indian	263.0	14	18.8	*	*
	Asian/Pacific Islander	13,363.0	1,509	8.9	3,915.1	0.67
	Latino/Hispanic	4,508.8	444	10.2	4,410.0	0.75
	White (reference)	24,080.0	2,963	8.1	5,867.0	1.00
	Multirace	353.0	25	14.1	2,719.8	0.46
	Other	16.7	1	16.7	*	*
	Missing	64.1	4	16.0	*	*
	Total	51,194.2	5,726		5438.6	

[a] YLL mean $= YLL \div$ Deaths
[b] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year
[c] Whites are reference groups for ratio comparison
* Rate was not calculated (less than 20 deaths or population estimate not available).

of premature death, respectively. Among women, suicide is 12th and drug overdose, 14th.

The leading causes of premature death by ethnicity (and sex) are displayed for African Americans (Table 3), Asians/Pacific Islanders (Table 4), Latino/Hispanics (Table 5), and whites (Table 6). The leading causes of death differ by ethnic group and sex. Among African American men, violent assault (homicide) is the leading cause of premature death. Breast cancer is the third leading cause of premature death among African American women, but fourth among other ethnic groups. Among Latino/Hispanic men, HIV/AIDS was the leading cause of premature death, violent assault (homicide) was third, and alcohol use disorders and liver cirrhosis were fourth and fifth, respectively. Among white men, HIV/AIDS was the second leading cause of premature death, and suicide was the third. Lung cancer was the second leading cause of death among white women. Among Asian/Pacific Islanders, liver cancer was the fourth leading cause of death among men and the eigth leading cause among women.

Age-standardized YLL rates ($ASYR$s) allows comparisons of the burden of premature mortal-

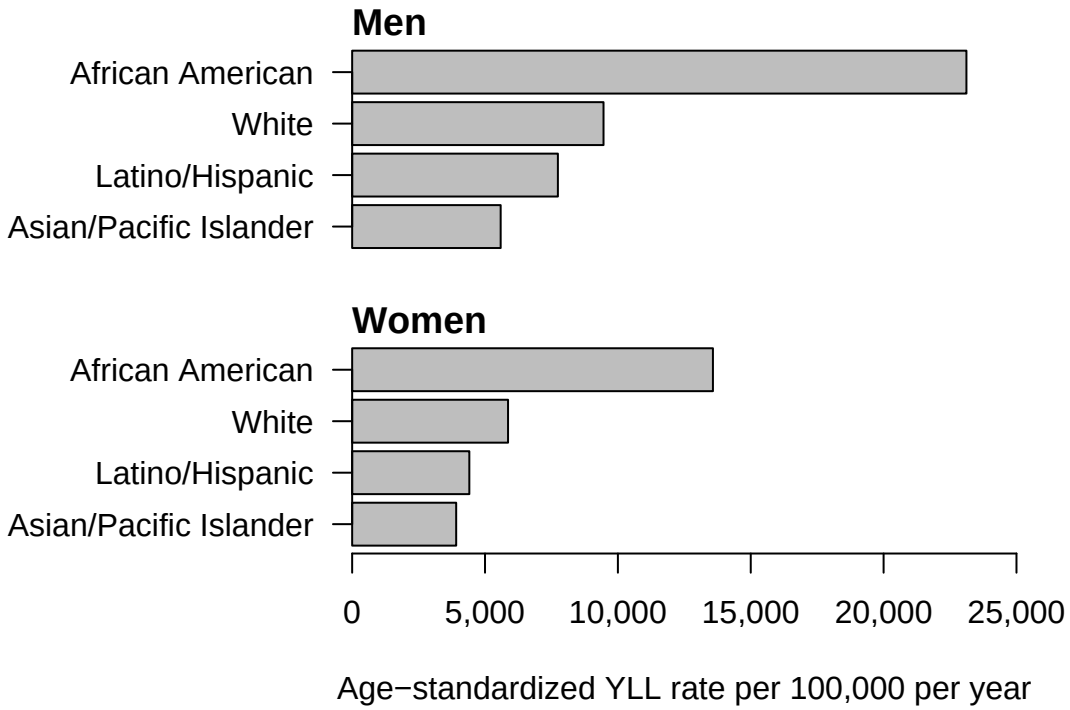

Figure 1: Comparison of age-standardized expected years of life lost rates (*ASYR*s), By sex and ethnicity, San Francisco, 2003–2004

ity by ethnic group and specific cause of death (Figures 2 and 3). For example, for almost every leading cause of premature death in men and women, African Americans had the highest *ASYR*s compared to other ethnic groups. Among African American men, the disparity in *ASYR*s was most notable for violent assault (homicide), followed by HIV/AIDS, vascular diseases (ischemic and hypertensive heart, and cerebrovascular disease), accidental drug overdose, and lung cancer. Among African American women, the disparity in *ASYR*s was most notable for vascular diseases (ischemic and hypertensive heart, and cerebrovascular disease), breast cancer, HIV/AIDS, and accidental drug overdose.

Table 2: Leading causes of premature death for San Francisco, By sex, 2003–2004

Rank	Underlying cause of death	*YLL*	*YLL* %[a]	Deaths	*YLL* mean[b]	*ASYR*[c]
Male						
1	Ischemic heart disease	9,853.9	13.4	1,103	8.9	1,246.1
2	HIV/AIDS	6,464.6	8.8	319	20.3	673.1
3	Lung, bronchus, and trachea cancers	4,134.3	5.6	387	10.7	515.8
4	Cerebrovascular disease	3,420.2	4.6	418	8.2	439.3
5	Hypertensive heart disease	3,379.0	4.6	287	11.8	413.4
6	Self-inflicted injuries, all mechanisms	3,026.2	4.1	152	19.9	330.2
7	Drug overdose, unintentional	2,908.1	3.9	134	21.7	301.8
8	Violence/assault, all mechanisms	2,879.9	3.9	115	25.0	419.8
9	Chronic obstructive pulmonary disease	2,241.5	3.0	269	8.3	293.1
10	Alcohol use disorders	2,228.5	3.0	128	17.4	245.8
11	Liver cancer	2,035.6	2.8	154	13.2	248.0
12	Lower respiratory infections	1,801.3	2.4	242	7.4	233.0
13	Diabetes mellitus	1,656.5	2.2	147	11.3	198.8
14	Cirrhosis of the liver	1,586.9	2.2	97	16.4	177.3
15	Colon and rectum cancers	1,394.7	1.9	136	10.3	173.5
Female						
1	Ischemic heart disease	6,721.3	13.1	1,017	6.6	646.3
2	Cerebrovascular disease	4,221.3	8.2	614	6.9	406.6
3	Lung, bronchus, and trachea cancers	3,376.2	6.6	326	10.4	361.4
4	Breast Cancer	2,975.1	5.8	222	13.4	335.8
5	Hypertensive heart disease	2,214.9	4.3	269	8.2	226.1
6	Chronic obstructive pulmonary disease	1,651.8	3.2	211	7.8	166.0
7	Lower respiratory infections	1,483.9	2.9	266	5.6	136.4
8	Alzheimer and other dementias	1,414.1	2.8	305	4.6	118.3
9	Colon and rectum cancers	1,407.7	2.7	153	9.2	145.3
10	Diabetes mellitus	1,207.9	2.4	141	8.6	122.1
11	Pancreas cancer	1,122.4	2.2	105	10.7	121.4
12	Self-inflicted injuries, all mechanisms	992.9	1.9	48	20.7	123.9
13	Lymphomas and multiple myeloma	852.0	1.7	86	9.9	89.8
14	Drug overdose, unintentional	843.8	1.6	37	22.8	96.6
15	HIV/AIDS	823.6	1.6	36	22.9	101.7

[a] $YLL\% = YLL \div$ Total YLL from all causes, by sex

[b] YLL mean $= YLL \div$ Deaths

[c] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year

Table 3: Leading causes of premature death for African Americans, San Francisco, 2003–2004

Rank	Underlying cause of death	*YLL*	*YLL* %[a]	Deaths	*YLL* mean[b]	*ASYR*[c,d]
Male						
1	Violence/assault, all mechanisms	1,607.8	11.9	62	25.9	3,110.9
2	Ischemic heart disease	1,420.5	10.5	120	11.8	2,376.2
3	HIV/AIDS	1,183.7	8.7	60	19.7	1,790.7
4	Hypertensive heart disease	882.2	6.5	60	14.7	1,391.5
5	Drug overdose, unintentional	711.5	5.3	36	19.8	1,118.8
6	Lung, bronchus, and trachea cancers	679.7	5.0	52	13.1	1,088.8
7	Cerebrovascular disease	557.2	4.1	52	10.7	938.7
8	Alcohol use disorders	468.4	3.5	30	15.6	729.7
9	Chronic obstructive pulmonary disease	460.1	3.4	39	11.8	755.9
10	Diabetes mellitus	429.5	3.2	34	12.6	730.9
11	Inflammatory heart disease	332.8	2.5	20	16.6	540.4
12	Drug use disorders	302.6	2.2	16	18.9	446.3
13	Cirrhosis of the liver	253.7	1.9	14	18.1	381.4
14	Nephritis and nephrosis	241.5	1.8	21	11.5	424.3
15	Endocrine, metabolic, immune disorders	238.9	1.8	15	15.9	413.1
Female						
1	Ischemic heart disease	1,161.4	13.6	137	8.5	1,554.4
2	Cerebrovascular disease	674.4	7.9	82	8.2	893.2
3	Breast Cancer	554.8	6.5	39	14.2	880.0
4	Hypertensive heart disease	525.9	6.2	49	10.7	761.5
5	Lung, bronchus, and trachea cancers	422.0	4.9	36	11.7	599.9
6	HIV/AIDS	379.9	4.4	17	22.3	685.6
7	Diabetes mellitus	296.3	3.5	32	9.3	407.0
8	Chronic obstructive pulmonary disease	244.7	2.9	21	11.7	369.9
9	Nephritis and nephrosis	217.0	2.5	18	12.1	338.1
10	Drug overdose, unintentional	203.4	2.4	9	22.6	360.5
11	Endocrine, metabolic, immune disorders	188.6	2.2	12	15.7	398.4
12	Pancreas cancer	165.4	1.9	13	12.7	238.1
13	Alzheimer and other dementias	160.9	1.9	33	4.9	175.3
14	Colon and rectum cancers	159.9	1.9	16	10.0	224.0
15	Leukemia	148.2	1.7	10	14.8	232.8

[a] $YLL\% = YLL \div$ Total YLL from all causes, by sex and ethnicity

[b] YLL mean $= YLL \div$ Deaths

[c] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year

[d] Rates calculated from less than 20 deaths may be unreliable.

Table 4: Leading causes of premature death for Asians/Pacific Islanders, San Francisco, 2003–2004

Rank	Underlying cause of death	*YLL*	*YLL* %[a]	Deaths	*YLL* mean[b]	*ASYR*[c,d]
Male						
1	Ischemic heart disease	2,204.6	14.8	289	7.6	820.9
2	Cerebrovascular disease	1,409.7	9.5	168	8.4	519.1
3	Lung, bronchus, and trachea cancers	1,345.6	9.1	144	9.3	475.3
4	Liver cancer	883.2	5.9	71	12.4	320.0
5	Self-inflicted injuries, all mechanisms	613.8	4.1	31	19.8	240.0
6	Chronic obstructive pulmonary disease	598.3	4.0	88	6.8	213.5
7	Hypertensive heart disease	564.7	3.8	58	9.7	205.3
8	Lower respiratory infections	434.9	2.9	73	6.0	160.3
9	Colon and rectum cancers	395.5	2.7	41	9.6	143.8
10	Lymphomas and multiple myeloma	334.9	2.3	33	10.1	121.6
11	Diabetes mellitus	317.2	2.1	40	7.9	114.1
12	Mouth and oropharynx cancers	301.5	2.0	23	13.1	116.2
13	Motor vehicle accident-Unspecified	279.7	1.9	14	20.0	120.6
14	Drug overdose, unintentional	273.9	1.8	12	22.8	97.8
15	Stomach cancer	234.0	1.6	24	9.7	86.8
Female						
1	Ischemic heart disease	1,860.7	13.9	265	7.0	489.0
2	Cerebrovascular disease	1,623.6	12.2	221	7.3	428.1
3	Lung, bronchus, and trachea cancers	957.8	7.2	93	10.3	263.4
4	Breast Cancer	752.6	5.6	49	15.4	235.9
5	Hypertensive heart disease	514.1	3.8	67	7.7	131.4
6	Colon and rectum cancers	491.8	3.7	48	10.2	138.1
7	Lower respiratory infections	378.1	2.8	69	5.5	96.9
8	Liver cancer	372.7	2.8	34	11.0	103.5
9	Diabetes mellitus	363.0	2.7	49	7.4	94.5
10	Lymphomas and multiple myeloma	346.7	2.6	33	10.5	95.0
11	Pancreas cancer	308.4	2.3	27	11.4	86.5
12	Stomach cancer	299.2	2.2	25	12.0	91.1
13	Alzheimer and other dementias	267.8	2.0	60	4.5	67.2
14	Ovary cancer	240.9	1.8	18	13.4	71.5
15	Leukemia	199.2	1.5	10	19.9	102.7

[a] $YLL\% = YLL \div$ Total YLL from all causes, by sex and ethnicity

[b] YLL mean $= YLL \div$ Deaths

[c] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year

[d] Rates calculated from less than 20 deaths may be unreliable.

Table 5: Leading causes of premature death for Latinos/Hispanics, San Francisco, 2003–2004

Rank	Underlying cause of death	*YLL*	*YLL* %[a]	Deaths	*YLL* mean[b]	*ASYR*[c,d]
Male						
1	HIV/AIDS	888.4	11.7	41	21.7	667.7
2	Ischemic heart disease	813.4	10.8	78	10.4	1,031.4
3	Violence/assault, all mechanisms	582.8	7.7	22	26.5	482.7
4	Alcohol use disorders	384.7	5.1	19	20.2	314.5
5	Cirrhosis of the liver	354.5	4.7	20	17.7	356.2
6	Hypertensive heart disease	283.9	3.8	22	12.9	359.8
7	Diabetes mellitus	257.3	3.4	19	13.5	283.3
8	Cerebrovascular disease	249.8	3.3	25	10.0	325.6
9	Self-inflicted injuries, all mechanisms	213.1	2.8	9	23.7	135.2
10	Liver cancer	203.7	2.7	14	14.5	235.5
11	Drug overdose, unintentional	168.1	2.2	8	21.0	126.0
12	Drug use disorders	150.8	2.0	7	21.5	133.1
13	Motor vehicle accident-Unspecified	136.6	1.8	6	22.8	95.0
14	Congenital anomalies	130.4	1.7	5	26.1	93.4
15	Lung, bronchus, and trachea cancers	129.8	1.7	11	11.8	161.1
Female						
1	Ischemic heart disease	418.9	9.3	60	7.0	401.0
2	Cerebrovascular disease	322.2	7.1	46	7.0	307.8
3	Cirrhosis of the liver	226.0	5.0	18	12.6	230.7
4	Breast Cancer	202.2	4.5	14	14.4	195.8
5	Lung, bronchus, and trachea cancers	197.0	4.4	19	10.4	193.1
6	Diabetes mellitus	161.6	3.6	17	9.5	159.4
7	Hypertensive heart disease	144.7	3.2	19	7.6	142.3
8	HIV/AIDS	138.5	3.1	6	23.1	132.4
9	Self-inflicted injuries, all mechanisms	124.6	2.8	5	24.9	119.8
10	Lower respiratory infections	113.1	2.5	19	6.0	109.4
11	Colon and rectum cancers	108.2	2.4	9	12.0	108.2
12	Pancreas cancer	92.0	2.0	8	11.5	92.8
13	Congenital anomalies	90.8	2.0	3	30.3	112.4
14	Corpus uteri cancer	82.7	1.8	6	13.8	85.1
15	Chronic obstructive pulmonary disease	80.2	1.8	10	8.0	78.0

[a] $YLL\% = YLL \div$ Total YLL from all causes, by sex and ethnicity

[b] YLL mean $= YLL \div$ Deaths

[c] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year

[d] Rates calculated from less than 20 deaths may be unreliable.

Table 6: Leading causes of premature death for Whites, San Francisco, 2003–2004

Rank	Underlying cause of death	*YLL*	*YLL* %[a]	Deaths	*YLL* mean[b]	*ASYR*[c,d]
Male						
1	Ischemic heart disease	5,339.0	14.7	607	8.8	1,463.4
2	HIV/AIDS	3,975.1	10.9	198	20.1	810.9
3	Self-inflicted injuries, all mechanisms	2,006.4	5.5	102	19.7	500.8
4	Lung, bronchus, and trachea cancers	1,913.9	5.3	175	10.9	506.5
5	Drug overdose, unintentional	1,670.9	4.6	74	22.6	393.4
6	Hypertensive heart disease	1,582.9	4.3	143	11.1	434.0
7	Alcohol use disorders	1,196.2	3.3	69	17.3	274.2
8	Cerebrovascular disease	1,156.3	3.2	168	6.9	329.2
9	Chronic obstructive pulmonary disease	1,041.2	2.9	126	8.3	299.0
10	Lower respiratory infections	1,039.2	2.9	137	7.6	282.5
11	Cirrhosis of the liver	809.5	2.2	52	15.6	184.4
12	Colon and rectum cancers	803.0	2.2	77	10.4	219.1
13	Liver cancer	685.6	1.9	48	14.3	197.2
14	Drug use disorders	666.6	1.8	32	20.8	136.0
15	Diabetes mellitus	642.8	1.8	53	12.1	162.5
Female						
1	Ischemic heart disease	3,179.5	13.2	547	5.8	674.9
2	Lung, bronchus, and trachea cancers	1,780.1	7.4	177	10.1	472.2
3	Cerebrovascular disease	1,556.2	6.5	262	5.9	324.0
4	Breast Cancer	1,416.1	5.9	118	12.0	383.8
5	Chronic obstructive pulmonary disease	1,139.6	4.7	152	7.5	270.8
6	Hypertensive heart disease	994.0	4.1	131	7.6	236.4
7	Alzheimer and other dementias	914.7	3.8	193	4.7	167.7
8	Lower respiratory infections	887.7	3.7	159	5.6	185.4
9	Self-inflicted injuries, all mechanisms	676.9	2.8	32	21.2	194.3
10	Colon and rectum cancers	647.6	2.7	80	8.1	158.5
11	Drug overdose, unintentional	547.8	2.3	24	22.8	126.5
12	Pancreas cancer	531.6	2.2	55	9.7	137.2
13	Alcohol use disorders	488.1	2.0	28	17.4	134.8
14	Ovary cancer	410.0	1.7	35	11.7	113.0
15	Diabetes mellitus	361.1	1.5	41	8.8	89.6

[a] $YLL\% = YLL \div$ Total YLL from all causes, by sex and ethnicity

[b] YLL mean $= YLL \div$ Deaths

[c] $ASYR =$ Age-standardized YLL rate per 100,000 persons per year

[d] Rates calculated from less than 20 deaths may be unreliable.

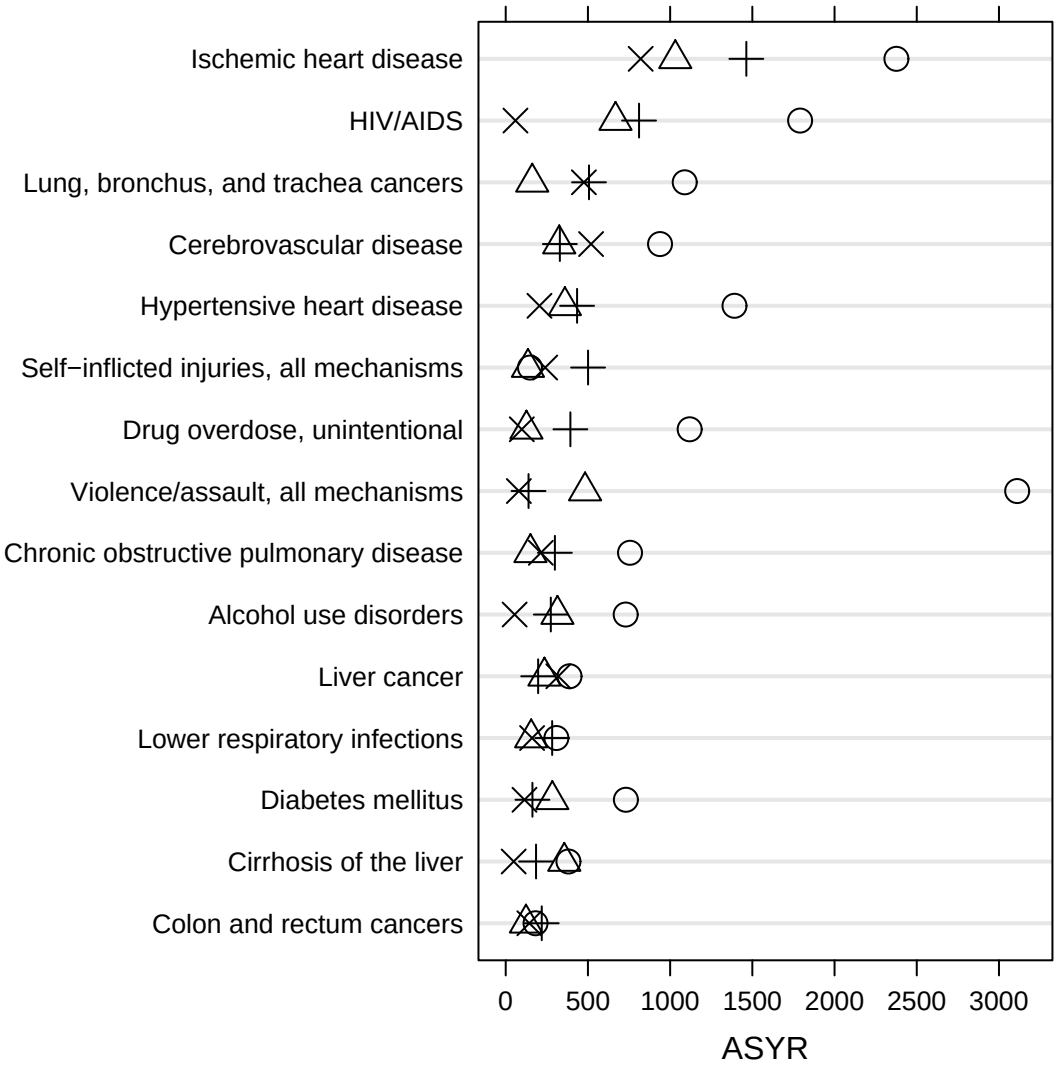

Figure 2: Leading causes of premature death among men (ranked by YLLs), comparing age-standardized YLL rates ($ASYR$) by cause of death and ethnicity, San Francisco, 2003–2004. Symbols: African American (◯), Latino/Hispanic (△), Asian/Pacific Islander (×), White (+)

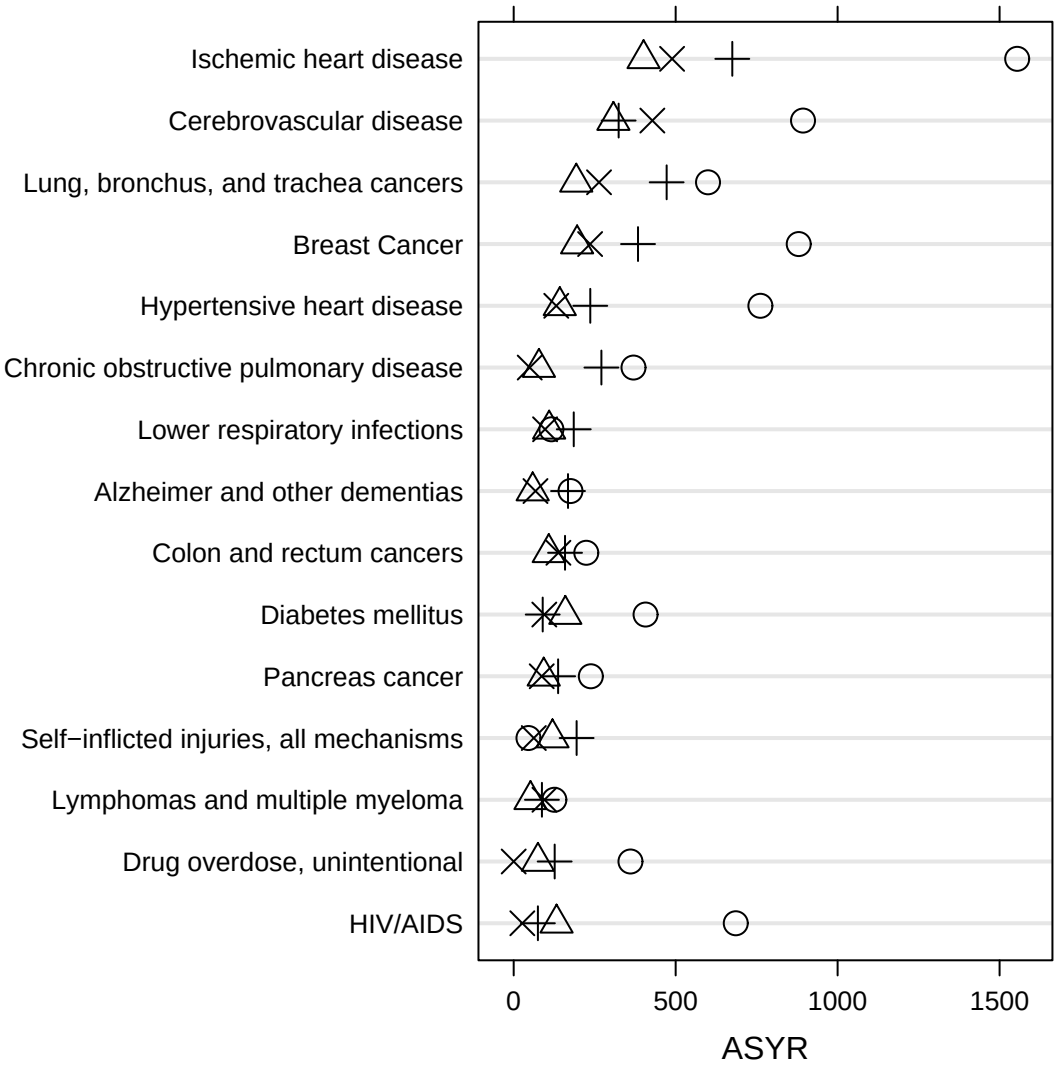

Figure 3: Leading causes of premature death among women (ranked by YLLs), comparing age-standardized YLL rates ($ASYR$) by cause of death and ethnicity, San Francisco, 2003–2004. Symbols: African American (◯), Latino/Hispanic (△), Asian/Pacific Islander (×), White (+)

4 Discussion

The key findings of this study are that (1) several of the leading causes of premature deaths in men and women (Table 2) were largely preventable: HIV/AIDS, lung cancer, ischemic heart disease, hypertensive heart disease, suicide, accidental drug overdose, homicide, chronic obstructive pulmonary disease, and alcohol use disorders; (2) leading causes of premature death differed remarkably between ethnic groups (Tables 3, 4, 5, and 6); (3) a large health disparity was measured between African Americans and other ethnic groups: African American age-adjusted overall and cause-specific YLL rates are remarkably higher, especially for homicide among men (Figures 1, 2, and 3); (4) except for homicide among Latino men, Latinos and Asians had comparable or lower YLL rates among the leading causes of premature death compared to whites (Figures 2 and 3); and (5) death registry data can be used to measure, rank, and monitor the leading causes of premature death for a local geographic region.

This study can be compared to our previous study conducted for San Francisco covering the period 1990–1995 [4]. Among men, for the period 1990–1995, HIV/AIDS was the leading cause of premature death overall; was leading cause among African Americans, Latinos, and whites; was the third leading cause among Asian/Pacific Islanders; and was the second leading cause among Filipinos. Among men, for the period 2003–2004, HIV/AIDS was the second leading cause of premature death overall; was the third leading cause among African Americans; was the first leading cause among Latinos; was the second leading cause among whites; and does not appear in the top 15 leading causes among Asian/Pacific Islanders (includes Filipino).

Among women, for the period 1990–1995, HIV/AIDS was the sixth leading cause of premature death overall; and was the second leading cause among African Americans and Latinos. For women, for the period 2003–2004, HIV/AIDS was the fifteenth leading cause of premature death overall; was the sixth leading cause among African Americans; was the eighth leading cause among Latinos; and did not appear in the top 15 leading causes among whites and Asian/Pacific Islanders (includes Filipino). Although there were significant improvements in reducing HIV/AIDS mortality rates in San Francisco [12], it remains a high ranking cause of death among specific ethnic groups.

Among African American men, violent death (homicide) was the third leading cause of premature death for the period 1990–1995, and was the leading cause for the period 2003–2004. Among Latino men, violent death (homicide) was the second leading cause of premature death for the period 1990–1995, and was the third leading cause for the period 2003–2004. Among Asian/Pacific Islander men, violent death (homicide) was the sixth leading cause of premature death for the period 1990–1995, and did not appear among the top 15 leading causes for the period 2003–2004. Therefore, comparing 2003–2004 to 1990–1995, only for African American men did homicide become a more prominent leading cause of death.

This study has several strengths. First, we used a simple measure of premature mortality—expected years of life lost—that can be calculated from death registry data that is readily available, population-based, and representative of the target population. Second, YLL estimates can be calculated for a comprehensive list of causes of death. Third, YLL calculations do not require population estimates, allowing leading cause of deaths to be ranked for parts of the population (such as specific ethnicities or geographic areas) for which population estimates are not avail-

able. Fourth, these leading causes of premature death bring attention to preventable deaths that contribute most to the mortality burden. Fifth, these analyses can be repeated periodically to monitor changes, guide and inform policy makers, and to direct and evalute interventions. Sixth, except for motor vehicle accidents [13], we used the Global Burden of Disease ICD-10 cause of death categories, making our methods similar to national and international studies [14,15]. Seventh, our study included Latinos/Hispanics, an important segment of the population that was not included in a similar national study [14]. Eighth, with the availability of ethnic-specific population estimates, one can age-standardize the YLLs to measure, compare, and monitor the ethnic health disparities in the burden of premature deaths. And ninth, our study findings are directly relevant to the diverse and unique needs of our communities, and to our local government and policymakers.

This study also has several limitations. First, the accuracy of data recorded on death certificates (e.g., underlying cause of death and ethnicity) varies by region and underlying cause [16]. Second, the YLL metric does not measure well conditions that cause significant disease and disability, but are difficult to measure (e.g., mental illness) or do not result in death (e.g., osteoarthritis) . Third, on average, there is an 18-month or longer delay from the time a calendar year ends and the availability of ICD-10-coded death registry data. Fourth, the ranking of a specific cause of death depends on its individual YLL magnitude as well as its relative contribution compared to other causes; changes in ranking for a cause over time may be due either to changes in the occurence of that cause, or to changes in the occurences of other causes ranked above or below it. Fifth, the YLL measure is not age-standardized and cannot be used to compare specific causes of death between groups with different age compositions. In spite of these limitations, using YLLs to rank the leading causes of premature death provides commmunity residents, community-based organizations, policy makers, public health authorities, and researchers with local, representative, objective, and informative data to guide and inform public health priorities, and to direct and evaluate public health interventions.

This study has the following key implications: First, we provide the methodological details for calculating YLL to measure the burden of premature mortality for any geographic area that has death registry data (Appendix A). We provide both the ICD-10 cause of death classification used for this study (Appendix B) and the computational program code for calculating age-specific expected years of life lost that can incorporate discounting (used in this study) and age weighting (not used in this study) (Appendix C). This code can be executed in a freely available, open source program for statistical computing and graphics [17]. And second, we demonstrate how these results can be used to rank the leading cause of premature death for different population groups. The rankings can be use to guide, inform, and monitor public health priorities and programs for each group. These analyses can be repeated and become part of routine public health surveillance for local health jurisdictions.

Our next steps are to link the leading causes of premature deaths to underlying causal risk factors based on population attributable fractions (PAFs) [15,18,19,20]. For example, what proportion of premature deaths can be attributed to tobacco consumption? Evidenced-based prevention interventions that target high PAF risk factors are more likely to result in measurable reductions in the burden of premature mortality. These analyses will be repeated to monitor changes.

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APPENDIX

A Technical Notes

Summarized in Table 7 are the notation and definitions used in this article. For the years 2003–2004, registered deaths for San Francisco were obtained from the State of California, Department of Health Services, Center for Health Statistics [10]. The data file contained the deaths of San Francisco residents (whether or not they died in San Francisco), and the deaths of non-residents that died in San Francisco. For this analysis only San Francisco resident deaths were used. Population estimates were obtained from the State of California, Department of Finance, Demographic Research Unit [11]. Standard life expectancies for men and women are from the Coale-Demeny Model Life Tables West: Levels 25 for men, and Level 26 for women (Table 8). For calculating age-standardized rates we use the Year 2000 United States standard million population (Table 9).

The deaths and population estimates were aggregated into 19 age intervals. The age intervals and their lengths are displayed in columns 1 and 2 of Table 10. These age intervals were used for calculating expected years of life lost (YLL) stratified by sex (Table 10), stratified by cause of death and sex (Table 2), and stratified by cause of death and ethnicity and sex (Tables 3–6).

Table 7: Summary of notation and definitions

Notation	Definition
Introduced in Equation 1	
x	Age
n	Age interval length
e_x	Life expectancy at age x
e_x^s	Standard life expectancy at age x
${}_ne_x^s$	Standard life expectancy for age interval x to $x+n$
${}_na_x$	Average age of death for age interval x to $x+n$
Introduced in Equations 2 to 5	
${}_nY_x$	Expected years of life lost for age interval x to $x+n$
${}_nD_x$	Number of deaths in age interval x to $x+n$
r	Discount rate (usually set to 0.03)
K	Age-weighting modulation constant ($K=0$, no weighting; $K=1$, weighting)
β	Age-weighting constant (set to $\beta = 0.04$)
C	Adjustment constant for age-weights (set to 0.1658)
YLL	Expected years of life lost ($YLL = \sum_n Y_x$)
Equation 6	
$ASYR$	Age-standardized YLL rate ($\sum_n y_x^s$)
${}_ny_x^s$	Weighted expected years of life rate for age interval x to $x+n$
${}_ny_x$	Expected years of life lost rate for age interval x to $x+n$
${}_nN_x$	Population (person-year) estimate for age interval x to $x+n$
${}_nw_x$	Year 2000 United States standard population as weights ($\sum_n w_x = 1$)
${}_nW_x$	Year 2000 United States standard population ($\sum_n W_x = 1,000,000$)

Table 8: Standard life expectancies based on Model Life Table West, Level 25 and 26

Age (x)	Male life expectancy (e_x^s)	Female life expectancy (e_x^s)	Age (x)	Male life expectancy (e_x^s)	Female life expectancy (e_x^s)
0	80.000	82.500	50	30.990	33.990
1	79.358	81.840	55	26.322	29.370
5	75.383	77.950	60	21.810	24.830
10	70.400	72.990	65	17.499	20.440
15	65.414	68.020	70	13.577	16.200
20	60.438	63.080	75	10.166	12.280
25	55.471	58.170	80	7.447	8.900
30	50.512	53.270	85	5.238	6.220
35	45.565	48.380	90	3.544	4.250
40	40.641	43.530	95	2.311	2.890
45	35.766	38.720			

Table 9: Year 2000 United States standard million population

Age interval	${}_nW_x$	${}_nw_x$
< 1	13,818	0.013818
1–4	55,317	0.055317
5–14	145,565	0.145565
15–24	138,646	0.138646
25–34	135,573	0.135573
35–44	162,613	0.162613
45–54	134,834	0.134834
55–64	87,247	0.087247
65–74	66,037	0.066037
75–84	44,842	0.044842
85+	15,508	0.015508

A.1 Cause of death categories

Using the International Classification of Diseases, 10th Revision (ICD-10) [21], the cause of death categories were adapted from the World Health Organization Global Burden of Disease Study [15] and the Centers for Disease Control and Prevention External Cause of Injury Mortality Matrix [13]. Our cause of death category definitions are presented in Appendix B and all categories are mutually exclusive. Cause of death categories were constructed to be specific (e.g., "lung cancer") instead of broad (e.g., "all cancers").

A.2 Interpolating standard model life table

For a single death at age x, the YLL for that individual is simply the expected years of life remaining at the age of death (i.e., life expectancy at age x: e_x) based on the model life table West, Level 25 and 26 (Table 8). However, the table does not contain life expectancies for deaths within age intervals. For ages that fall within an interval, the life expectancy must be interpolated from the table.

For a group of deaths that occurred at ages within age interval x to $x+n$, (i.e., n = age interval length), the expected years of life remaining for those deaths (${}_ne_x^s$) is estimated using a formula for linear interpolation (Equation 1) [22]:

$$ {}_ne_x^s = e_x^s + ({}_na_x - x)\frac{e_{x+n}^s - e_x^s}{(x+n)-x} \tag{1} $$

where ${}_na_x$ is the average age of death, and e_x^s and e_{x+n}^s are Table 8 model life expectancies at ages x and $x+n$, respectively.

See Table 10 for ${}_na_x$ and e_x^s results calculated for this study.

A.3 Calculating expected years of life lost (YLL)

For a group of deaths that occurred at ages within age interval x to $x+n$, the crude expected years of life lost is

$$ {}_nY_x = ({}_nD_x)\,({}_ne_x^s) \tag{2} $$

where ${}_nD_x$ is the number of deaths between age x and age $x+n$.

To incorporate discounting and age weighting, one would use Equation 3:

$$ {}_nY_x = ({}_nD_x)\left[\frac{KCe^{r({}_na_x)}}{(r+\beta)^2}\left(e^z\,[z-1] - e^{-(r+\beta)_na_x}\,[-(r+\beta)_na_x - 1]\right) + \frac{1-K}{r}\left(1 - e^{r({}_ne_x^s)}\right)\right] \tag{3} $$

where $z = -(r+\beta)({}_ne_x^s + {}_na_x)$. For this equation, r is the discount rate, and β, C, and K are age weighting constants (see Table 7 for definitions). To include age weighting, K (the modulation constant) can be set to 1. For this study, age weighting was not used ($K = 0$) and $r = 0.03$.

When the discount rate (r) is 0, Equation 3 simplifies to Equation 4:

$$ {}_nY_x = ({}_nD_x)\left[\frac{KCe^{-\beta({}_na_x)}}{\beta^2}\left(e^{-\beta({}_ne_x^s)}\left[-\beta({}_ne_x^s + {}_na_x) - 1\right] - \left[-\beta({}_na_x) - 1\right]\right) + (1-K)({}_ne_x^s)\right] \quad (4) $$

First, we calculated the expected of years of life lost, comparing men to women, by summing ${}_nY_x$ for all age intervals (Table 10):

$$ YLL = \sum {}_nY_x \quad (5) $$

Using this approach, we calculated YLLs for 117 specific causes of death stratified by sex, and stratified by sex and ethnicity.

Displayed in Table 10 is the spreadsheet format for calculating expected years of life lost (YLL) for San Francisco men and women. The age-interval specific number of deaths (${}_nD_x$), average age of death (${}_na_x$), standard life expectancy (${}_ne_x^s$), and years of life lost (${}_nY_x$) are shown. In the years 2003–2004, 6312 men died with 73,627 years of life lost, and 5726 women died with 51,194 years of life lost.

Table 10: Calculating expected years of life lost for San Francisco men and women, 2003–2004

Age interval	n	Male				Female			
		${}_nD_x$	${}_na_x$	${}_ne_x^s$	${}_nY_x$	${}_nD_x$	${}_na_x$	${}_ne_x^s$	${}_nY_x$
< 1	1	28	0.1	80.0	848.6	30	0.1	82.4	915.6
1–4	4	10	2.4	78.0	301.2	3	3.3	79.6	90.8
5–9	5	3	6.4	74.0	89.1	5	9.3	73.7	148.4
10–14	5	4	13.3	67.1	115.5	2	12.9	70.1	58.5
15–19	5	27	17.9	62.5	762.1	6	17.7	65.3	171.8
20–24	5	56	22.6	57.9	1,538.0	16	22.6	60.5	446.5
25–29	5	72	27.4	53.1	1,912.6	27	27.1	56.1	732.8
30–34	5	111	33.0	47.5	2,810.4	32	32.6	50.7	833.6
35–39	5	156	37.7	42.9	3,764.2	49	37.2	46.2	1,224.9
40–44	5	249	42.6	38.1	5,655.8	79	42.8	40.8	1,859.5
45–49	5	325	47.6	33.3	6,844.8	141	47.7	36.2	3,113.3
50–54	5	434	52.5	28.6	8,340.5	188	52.7	31.5	3,833.6
55–59	5	454	57.5	24.1	7,782.5	217	57.5	27.1	4,022.4
60–64	5	403	62.4	19.7	5,999.3	214	62.3	22.8	3,534.4
65–69	5	465	67.7	15.4	5,738.5	263	67.5	18.3	3,709.9
70–74	5	547	72.6	11.8	5,432.1	406	72.7	14.0	4,653.9
75–79	5	787	77.6	8.7	6,054.1	697	77.7	10.5	6,258.3
80–84	5	887	82.5	6.3	5,117.3	948	82.6	7.5	6,385.5
85+	10	1,294	90.3	3.7	4,520.3	2,403	91.5	4.1	9,200.3
Total	95	6,312 (Deaths)			73,626.8 (YLL)	5,726 (Deaths)			51,194.2 (YLL)

A.4 Calculating age-standardized expected years of life lost rates

Using the direct method [23], we calculated age standardized YLL rates ($ASYR$). First, we calculated age-specific rates of years of life lost (${}_nY_x$). Then, these rates were reweighted using the Year 2000 United States standard million population (${}_nw_x$ in Table 9) [23]. The reweighted rates (${}_ny_x^s$) were summed to get an ASYR (Equation 6).

$$ASYR = \sum {}_ny_x^s = \sum ({}_nw_x)({}_ny_x) = \sum ({}_nw_x) \left(\frac{{}_nY_x}{{}_nN_x} \right) \tag{6}$$

Displayed in Table 11 is the spreadsheet format for calculating direct age-standardized YLL rates ($ASYR$) for San Francisco men and women, combining years 2003–2004. The sex and age-interval specific population estimates (${}_nN_x$), expected years of life lost (${}_nY_x$), expected YLL rate (${}_ny_x$), and weighted expected YLL rate (${}_ny_x^s$) are displayed in each column. The $ASYR$ for men was 65% higher compared to the $ASYR$ for women (8971.1 per 100,000 persons per year vs. 5438.6 per 100,000 persons per year).

A.5 Ranking leading causes of premature death

To determine the leading causes of premature death, the cause of death categories were ranked by YLL values stratified by sex, and sex and ethnicity. Age-standardized YLL rates were included to allow comparisons of ethnic groups within sex strata.

Table 11: Calculating direct age-standardized expected years of life lost rate for San Francisco men and women, 2003–2004

Age interval	Male				Female			
	${}_nN_x$	${}_nY_x$	${}_ny_x$	${}_ny_x^s$	${}_nN_x$	${}_nY_x$	${}_ny_x$	${}_ny_x^s$
< 1	8,490	848.6	0.0999	0.00138	8,165	915.6	0.1121	0.00155
1–4	31,922	301.2	0.0094	0.00052	30,767	90.8	0.0030	0.00016
5–14	62,511	204.7	0.0033	0.00048	59,534	206.9	0.0035	0.00051
15–24	66,947	2,300.1	0.0344	0.00476	64,744	618.3	0.0096	0.00132
25–34	175,515	4,722.9	0.0269	0.00365	168,896	1,566.4	0.0093	0.00126
35–44	169,625	9,420.0	0.0555	0.00903	134,598	3,084.4	0.0229	0.00373
45–54	119,555	15,185.3	0.1270	0.01713	105,231	6,946.9	0.0660	0.00890
55–64	76,742	13,781.8	0.1796	0.01567	76,907	7,556.9	0.0983	0.00857
65–74	49,239	11,170.6	0.2269	0.01498	56,924	8,363.8	0.1469	0.00970
75–84	33,375	11,171.3	0.3347	0.01501	47,799	12,643.9	0.2645	0.01186
85+	9,868	4,520.3	0.4581	0.00710	20,919	9,200.3	0.4398	0.00682
Total	803,789 (Pop.)	73,626.8 (YLL)	1.5557	0.08971 ($ASYR$)	774,484 (Pop.)	51,194.2 (YLL)	1.1758	0.05439 ($ASYR$)

A.6 Numerical computing

All analyses and graphics were conducted in R—a widely available, open source programming language for statistical computing and graphics [17]. To facilitate the YLL calculation for readers, we provide and demonstrate a numerical function for R (see Appendix C).

Figure 4: San Francisco Department of Public Health, 101 Grove Street, July 29, 1935. In 1935, tuberculosis was a leading cause of death.

B Cause of Death Categories

Table 12: Definitions of cause categories in terms of International Classification of Diseases, 10th Revision (ICD-10) codes

Code	Underlying cause of death	ICD-10 codes
U003	Tuberculosis	A15–A19, B90
U005	Syphilis	A50–A53
U006	Chlamydia	A55–A56
U007	Gonorrhea	A54
U008	Other STDs	A57–A64, N70–N73
U009	HIV/AIDS	B20–B24
U010	Diarrheal Diseases	A00, A01, A03, A04, A06–A09
U012	Pertussis	A37
U013	Poliomyelitis	A80, B91
U014	Diphtheria	A36
U015	Measles	B05
U016	Tetanus	A33–A35
U017	Meningitis	A39, G00, G03
U017.5	Hepatitis A	B15
U018	Hepatitis B	B16–B19 (minus B17.1, B18.2)
U019	Hepatitis C	B17.1, B18.2
U020	Malaria	B50–B54
U021	Tropical-cluster diseases	B55–B57, B65, B73, B74.0–B74.2
U028	Leprosy	A30
U029	Dengue	A90–A91
U030	Viral encephalitis, mosquito-borne	A83
U031	Trachoma	A71
U032	Intestinal nematode infections	B76–B81
U039	Lower respiratory infections	J10–J18, J20–J22
U040	Upper respiratory infections	J00–J06
U041	Otitis media	H65–H66
U043	Maternal hemorrhage	O44–O46, O67, O72
U044	Maternal sepsis	O85–O86
U045	Hypertensive disorders of pregnancy	O10–O16
U046	Obstructed labor	O64–O66
U047	Abortion	O00–O07
U048	Other maternal conditions	O20–O43, O47–O63, O68–O71, O73–O75, O87–O99
U050	Low birth weight	P05–P07
U051	Birth asphyxia and birth trauma	P03, P10–P15, P20–P29
U052	Other perinatal conditions	P00–P02, P04, P08, P35–

Table 12: (continued)

Code	Underlying cause of death	ICD-10 code
		P96
U053	Nutritional disorders	E00–E02, E40–E46, E50, D50–D53, D64.9, E51–E64
U061	Mouth and oropharynx cancers	C00-C14
U062	Esophagus cancer	C15
U063	Stomach cancer	C16
U064	Colon and rectum cancers	C18–C21
U065	Liver cancer	C22
U066	Pancreas cancer	C25
U067	Lung, bronchus, and trachea cancers	C33–C34
U068	Melanoma and other skin cancers	C43–C44
U069	Breast Cancer	C50
U070	Cervix uteri cancer	C53
U071	Corpus uteri cancer	C54–C55
U072	Ovary cancer	C56
U073	Prostate cancer	C61
U074	Bladder cancer	C67
U075	Lymphomas and multiple myeloma	C81–C90, C96
U076	Leukemia	C91–C95
U077	Other malignant neoplasms	C17, C23, C24, C26–C32, C37–C41, C45–C49, C51, C52, C57–C60, C62–C66, C68–C80, C97
U078	Other neoplasms, non-malignant	D00–D48
U079	Diabetes mellitus	E10–E14
U080	Endocrine, metabolic, immune disorders	D55–D64 (minus D64.9), D65–D89, E03–E07, E15–E16, E20–E34, E65–E88
U082	Unipolar depressive disorders	F32–F33
U083	Bipolar affective disorder	F30–F31
U084	Schizophrenia	F20–F29
U085	Epilepsy	G40–G41
U086	Alcohol use disorders	F10
U087	Alzheimer and other dementias	F01, F03, G30–G31
U088	Parkinson disease	G20–G21
U089	Multiple sclerosis	G35
U090	Drug use disorders	F11–F16, F18–F19
U091	Post-traumatic stress disorder	F43.1
U092	Obsessive-compulsive disorder	F42
U093	Panic disorder	F40.0, F41.0
U094	Insomnia (primary)	F51
U095	Migraine	G43
U096	Mental Retardation due to lead exposure	F70–F79

Table 12: (continued)

Code	Underlying cause of death	ICD-10 code
U097	Other neuropsychiatric disorders	F04–F09, F17, F34–F39, F401–F409, F411–F419, F43 (minus F43.1), F44–F50, F52–F69, F80–F99, G06–G12, G23–G25, G36, G37, G44–G98
U099	Glaucoma	H40
U100	Cataracts	H25–H26
U103	Other sense organs disorders	H00–H21, H27–H35, H43–H61 (minus H524), H68–H83, H92–0H93
U105	Rheumatic heart disease	I01–I09
U106	Hypertensive heart disease	I10–I13
U107	Ischemic heart disease	I20–I25
U108	Cerebrovascular disease	I60–I69
U109	Inflammatory heart disease	I30–I33, I38, I40, I42
U110	Other cardiovascular diseases	I00, I26–I28, I34–I37, I44–I51, I70–I99
U112	Chronic obstructive pulmonary disease	J40–J44
U113	Asthma	J45–J46
U114	Other respiratory diseases	J30–J39, J47–J98
U116	Peptic ulcer disease	K25–K27
U117	Cirrhosis of the liver	K70, K74
U118	Appendicitis	K35–K37
U119	Other digestive diseases	K20–K22, K28–K31, K38, K40–K66, K71–K73, K75–K92
U121	Nephritis and nephrosis	N00–N19
U122	Benign prostatic hypertrophy	N40
U123	Other genitourinary system diseases	N20–N39, N41–N64, N75–N98
U124	Skin diseases	L00–L98
U126	Rheumatoid arthritis	M05–M06
U127	Osteoarthritis	M15–M19
U128	Gout	M10
U129	Low back pain	M45–M48, M54 (minus M54.2)
U130	Other musculoskeletal disorders	M00–M02, M08, M11–M13, M20–M43, M50–M53, M54.2, M55–M99
U131	Congenital anomalies	Q00–Q99
U143	Oral conditions	K00-K14
U150.1	Motor vehicle accident-Occupant	V30–V39 (.4–.9), V40–

Table 12: (continued)

Code	Underlying cause of death	ICD-10 code
		V49 (.4–.9), V50–V59 (.4–.9), V60–V69 (.4–.9), V70–V79 (.4–.9), V83–V86 (.0–.3)
U150.2	Motor vehicle accident-Motorcyclist	V20–V28 (.3–.9), V29 (.4–.9)
U150.3	Motor vehicle accident-Pedal cyclist	V12–V14 (.3–.9), V19 (.4–.6)
U150.4	Motor vehicle accident-Pedestrian	V02–V04 (.1, .9), V09.2
U150.5	Motor vehicle accident-Other	V80 (.3–.5), V81.1, V82.1
U150.6	Motor vehicle accident-Unspecified	V87 (.0–.8), V89.2
U150.7	Pedal cyclist, other	V10–V11, V12–V14 (.0–.2), V15–V18, V19 (.0–.3, .8, .9)
U150.8	Pedestrian, other	V01, V02–V04 (.0), V05, V06, V09 (.0, .1, .3, .9)
U151	Drug overdose, unintentional	X40–X49
U152	Falls, unintentional	W00–W19
U153	Fires, unintentional	X00–X09
U154	Drownings, unintentional/unknown	W65–W74, Y21
U155.1	Medical care and drug adverse effects	Y40–Y59, Y60–Y84, Y88
U157	Self-inflicted injuries, all mechanisms	X60–X84, Y870
U158	Violence/assault, all mechanisms	X85–Y09, Y871
U159	War operations	Y36
U160	Legal intervention, all mechanisms	Y35
U999	Other causes (not categorized)	ICD-10 codes not above

C R function for calculating expected years of life lost

R is a comprehensive, open source software package for statistical computing and graphics [17]. R was developed and is maintained by university-affiliated statistical programers from around the world. Corresponding to Equations 3 and 4, below is the R function used to calculate the *YLL*s for this study:

```
yll <- function(number.deaths, average.age.death, model.life.expectancy,
                discount.rate = 0.03, beta.constant = 0.04,
                modulation.constant = 0, adjustment.constant = 0.1658){
  ##abbreviate inputs
  N <- number.deaths;         a <- average.age.death
  L <- model.life.expectancy; r <- discount.rate
  b <- beta.constant;         K <- modulation.constant
  CC <- adjustment.constant
  ##do calculations
  if(discount.rate==0){
    N*(K*CC*((exp(-b*a))/b^2)*((exp(-b*L))*
                               (-b*(L+a)-1)-(-b*a-1))+((1-K)*L))
  } else {
    N*(K*((CC*exp(r*a))/(-(r+b)^2))*((exp(-(r+b)*(L+a))*(-(r+b)*
      (L+a)-1))-(exp(-(r+b)*a)*(-(r+b)*a-1)))+((1-K)/r)*((1-exp(-r*L))))
  }
}
```

For age interval x to $x+n$: to calculate the expected years of life lost for this age interval (${}_nY_x$), we only need the number of deaths in that interval (${}_nD_x$), the average age of death for deaths in that interval (${}_na_x$), and the corresponding interpolated model life expectancy for that interval (${}_ne_x^s$) using Equation 1. To use this function, we must provide these input values. The other parameters have their default values; for example, the discounting rate parameter is set to 0.03 (3%).

For example, for the years 2003–2004 in San Francisco, for men ages 50 to 54 years (see Table 10), there were 434 deaths with an average age of death of 52.5 years. The interpolated model life expectancy for that age interval was 28.6 years. Once the function has been loaded into, we only need to provide the first three values. Here is the calculation in R, including changing the discounting rate:

```
> yll(434, 52.5, 28.6)
[1] 8332.666
> yll(434, 52.5, 28.6, discount.rate=0)
[1] 12412.4
```

The expected years of life lost for San Francisco male deaths, ages 50 to 54 years, during years 2003–2004, was 8,332.7 years with discounting and 12,412.4 years without discounting. The value 8,332.7 differs from our study results due to rounding error.