

Trends and projection of demographic indices of the Libyan population using a fifty-year census data 1954-2016

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Abstract

Background: Libya is a North African country with the longest coast on the Mediterranean basin facing Europe. Little is known about the demographic characteristics of the Libyan population. Herein, we examine the demographic features and disparities in age and gender among Libyans over the last fifty years, which could be useful for future planning and allocation of resources.

Data and methods: Census data were used to analyze the demographic parameters and age trends from 1954 to 2016 by decades.

Findings The total Libyan population increased with significant sex differences during all decades. Fertility rates increased and mortality rates decreased. There had been more males during the first three decades but then their percentage declined since 1984, with women accounting for 49% in 2006. The working-age population increased to 67% by 2006.

Conclusion: These findings are discussed in the light of major demographic changes that has occurred in the Libyan society. Libya as a whole has enjoyed low mortality and great improvement in socioeconomic status.

Keywords: Libya, census data, demography, mortality, infertility, population

Introduction

The relationship between population characteristics and socio-economic development is well established. Demographic parameters such as population growth, structure and distribution have a great influence on economic status as well as on social and gender inequalities worldwide [Vogel and Porter, 2016; Wang *et al.*, 1913]. Population census is the source of the basic population data required for planning and administration and also for many aspects of economic and social research [Coast *et al.* 2013; Groves, 2010]. The major overriding criteria for deciding on the amount of information collected in censuses and surveys and from vital registration systems have been the planning needs and the availability of financial and human resources for carrying out the plans [Huselid 1995; Tejada *et al.*, 2014].

The scope, nature and availability of demographic data vary throughout the world. Collecting population data by age and sex over time is difficult not only in developing countries but also in developed countries with established statistical offices and routinely organized censuses [Meyer *et al.*, 2015; Hsu *et al.* 2014]. The United Nations (UN, 2005) projected that the percentage of the population over during the same period [17,18]. Hence evaluation of demographic and health parameters are needed for

60 years of age will rise from the 10% figure of 2000 to 20% by 2025 and to 31% by 2050, while the percentage of the working-age population (15-59 years) will fall by more than ten percentage points during the same period [United Nation Report 1995]. It has been suggested that sometime between 2015 and 2020 the growth of the working age population will become negative, which in turn indicates that the growth in gross domestic product will suffer [Lutz *et al.*, 2007; Shetty 2012]. Many developing countries are currently undergoing rapid demographic and economic transitions, and particularly the proportion of aged individuals in lower- and middle-income nations [Hatton 2011; Andersen 1991]. In Africa, there is growing concern about the demographics in the coming decades due to the absence of an efficient registration system in most African countries [United Nation Report 2008]. However, many attempts were made in the beginning of the previous century to overcome this deficiency in both North and Sub-Saharan Africa [Booyesen 2008; Anyangwe and Mtonga 2007]. The population growth rate in Africa estimated by united Nation (2.2%) was higher than that of North America (1%), Asia (1.3%) and Europe (-0.1%) future planning. Libya, the second largest country in Africa, with longest coast on the Mediterranean

facing Europe and is one of the richest countries. The country has experienced considerable social, economic and political changes over the last 50 years. Studying these changes in Libya could be used as a model for North-African, Sub-Saharan and Arab countries [Daw *et al.* 2014; Daw *et al.* 2019; Daw *et al.* 2019]. National censuses are among the most useful tools for analyzing bio-data and demographic changes over time. Such surveys provide the practical indicators of the quality of life, social structure, and poverty. They are also the source of data for planning economic and health improvements [CAI 2013; Ross *et al.* 200]. In Libya, censuses have been conducted roughly every decade. Hence then we used these censuses to examine the demographic features and disparities in age and gender among Libyans over the last 50 years and how they could be used for planning and allocation of resources.

Methods

Birth and death statistics in Libya

Data for 1954-1967 were not available at a central location and were collected by personal contact from

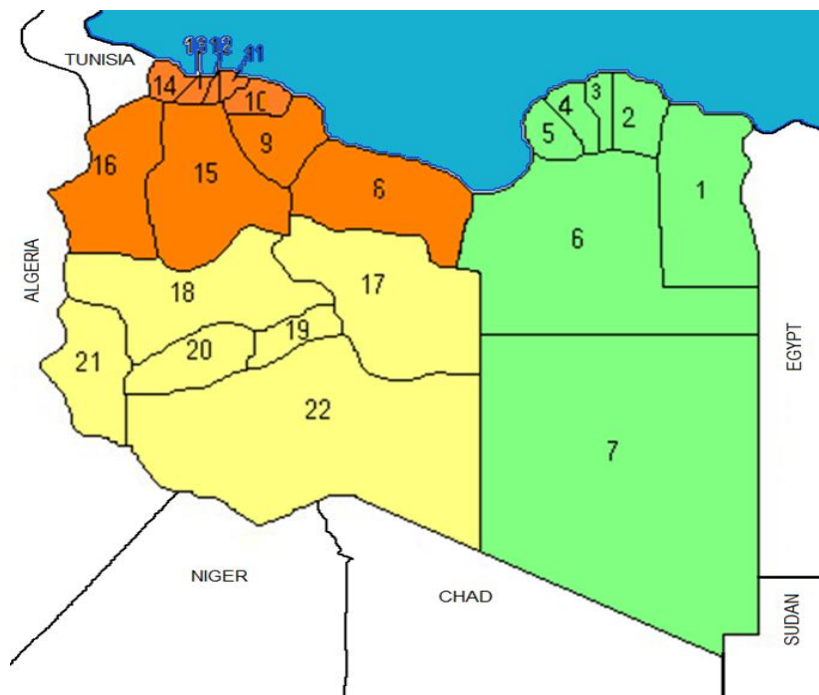
different resources. Before 1969, provinces was missing and monthly data were estimated. But since then, the Office of National Statistics (ONS) has published those statistics for all the provinces in Libya monthly. Moreover, since 1969, the ONS did not attempt to make any adjustments in the data on births as was done in the past; the births and deaths were reported by the municipalities without any adjustments. Since 1993, all the statistics on births and deaths have been reported monthly to the Authority for Information and Communication (GAIC).

Data analysis

To model the population growth rate from 1954 to 2006, the available census data were analyzed by the least squares method and by geometric growth rate. The geometric growth model has been adopted by the Libyan General Authority for Information and Communication and the data were collected from all over the Libyan regions and districts [Supplementary].

Supplementary 3 -Figure; Map of Libya showing the geographical locations and administrative boundaries of regions and districts involved in the study; Eastern Region districts [1-7], West Region Districts [8-16], South Regions Districts [17-22].

Supplementary-Table ; Libyan regions, Districts, administrative boundaries and population density



Arabic	English	Area (km ²)	Population	Number (on map)
East Region[Cyrenaica]				
البطنان	<u>Butnan</u>	84,996	159,536	1
درنة	<u>Derna</u>	31,511	163,351	2
الجبل الاخضر	<u>Jabal al Akhdar</u>	11,429	203,156	3
المرج	<u>Marj</u>	13,515	185,848	4
بنغازي	<u>Benghazi</u>	11,372	670,797	5
الواحات	<u>Al Wahat</u>	105,523	177,047	6
الكفرة	<u>Kufra</u>	433,611	50,104	7
West Region[Tripolitania]				
سرت	<u>Sirte</u>	225,437	193,720	8
مصراتة	<u>Misrata</u>	29,172	550,938	9
المرقب	<u>Murqub</u>	6,796	432,202	10
طرابلس	<u>Tripoli</u>	835	1,065,405	11
الجفارة	<u>Jafara</u>	2,666	453,198	12
الزاوية	<u>Zawiya</u>	2,753	290,993	13

Arabic	English	Area (km ²)	Population	Number (on map)
East Region [Cyrenaica]				
النقاط الخمس	<u>Nuqat al Khams</u>	6,089	287,662	14
الجبل الغربي	<u>Jabal al Gharbi</u>	76,717	304,159	15
نالوت	<u>Nalut</u>	67,191	93,224	16
South Region [Fezzan]				
الجفرة	<u>Jufra</u>	117,410	52,342	17
وادي الشاطئ	<u>Wadi al Shatii</u>	97,160	78,532	18
سبها	<u>Sabha</u>	107,310	134,162	19
وادي الحياة	<u>Wadi al Hayaa</u>	31,485	76,858	20
غات	<u>Ghat</u>	68,482	23,518	21
مرزق	<u>Murzuq</u>	356,308	78,621	22

Results

The total Libyan population in 1954 was 1,041,599, had increased over five-fold to 5,323,991 and the of whom 51.9% were males. By 2006, the population percentage of males dropped to 50.6% (Tables 1).

Table-1: The Libyan population censuses 1954-2006 as reported by the Libyan Office of National Statistics

Census year	Males	Females	Total
1954	540364	501235	1041599
1964	788657	726844	1515501
1973	1057919	994453	2052372

1984	1651562	1579497	3231059
1995	2231079	2158660	4389739
2006	2695145	2628846	5323991

Table -2: The Libyan male population from 1954 to 2006.

Year	Age group (years)									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1954	146234	107567	91885	61551	43844	38083	27435	14259	9506	540364
1955	150572	109266	93362	62906	44631	38302	27586	14414	9609	550648
1956	159631	112732	96376	65703	46241	38749	27893	14725	9817	571867
1957	169187	116276	99457	68607	47895	39207	28206	15039	10026	593900
1958	179266	119901	102607	71623	49594	39677	28526	15356	10237	616787
1959	189893	123606	105826	74753	51338	40160	28854	15674	10449	640553
1960	201097	127393	109114	78002	53129	40655	29188	15994	10663	665235
1961	212904	131263	112473	81374	54966	41163	29531	16316	10878	690868
1962	225345	135216	115902	84873	56850	41686	29883	16640	11094	717489
1963	238450	139253	119403	88502	58784	42224	30242	16966	11311	745135
1964	259446	145475	124795	94206	61778	43060	30800	17458	11639	788657
1965	266179	149290	125309	94775	62916	43415	30946	17546	11698	802074
1966	280101	157186	126303	95890	65236	44123	31227	17717	11812	829595
1967	294594	165415	127245	96969	67607	44823	31495	17881	11920	857949
1968	309671	173987	128132	98010	70027	45514	31748	18036	12024	887149
1969	325342	182907	128964	99010	72495	46195	31985	18182	12122	917202
1970	341619	192185	129739	99967	75011	46866	32206	18320	12213	948126
1971	358513	201828	130455	100881	77572	47525	32411	18449	12299	979933
1972	376035	211843	131111	101750	80177	48172	32600	18569	12379	1012636
1973	401449	226414	131295	102431	83732	48863	32680	18633	12422	1057919
1974	408197	233275	134885	103569	84606	50045	33316	18862	12574	1079329
1975	422004	247632	142372	105876	86370	52495	34625	19325	12884	1123583
1976	436181	262823	150256	108212	88149	55055	35981	19795	13197	1169649
1977	450734	278892	158557	110579	89942	57730	37385	20272	13515	1217606
1978	465669	295886	167295	112976	91748	60524	38839	20755	13837	1267529
1979	480989	313855	176493	115402	93566	63442	40344	21244	14163	1319498
1980	496701	332850	186172	117856	95396	66488	41902	21740	14493	1373598
1981	512809	352925	196357	120339	97237	69667	43514	22241	14827	1429916
1982	529319	374138	207071	122849	99088	72985	45181	22748	15165	1488544
1983	546233	396546	218341	125387	100947	76446	46906	23261	15507	1549574
1984	573908	434700	237424	129466	103913	82245	49763	24086	16057	1651562
1985	574682	441276	244772	133408	105089	83390	50806	24381	16254	1674058
1986	576014	454629	260102	141629	107447	85701	52952	24977	16651	1720102
1987	577048	468195	276254	150288	109799	88028	55167	25578	17052	1767409
1988	577781	481969	293261	159403	112144	90371	57456	26183	17455	1816023
1989	578208	495944	311156	168991	114477	92725	59817	26792	17861	1865971
1990	578327	510111	329972	179071	116796	95089	62252	27404	18270	1917292
1991	578136	524462	349746	189662	119098	97459	64763	28020	18680	1970026
1992	577633	538989	370512	200784	121379	99834	67350	28637	19092	2024210
1993	576819	553683	392306	212455	123635	102210	70014	29257	19505	2079884
1994	575692	568536	415164	224695	125865	104584	72757	29878	19919	2137090
1995	573266	592396	453697	245331	129338	108339	77270	30865	20577	2231079
1996	578354	597654	457724	247508	130486	109301	77956	31139	20759	2250881
1997	588666	608310	465885	251922	132813	111249	79346	31694	21130	2291015
1998	599192	619187	474215	256426	135187	113239	80764	32261	21507	2331978

1999	609905	630258	482694	261011	137604	115263	82208	32838	21892	2373673
2000	620840	641558	491348	265690	140071	117330	83682	33427	22284	2416230
2001	631910	652997	500109	270428	142569	119422	85174	34023	22682	2459314
2002	643208	664672	509051	275263	145118	121557	86697	34631	23087	2503284
2003	654708	676556	518153	280184	147712	123731	88247	35250	23500	2548041
2004	666447	688686	527443	285208	150361	125949	89830	35882	23921	2593727
2005	678330	700966	536847	290293	153042	128195	91431	36522	24348	2639974
2006	560982	576790	588420	445562	226353	120372	99430	46342	30894	2695145

Table 3: The Libyan female population from 1954 to 2006.

Year	Age groups (years)									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1954	144994	92215	82591	58197	43569	31845	23958	14320	9546	501235
1955	149139	93938	84174	59356	44187	32003	23948	14319	9546	510610
1956	157762	97458	87411	61733	45440	32340	23942	14314	9542	529943
1957	166813	101069	90734	64179	46714	32705	23957	14302	9535	550008
1958	176312	104771	94145	66696	48009	33101	23993	14284	9523	570833
1959	186277	108565	97644	69286	49324	33530	24053	14261	9507	592447
1960	196730	112453	101233	71951	50661	33995	24136	14232	9488	614878
1961	207692	116437	104915	74692	52019	34498	24245	14197	9465	638159
1962	219185	120519	108689	77511	53399	35042	24380	14158	9438	662322
1963	231233	124700	112560	80411	54802	35631	24543	14113	9409	687399
1964	250415	131167	118553	84918	56951	36603	24842	14037	9358	726844
1965	256912	134587	119023	85421	57997	36914	24960	14109	9406	739328
1966	270348	141663	119929	86407	60129	37533	25188	14247	9498	764943
1967	285021	149431	121241	88651	61367	38319	26219	14918	9946	795112
1968	298882	156711	121590	88277	64530	38753	25609	14506	9671	818528
1969	314004	164696	122342	89158	66797	39352	25802	14625	9750	846525
1970	331477	174177	124065	93086	66859	40329	27870	15981	10654	884498
1971	346013	181626	123679	90803	71458	40523	26148	14843	9895	904986
1972	362920	190582	124262	91564	73850	41093	26301	14940	9960	935471
1973	390867	206241	126090	97640	73104	42352	29619	17124	11416	994453
1974	397340	213045	129383	98845	73998	43514	30268	17384	11589	1015367
1975	410566	227335	136245	101295	75808	45935	31607	17912	11941	1058643
1976	424120	242526	143466	103786	77638	48480	32998	18451	12301	1103765
1977	438004	258670	151063	106319	79490	51154	34441	19001	12667	1150809
1978	452221	275823	159055	108894	81360	53964	35939	19561	13041	1199859
1979	466773	294041	167463	111511	83250	56916	37493	20132	13421	1250999
1980	481661	313386	176305	114169	85158	60015	39104	20713	13808	1304319
1981	496887	333921	185604	116869	87082	63269	40774	21304	14203	1359911
1982	512451	355713	195383	119609	89022	66683	42504	21905	14604	1417873
1983	528354	378832	205663	122389	90977	70266	44297	22517	15011	1478306
1984	554278	418408	223063	126881	94106	76311	47272	23507	15671	1579497
1985	555181	424935	230401	130677	95645	77158	48153	23819	15879	1601848
1986	556767	438193	245759	138586	98768	78854	49960	24447	16298	1647632
1987	558047	451669	262006	146905	101936	80543	51822	25078	16718	1694723
1988	559016	465358	279183	155647	105147	82222	53739	25710	17140	1743161
1989	559669	479250	297331	164829	108398	83890	55713	26342	17561	1792984
1990	560003	493337	316492	174467	111686	85543	57744	26974	17983	1844230
1991	560015	507611	336709	184577	115007	87180	59834	27606	18404	1896941
1992	559702	522060	358025	195175	118359	88797	61982	28235	18823	1951158
1993	559063	536676	380486	206277	121738	90392	64191	28861	19241	2006925
1994	558098	551449	404138	217900	125140	91962	66460	29483	19656	2064286
1995	555898	575175	444213	237446	130576	94397	70187	30461	20307	2158660

1996	561044	580500	448325	239644	131785	95271	70837	30743	20495	2178644
1997	571480	591297	456665	244102	134236	97043	72154	31315	20876	2219168
1998	603804	648416	496601	268531	141569	118584	84577	33784	22523	2418388
1999	592998	613561	473859	253293	139291	100697	74871	32494	21663	2302725
2000	604089	625037	482722	258030	141896	102580	76271	33102	22068	2345795
2001	615325	636663	491701	262830	144535	104488	77690	33717	22478	2389429
2002	626803	648538	500872	267732	147231	106437	79139	34346	22897	2433997
2003	638494	660635	510215	272726	149978	108423	80615	34987	23325	2479396
2004	638526	660669	510241	272740	149985	108428	80619	34989	23326	2479522
2005	650403	672958	519732	277813	152775	110445	82119	35639	23760	2525643

The temporal trends of the estimated and observed census (Figure 1) show a linear trend. Comparison of the outcomes of the linear and geometric models of

the Libyan population from 1954 to 2006 indicates linear population growth (Figure 2).

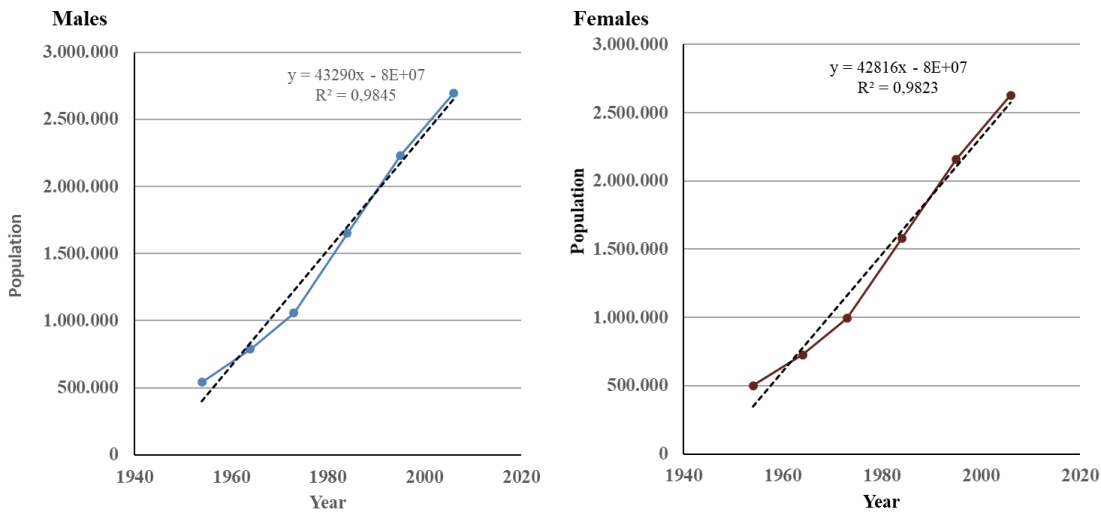


Figure 1: The Libyan populations' census as reported by the Libyan Office of National Statistics. The dotted line shows the linear regression line.

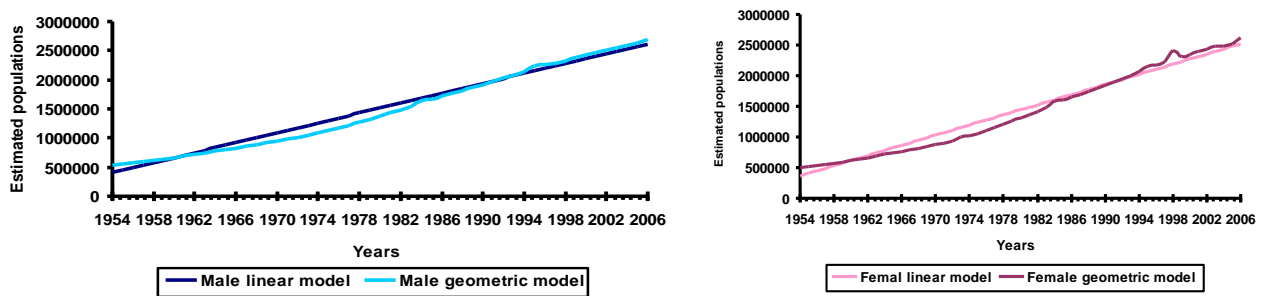


Figure 2: Linear and geometric modeling of Libyan population growth during 1954-2006 based on the national censuses.

The trends of fertility and mortality rates between 1954 and 2006 in the Libyan population were

analyzed. The number of births increased until 1992 but plunged precipitously in the following year (Figure 3).

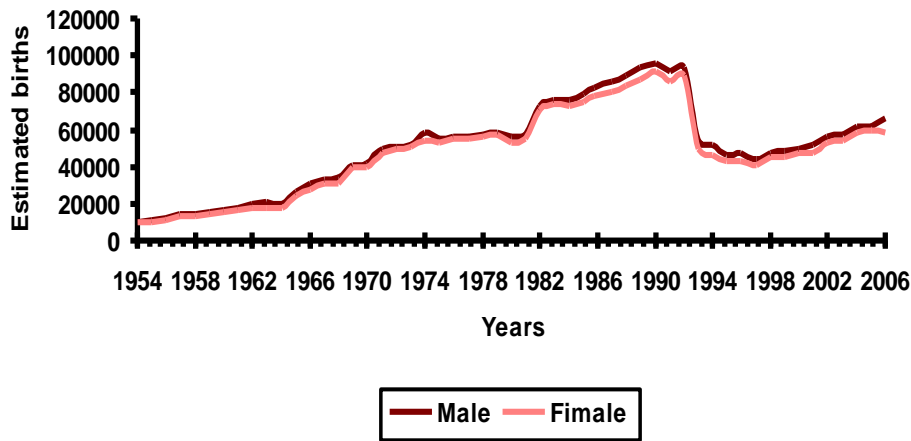


Figure 3: Estimated Libyan fertility 1954-2006

The same was true for the estimated annual number of deaths (Figure 4). Figure 5

shows the age-gender profile of the Libyan population, during 2016.

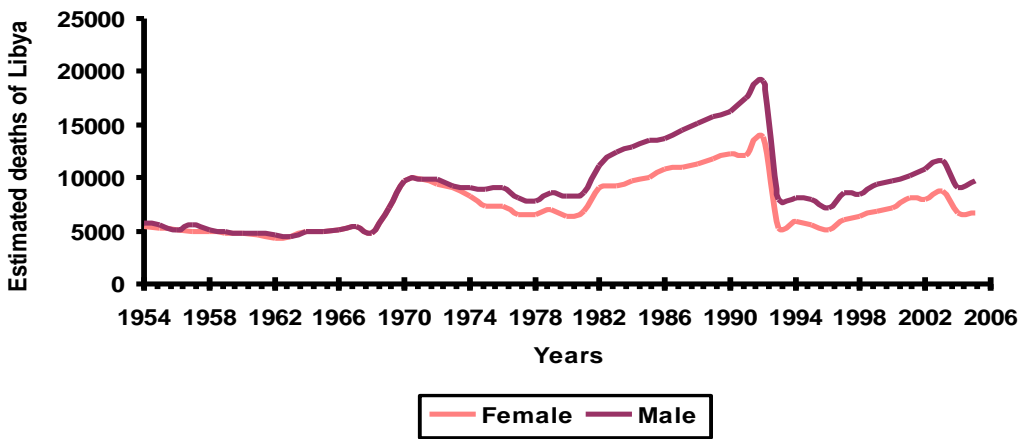


Figure 4: Estimated Libyan mortality 1954-2006

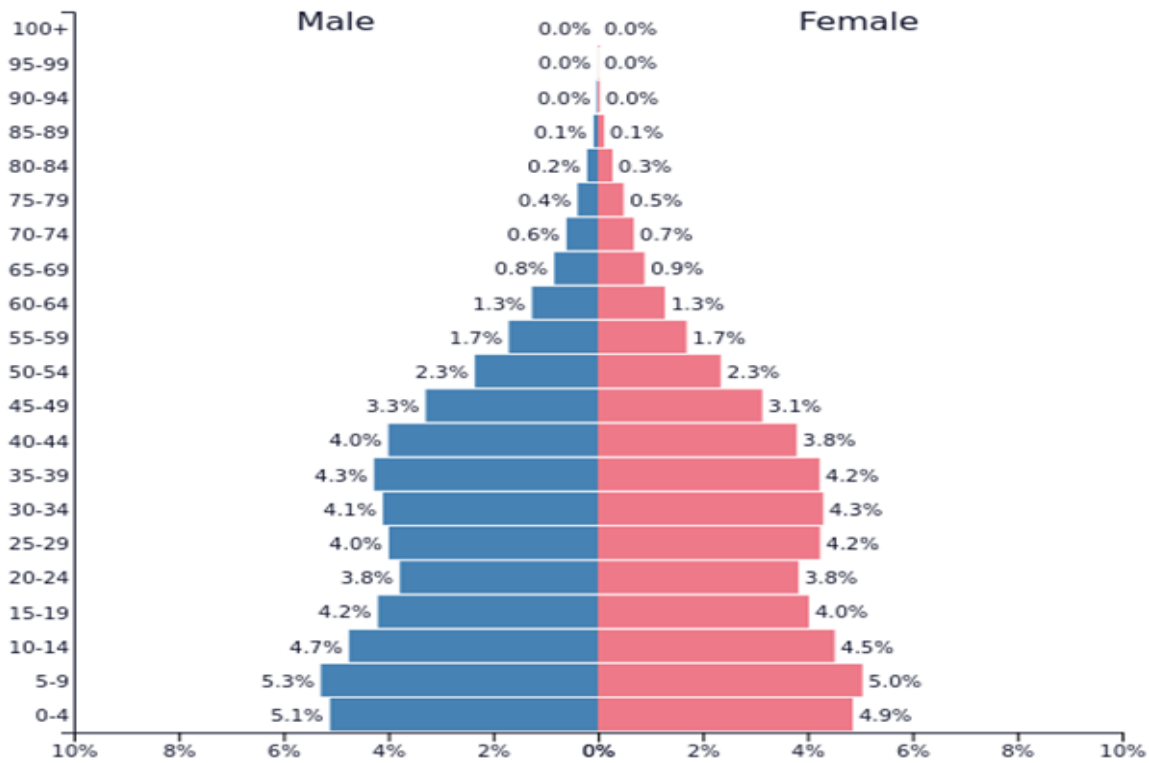


Figure 5; Age-gender profile of the Libyan population in person-years. (M;F) 2016

This anomaly was attributed to the adjustments and estimates made by the National Statistics Office before 1993. But upon establishment of the General Authority for Information and Communication (GAIC) in 1993, the vital statistics data started to be

sent directly from civil record offices to GAIC without making any estimates.

The number of deaths in the Libyan population from all causes from 1954 to 2006 is shown in table 4 (males) and table 5 (females).

Table-4: Male mortality from all causes.

Year	Age group (years)								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
1954	2733	311	245	188	345	211	423	578	644
1955	2677	356	268	209	278	215	465	524	593
1956	2493	312	256	178	264	233	367	489	573
1957	2517	316	256	293	234	273	445	562	614
1958	2381	267	233	261	222	233	423	488	576
1959	2346	251	229	244	223	244	442	479	568
1960	2305	254	246	232	241	261	455	471	552
1961	2076	298	266	199	233	245	467	497	566
1962	1948	166	237	259	188	235	478	445	678
1963	1944	197	211	188	211	215	534	366	589
1964	2169	246	178	213	189	246	673	389	564
1965	2133	269	263	195	156	256	567	495	621
1966	2440	278	178	158	162	216	621	567	533
1967	2276	184	256	197	178	358	765	480	657
1968	2236	167	189	157	143	240	528	562	580
1969	3677	245	287	232	254	362	684	752	732
1970	5466	287	305	284	367	432	745	866	896
1971	6558	317	324	292	401	453	782	923	1021

1972	6268	286	292	269	361	409	704	833	920
1973	5578	255	260	239	321	365	626	741	819
1974	5483	250	255	235	316	358	616	729	805
1975	3795	368	410	326	403	527	700	862	1500
1976	3836	435	456	313	376	553	802	1045	1217
1977	3509	334	342	255	341	469	649	812	1422
1978	3355	319	327	244	326	448	621	776	1360
1979	3694	358	399	317	392	513	681	839	1460
1980	3545	402	421	289	347	511	741	966	1125
1981	3643	413	433	297	357	525	762	993	1156
1982	4481	501	468	338	464	733	980	1427	1713
1983	5163	568	571	340	509	878	1060	1519	1862
1984	5070	662	623	439	484	884	1256	1425	2047
1985	4993	622	580	386	519	1040	1299	1563	2508
1986	4863	645	695	370	487	1037	1457	1734	2332
1987	4884	711	823	483	621	1163	1593	1651	2611
1988	4822	750	793	496	619	1164	1763	2053	2650
1989	4717	751	878	724	683	1082	1912	2009	2942
1990	5065	774	845	596	715	1241	1865	2149	2920
1991	4728	931	1231	723	782	1334	2428	2271	3046
1992	5162	860	1391	1208	911	1435	2552	2532	3075
1993	1899	392	649	385	397	693	1158	1112	1267
1994	2218	370	566	473	368	595	1108	1107	1362
1995	1357	319	600	674	559	657	1076	1249	1406
1996	1261	339	539	503	392	618	1122	1222	1185
1997	1459	360	597	581	470	705	1458	1580	1333
1998	1317	359	529	425	444	766	1499	1695	1441
1999	1455	394	596	507	501	820	1594	1960	1632
2000	1616	386	687	562	548	844	1599	1982	1515
2001	1844	393	660	603	586	790	1707	1999	1577
2002	1811	418	732	732	570	813	1726	2233	1828
2003	1746	433	809	800	664	872	1875	2359	2056
2004	1533	338	562	644	552	683	1326	1783	1731
2005	1780	297	498	665	718	704	1424	1857	1727
2006	1308	286	602	765	772	842	1671	2229	1842

Table -5: Female mortality from all causes

Year	Age group (years)								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
1954	2533	311	245	188	345	211	423	578	544
1955	2477	356	268	209	278	215	385	474	593
1956	2493	312	256	178	264	233	367	489	573
1957	2217	316	256	293	234	273	445	462	514
1958	2281	267	233	261	222	233	423	488	476
1959	2105	254	246	232	241	261	455	471	452
1960	2005	234	226	212	221	251	435	451	462
1961	1918	228	216	199	233	245	467	497	466

1962	1848	166	237	259	188	235	378	445	578
1963	1944	197	211	188	211	215	534	366	589
1964	2169	246	178	213	189	246	673	389	564
1965	2133	269	263	195	156	256	567	495	621
1966	2440	278	178	158	162	216	621	567	533
1967	2276	184	256	197	178	358	765	480	657
1968	2236	167	189	157	143	240	528	562	580
1969	3677	245	287	232	254	362	684	752	732
1970	5466	287	305	284	367	432	745	866	896
1971	5558	317	324	292	401	453	782	923	921
1972	6055	257	223	257	227	262	549	694	897
1973	5808	246	214	247	218	251	527	666	861
1974	5280	224	194	224	198	228	479	605	782
1975	3396	247	221	208	268	337	544	736	1300
1976	3656	262	144	207	237	349	599	814	1018
1977	3056	223	199	187	242	304	491	664	1178
1978	3102	219	175	183	240	298	488	673	1172
1979	3254	237	212	199	257	323	522	706	1246
1980	3099	222	122	175	201	296	507	689	1029
1981	3437	246	135	194	223	328	563	765	957
1982	4330	291	227	276	346	468	748	1053	1391
1983	4275	283	262	257	288	489	798	1130	1518
1984	4358	324	262	237	320	507	778	1200	1784
1985	4270	301	270	255	332	574	870	1282	1876
1986	4564	337	272	266	362	601	1014	1415	2009
1987	4282	326	335	299	299	735	1097	1492	2124
1988	4006	403	373	317	437	791	1127	1599	2247
1989	3945	378	404	417	468	769	1232	1668	2461
1990	4296	428	422	353	524	793	1211	1745	2568
1991	3909	461	487	416	443	860	1414	1772	2385
1992	4379	465	467	524	623	850	1649	1993	2901
1993	1534	200	224	239	247	352	622	781	1090
1994	1852	198	198	217	255	361	700	853	1235
1995	1076	182	224	460	358	392	702	902	1345
1996	930	177	201	374	297	434	744	850	1093
1997	1172	193	289	297	359	485	902	1127	1293
1998	1125	192	253	337	397	510	1043	1218	1345
1999	1190	193	268	349	407	541	1111	1304	1471
2000	1285	243	224	324	472	716	1110	1339	1413
2001	1582	270	300	386	479	682	1233	1600	1643
2002	1449	230	260	442	480	599	1164	1541	1742
2003	1536	267	300	464	521	657	1252	1842	1965
2004	1240	142	238	324	357	502	898	1256	1656
2005	1395	174	191	328	399	426	890	1375	1577
2006	1219	161	260	345	462	532	1216	1687	1776

Figure 6 shows the number of deaths in males and females per age group, as well as the death rate per age group, in 2006. These rates are different

between males and females, likely due to differences in lifestyle. The death rate from all causes ranged from 0-0.5% in age group 0-45 years to 0.5-2% in

age group 45-65 years, and up to 6% above 65 years. The death rate was lower among those aged less

than 40 years. A difference in death rate between males and females emerged after the age of 40 years.

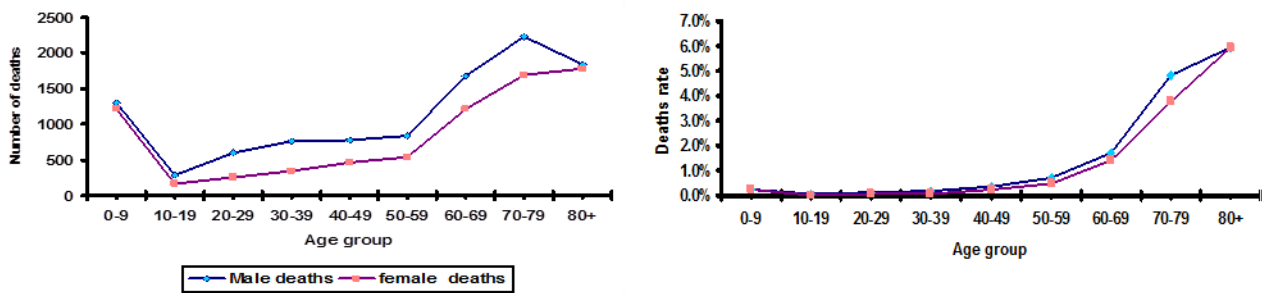


Figure 6: Libyan population deaths and death rates from all causes per age group in 2006.

Discussion

Population censuses provide the demographics of a whole population and therefore avoid issues of representativeness that often hamper estimates based on medical statistics. Recently, there has been extensive research in the area of census biodata using statistical models to provide a better understanding of the demographic parameters and to plan for future prospects [Byars-Winston et al. 2015]. In contrast to demographic surveys with limited sample sizes, the census is based on large numbers and provides narrow confidence intervals. The geometric and linear models are the most useful models for estimating the rate of growth during the inter-censuses years and for extrapolating the findings to the future [Ribeiro and Petyt 199; Faraway 2014].

In this study, we combined these two statistical models to determine the key demographic parameters within the Libyan population during 1954-2006. These parameters include birth rates, sex ratios at birth, and age- and gender-specific death and life expectancies. Both males and females had linear growth patterns and gave a close resemblance to the estimation of the population growths. A steady growth trend was followed by a steeper upward trend that started in most of the age groups at about the end of the 1970s and extended well beyond the 1980s. These results are in agreement with census data published in other developed countries. In Western countries, such as Britain, Sweden and Italy, the growth rates showed an upward trend around the end of the nineteenth century that extended well beyond the Second World War [Hatton and Martin 2010; Molitoris 2017; Helliwell and Putnam 1995].

In our study, the sex ratio in the Libyan population was skewed towards males. The number of girls per 1000 boys aged 0-9 years was 991 in 1954, 965 in 1964, and 974 in 1973, and from 960 to 970 between 1984 and 2006, suggesting that fewer girls are born. Similar sex ratios have also been recorded in other developing countries, most notably India, where 959-962 girls were born for every 1000 boys in 1981 and 4887

2001 [Lee et al., 2015]. Further studies are needed to explain the unequal sex ratio in Libyan society. The population profile in Libya has changed substantially during the last fifty years. The proportion of children aged 0-9 years had increased from 28% in 1954 to 35% in 1985 and then declined to 25% after 1995. This trend could be interpreted as a shift away from having many children towards providing a better quality of life for children and parents. Similar trends reported in other developing countries, including Latin American and Asian countries; has contributed to the level of urbanization, female education, and the improved life-expectancy of new-born children [Matus-Lopez and Pedraza 2016; Conde-Agudelo et al., 2012; Lloyd-Sherlock 2014]. Libya has been reported among the top African and Arab countries in education and child health care practice [Daw & Elkhammas 2008; United nation Report-HDI 2011; Daw et al. 2018]. The age profile has a major contribution to the entity of the Libyan population. Those aged from 10 to 59 years ranged from 55% to 58% between 1953 and 1973 to reach 59-67% between 1994 and 2006. Those aged over 60 years ranged from 5% in 1954 to 6% in 2006. In the first three decades, women comprised about 48% of the Libyan population and 49% by 2006. The working-age population increased by more than ten percentage points due to an increase in the number of women. What is less clear is the effect of these demographic shifts, particularly how they are reflected in the work force, and whether women are represented proportionately across the wide spectrum of occupations. Statistical data continuously reveal that not every qualified individual has an equal opportunity to work in a range of occupational fields. The labor market is not sex neutral and the longstanding occupational disparities between women and men are evident in Arab countries. Thus, this study provides an important analysis of the demographic and employment context within the Libyan population, which could be reflected on demographic changes in the workforce indicated by

the diversity in age and sex [Cervellati and Sunde 2011]. Further studies are needed to understand the relationship between demographic diversity in the general population, development, and choices in the labor market.

Mortality is the most sensitive indicator of the health disparities between poorer and richer nations. It clearly reflects the quality of life and is affected by modernization of health care practices in any country [Aksan and Chakraborty 2014; Haines 2011]. The mortality patterns among Libyans remained virtually unchanged between 1954 and 1973. The sustained decline in population mortality in Libya did not begin until the 1970s onwards. Within 50 years, the mortality rate in the country declined by more than two-thirds. This is clearly evident in 2006, where the mortality rate notably declined in all age groups. It ranged between 0.0% and 0.5% among those aged between those aged 0-45 years and was up to 6% in those aged above 60 years, but there was no sex disparity. This may reflect declines in some of the deadliest diseases of the past and improvement of the socioeconomic status of the country. Tuberculosis, measles and pertussis, for instance, were rampant in Libya till the 1970s. By the 1990s, clean water access had improved for everyone, and electricity had reached most of the population. Moreover, Libya is the only African country where children have easy access to free vaccination and better nutrition [Daw *et al.* 2016; Daw *et al.* 2018]. Similar results were observed in developed countries during the first quarter of the 20th century. In European countries, deaths from all causes were under 2 deaths per 1,000 for nearly the entire period till 1926 [Post *et al.* 1997; Szreter 2003]. In this study, the causes of death were not investigated and we were not able to quantify the influence of various factors on overall mortality differentials. Hence, further studies are needed to understand the inequalities of mortality and its causes.

Our study showed substantial variation in the age trends of the Libyan population. Most Libyans are aged 10-59 years and only 5% are above 50 years of age, without significant changes in the pattern of death. Good fertility and declining mortality rates have been a major contributing factor to Libya's demographic changes. Similar results were reported in other African and Latin American countries [UN Millennium Report 2005; World Health Report 2006]. We suggest that the proportion of the working age population has been increasing in Libya. This should be useful for identifying certain policy directions that could be reflected in greater economic growth in the country. Released censuses usually consist of limited statistics that have been debated by scholars and policy makers, and some people are always missed in

every census count, particularly in a large and sparsely populated country like Libya. Places that are undercounted in the census receive little attention and a limited proportion of the available national resources [43, 44 Anderson and Fienberg 2001; O'Hare 2015]. Mortality rates and causes of death are not well documented in decennial census; affordable and sustainable approaches to data collection on mortality that are representative of populations are required. Definitely, complete registration of deaths with full medical certification is the most appropriate means to monitor the health of populations [Alkema *et al.*, 2016].

Concluding remarks

This is to be considered the first study in the Arab and North African countries that used national census to analyse the demographic parameters and changes that occurred within the Libyan society over last fifty years. The study provides a first attempt to examine the Libyan population demography, age structure and ability to contribute to the work force. Major sociodemographic factors in Libya are clearly evident from the population's structure. The population trends have shown a low mortality patterns and an increase in fertility rates emerging from the early 1970s.

Recommendations

The findings of this study could be used to guide strategies to improve the labor sector and strengthen the health care system in the country. Such census biodata could be useful in conducting epidemiologic analyses as diverse as maternal mortality and viral hepatitis and HIV infection rates [Daw *et al.*, 2014; Austin 2016].

Conflict of interest

The authors declare that they have no conflict of interests.

References

- African Center for Statistics: Africa Addendum to the United Nations Principles and Recommendations for Population and Housing Censuses, Rev. 2, Draft 2008, dated March 2008.
- Aksan, A. & Chakraborty, S., 2014. Mortality versus morbidity in the demographic transition. *European Economic Review* 70(1): 470–492. doi:10.1016/j.euroecorev.2014.06.011.
- Alkema, L., Chou D., Hogan D, Zhang, S., Moller, AB, Gemmill, A, Fat, DM, Boerm, a T, Temmerman, M., Mathers, C., Say, L., 2016 Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic

- analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *The Lancet*. 2016 Feb
- Andersen, O. 1991. "Occupational impacts on mortality declines in the Nordic countries." In: W. Lutz, (ed.) *Future demographic trends in Europe and North America. What can we assume today?* London: Academic Press, pp. 41-54.
- Anderson, M. & Fienberg, S.E. (2001). *Who counts? The politics of census taking in contemporary America*, New York: Russell Sage Foundation.
- Anderson, M. & Fienberg, S.E. (2001). *Who counts? The politics of census taking in contemporary America*, New York: Russell Sage Foundation.
- Anyangwe, SC., Mtonga C., 2007 Inequities in the global health workforce: the greatest impediment to health in sub-Saharan Africa. *International journal of environmental research and public health*. Jun 30;4(2):93-100.
- Austin, P.C., Lee, D.S., and Fine, J.P. 2016. Introduction to the analysis of survival data in the presence of competing risks. *Circulation* 133(6): 601-609. doi:10.1161/CIRCULATIONAHA.115.0177.
- Booyesen F, Van Der Berg S, Burger R, Von Maltitz M, Du Rand G., 2008. Using an asset index to assess trends in poverty in seven Sub-Saharan African countries. *World Development*. Jun 30;36(6):1113-30.
- Byars-Winston, A., Fouad N., Wen Y, Race/ethnicity and sex in US occupations 2015. 1970–2010: Implications for research, practice, and policy. *Journal of vocational behavior*. Apr 30;87:54-70
- Cai, Y., China's new demographic reality: Learning from the 2010 census. 2013. *Population and development review*. Sep 1;39(3):371-96.
- Cervellati, M., and Sunde, U.. 2011. Life expectancy and economic growth: The role of the demographic transition. *Journal of Economic Growth* 16(2): 99–133. doi:10.1007/s10887-011-9065-2.
- Coast E, Fanghanel A, Lelièvre ,E., Randall, S. 2016. Counting the Population or Describing Society? A Comparison of English and Welsh and French Censuses. *European Journal of Population*. May 1;32(2):165-88.
- Conde-Agudelo, A., Rosas-Bermudez, A., Castaño, F., and Norton, M.H. 2012. Effects of birth spacing on maternal, perinatal, infant, and child health: A systematic review of causal mechanisms. *Studies in Family Planning* 43(2): 93– 114. doi:10.1111/j.1728-4465.2012.00308.x.
- Daw MA, Ali LA, Daw AM, Sifennasr NE, Dau AA, Agnan MM, El-Bouzedi A. 2018. The geographic variation and spatiotemporal distribution of hepatitis C virus infection in Libya: 2007–2016. *BMC infectious diseases*. Dec;18(1):594.
- Daw MA, Daw AM, Sifennasr NE, Draha AM, Daw AM, Daw AM, Ahmed MO, Mokhtar ES, El-Bouzedi A, Daw IM. 2018. The Epidemiology of Hepatitis D Virus in North Africa: A Systematic Review and Meta-Analysis. *The Scientific World Journal*. 2018;2018.
- Daw MA, Daw AM, Sifennasr NEM, Draha AM, Daw AA, Daw AA, Ahmed MO, Mokhtar ES, El-Bouzedi AH, Daw IM, Adam SI, Warrag S. 2019 In association with Libyan Study Group of Hepatitis & HIV Spatiotemporal analysis and epidemiological characterization of the human immunodeficiency virus (HIV) in Libya within a twenty five year period: 1993-2017. *AIDS Res Ther*. Jun 25;16(1):14. doi: 10.1186/s12981-019-0228-0. PMID: 31238947
- Daw MA, El-Bouzedi A. 2014. Prevalence of hepatitis B and hepatitis C infection in Libya: results from a national population based survey. *BMC infectious diseases*. Jan 9;14(1):17.
- Daw MA, El-Bouzedi A, Dau AA. 2016. The assessment of efficiency and coordination within the Libyan health care system during the armed conflict-2011. *Clinical Epidemiology and Global Health*. Sep 30;4(3):120-7.
- Daw, MA, and. Elkhammas EA. 2008. "Libyan medical education; time to move forward." *Libyan Journal of Medicine* 1-3.
- Daw MA, El-Bouzedi AH, Dau AA. 2019. Trends and patterns of deaths, injuries and intentional disabilities within the Libyan armed conflict: 2012–2017. *PloS one*. May 10;14(5):e0216061.
- Daw MA, Shabash A, El-Bouzedi A, Dau AA. 2014. Seroprevalence of HBV, HCV & HIV co-infection and risk factors analysis in Tripoli-Libya. *PloS one*. Jun 17;9(6):e98793.
- Day C, Gray A, Budgell E. 2011. Health and related indicators. *South African health review*. 2011 Jan 1;(1):119-248
- Faraway JJ. *Linear models with R*. CRC press; 2014 Jul 1.
- Groves, R.M. 2010. Director's blog: Quality in a census, some overview thoughts. <http://blogs.census.gov/directorsblog/2010/09/quality-in-a-census-some-overview-thoughts.html> (July 2011).
- Haines, M.R. 2011. Inequality and infant and childhood mortality in the United States in the twentieth century. *Explorations in Economic History* 48(3): 418–428. doi:10.1016/j.eeh.2011.05.009.
- Hatton, T.J. 2011. Infant mortality and the health of survivors: Britain, 1910–50. *Economic History Review* 64(3): 951–972. doi:10.1111/j.1468-0289.2010.00572.x.
- Hatton TJ, Martin RM. 2010. Fertility decline and the heights of children in Britain, 1886–

1938. Explorations in Economic History. Oct 31;47(4):505-19.
- Helliwell JF, Putnam RD. 1995. Economic growth and social capital in Italy. *Eastern economic journal*. Jul 1;21(3):295-307.
- Hsu CY, Hu GC. 2014. Beyond Neglect: Long-term Care Research in Low and Middle Income Countries. *International Journal of Gerontology*. Sep 1;8(3):107.
- Huselid MA. 1995. The impact of human resource management practices on turnover, productivity, and corporate financial performance. *Academy of management journal*. Jun 1;38(3):635-72.
- Lee J, McGovern ME, Bloom DE, Arokiasamy P, Risbud A, O'Brien J, Kale V, Hu P. 2015. Education, gender, and state-level disparities in the health of older Indians: Evidence from biomarker data. *Economics & Human Biology*. Dec 31;19:145-56
- Lloyd-Sherlock P. 2014. Beyond neglect: long-term care research in low and middle income countries. *International Journal of Gerontology*. Jun 30;8(2):66-9.
- Lutz, W., Goujon, A., KC, S. and Sanderson, W., 2007. Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000. *Vienna yearbook of population research*, pp.193-235.
- Matus-Lopez M, Pedraza CC. 2016. New Long-Term Care Policies in Latin America: The National System of Care in Uruguay. *Journal of the American Medical Directors Association*. Jul 1;17(7):663-5
- Meyer BD, Mok WK, Sullivan JX. 2015. Household surveys in crisis. *The Journal of Economic Perspectives*. Dec 1;29(4):199-226.
- Molitoris JJ. 2017. Disparities in death: Inequality in cause-specific infant and child mortality in Stockholm, 1878-1926. *Demographic Research*. <http://www.demographic-research.org/Volumes/Vol36/15/> DOI: 10.4054/DemRes.2017.36.15
- O'Hare WP. 2015. The undercount of young children in the US Decennial Census. *Springer International Publishing*; Jun 5. 5;387(10017):462-74.
- Post W, Van Poppel F, Van Imhoff E, Kruse E. 1997. Reconstructing the extended kin-network in the Netherlands with genealogical data: Methods, problems, and results. *Population Studies*. Nov 1;51(3):263-78
- Ribeiro P, Petyt M. 199. Geometrical non-linear, steady state, forced, periodic vibration of plates, part I: model and convergence studies. *Journal of Sound and Vibration*. 1999 Oct 7;226(5):955-83.
- Turner BL, Hydén G, Kates RW. 1993. Population growth and agricultural change in Africa 1993.
- Ross NA, Wolfson MC, Dunn JR, Berthelot JM, Kaplan GA, Lynch JW. 2000. Relation between income inequality and mortality in Canada and in the United States: cross sectional assessment using census data and vital statistics. *Bmj*. Apr 1;320(7239):898-902.
- Shetty, P., 2012. Grey matter: ageing in developing countries. *Lancet* 379, 1285–1287
- Szreter S. 2003. The population health approach in historical perspective. *American Journal of Public Health*. Mar;93(3):421-31
- Tejada CA, Triaca LM, da Costa FK, Hellwig F. 2017. The sociodemographic, behavioral, reproductive, and health factors associated with fertility in Brazil. *PLoS One*. Feb 10;12(2):e0171888. doi: 10.1371/journal.pone.0171888. PMID:28187167
- United Nations. Population Division. World population prospects: the 1994 revision. United Nations; 1995.
- United Nation Human Development Index- Libya Country Profile, Posted by Alexandra Valiente on March 5, 2011, <https://libyadiary.wordpress.com/2011/03/05/libya-un-hdi-country-profile/>
- United Nation Millennium Project, United Nations. Economic Commission for Latin America. The Millennium Development Goals: A Latin American and Caribbean Perspective. United Nations Publications; 2005.
- Vogel M, Porter LC. 2016. Toward a Demographic Understanding of Incarceration Disparities: Race, Ethnicity, and Age Structure. *J Quant Criminol*. 2016;32(4):515-530. PMID: 27928196
- Wang H, Dwyer-Lindgren L, Lofgren KT, Rajaratnam JK, Marcus JR, Levin-Rector A, Levitz CE, Lopez AD, Murray CJ. 2013. Age-specific and sex-specific mortality in 187 countries, 1970–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. Jan 4;380(9859):2071-94.
- World Health Organization Report (WHO) 2006: working together for health. Geneva: World Health Organization, 2006