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PRE-COVID MORTALITY IN NORTH OSSETIA-ALANIA

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Abstract

North Ossetia-Alania (NOA) regional mortality over thirty years of transition is described in detail for the first time. Though NOA and other Caucasus regions are perceived to have higher life expectancy than Russia overall, we find that, like the rest of Russia, men live much shorter lives in both rural and urban areas. Urban mortality is lower for most causes of death than rural mortality with women in particular showing improvements in lowering mortality and higher life expectancy at birth. Male mortality across all ages is better in the 21st century than the 1990s but has not improved recently relative to the early 2000s. Sigma and beta mortality divergence reveal little improvement in male mortality relative to female mortality with the gender gap unchanged since the Soviet era which is unusual at the regional level. Nostalgia for Soviet era health systems is misplaced as health has improved since then especially like other regions in the area of infant mortality and deaths before the age of 5. Policy recommendations include moving some health care out of the capital of Vladikavkaz to take advantage of relatively lower rural mortality as well as promoting more rural economic development.

Keywords: North Ossetia-Alania, Public Health, Mortality, Divergence

1. Introduction

Some regions in the Caucasus area of the Russian Federation are understudied to the point where formal economic analysis of them in English is rare and those in Russian are purely descriptive and hard to find. The lack of attention is somewhat surprising given the special attention from the Russian government with such programs as The 2010 Strategy of Socioeconomic Development of the North Caucasus Federal Okrug until 2025 for targeted subsidies (Kazenin and Starodubrovskaya, 2020), the creation of a new Federal District in 2010 from part of the Southern Federal District (Holland, 2016), Putin's personal support for reducing mortality (Brooke and Gans-Morse, 2016) and even the creation of a special Ministry of North Caucasus Affairs in 2014 that closed in 2020. These special programs recognize that the North Caucasus has been import dependent and a constant drain on the federal budget for many decades and even centuries as Russia seeks to control the restive area (Abdulgalimov and Arsakhanova, 2018). Regions rely heavily on federal budget subsidies and localities in turn are heavily reliant on regional and federal transfers (Kolosov *et al.* 2017). While many see the Caucasus as being overly influenced by Russia, there is a case that just the opposite is occurring with the Caucasus having an outsized influence on Russia (Ware, 2013).

Within the North Caucasus, the Republic of North Ossetia–Alania (NOA) is distinctive for several reasons. First it is predominantly non-Muslim and has trans-Caucasian ties to fellow Ossetians further south (O'Loughlin *et al.* 2008). Second, it did not experience a rural to urban migration during the Soviet or transition eras maintaining a steady 35% rural/65% urban split 1970-2020 with a slight change toward urban living in the 1990s that reverted back in the 2000s as urban jobs decreased, urban Russians emigrated out, and flows of refugees from neighboring regions stopped. Third, NOA escaped much of the recent violence in the North Caucasus that recently has declined (Holland *et al.* 2017) with refugees coming to NOA (O'Loughlin *et al.* 2008) for safety. Fourth, NOA has one of the highest population densities of any Russian region (Badov, 2015) but also consistently has one of the lowest living standards of Russia's 89 regions with low wages, poor development of SMEs and high unemployment (Dobronosov *et al.* 2020). During the transition decades and even in the Soviet era back to 1970, the male/female split has remained quite stable with only a 1% drop in the male share (46%) of the population relative to the female share (54%) with the gap not closing due in part to young men either leaving NOA or dying prematurely (Kaberti *et al.* 2017). Across both these relatively fixed gender and urban/rural categories, the NOA age structure is steadily getting older with little prospect of reversing it. Currently, life in NOA is difficult for most with even knowledge of the Ossetian language fading especially among the young (Foltz, 2022).

NOA is subdivided in to 9 districts with one being the capital Vladikavkaz with that city and its surrounding area being the only predominantly urban area. Prigorodnyy district has an unresolved territorial dispute with the neighboring region of Ingushetia that resulted in open warfare in 1992 (O'Loughlin *et al.* 2008) and an influx of Ingushetians. Mozdoksky and Ardonsky districts are favored relative to the other 6 rural districts by relatively well-developed infrastructure, no population decline and location. Alagirskiy district, on the other hand, has experienced a lot of emigration despite an inflow of some refugees resulting in a steadily declining population. Rural Digorskiy and Irafskiy districts also have declining populations but few refugees from other regions (Kaberti *et al*. 2017). NOA is connected by a single tunnel to South Ossetia which following a 2008 war with Georgia is now controlled by Russia.

Section 2 extensively discusses the literature on NOA mortality as this remote region is understudied. Section 3 describes the data and the convergence analysis which is used in many countries to analyze growth but here will be used with mortality. Section 4 discusses the results. Finally, Section five concludes the paper.

2. Literature review

The population of NOA peaked around 2010 at 713,000 and is now just below 700,000. Transition period population growth benefitted from a lower number of deaths before the age of 5 than the Soviet era in the 1990s and a further 1% drop in the early 21st century. Unfortunately, in the 21st century there was no further progress in further lowering this percentage across gender and urban/rural areas when comparing 1999-2008 with 2009-2019 (table available upon request from author). By 2015 any gains from lower mortality were exceeded by the fall in both the number of births and out migration leading to steady depopulation (Kuchmasova, 2018). NOA life expectancy at birth followed the federal pattern of a steep drop especially for males in the 1990s with neither male nor female life expectancy returning to the 1990 level until the mid-2000s (Table 1). This fall illustrates that unlike other countries where a recession might improve health (Ariizumi and Schirle, 2012; Economou *et al.* 2008), the Russian experience of the 1990s was far different. All Russia male life expectancy dropped more than female life expectancy but recovered faster in the last twenty years (Shkolnikov *et al.* 2013; Timonin *et al*. 2017) to restore the 10-year male/female differential that existed in 1990. By 2019, both sexes lived 4-5 years longer than thirty years ago. While rural women have consistently had longer life expectancies than urban women over the past thirty years, rural men had lower life expectancies thirty years ago and recently (2019) compared to either group. However, during the transition rural men had longer life expectancies than urban men (table available upon request from author).

Table 1. Life expectancy at birth in NOA

	All	Male	Female
1985	72.86	66.17	76.25
1989	71.55	66.13	76.42
1990	71.32	65.57	76.58
1991	70.5	64.77	76.005
1992	69.72	63.97	75.43
1993	67.9	62.56	74.555
1994	67.31	61.15	73.68
1995	66.64	59.51	74.37
1996	67.3	60.75	74.22
1997	67.32	60.89	74.04
1998	67.98	61.77	74.44
1999	67.94	61.62	74.58
2000	68.42	62.07	75.07
2001	69.38	63.12	75.81
2002	68.84	62.51	75.39
2003	68.63	62.32	75.2
2004	68.41	62.39	74.55
2005	69.6	63.33	76.01
2006	70.7	64.38	77.08
2007	71.69	66.05	77.11
2008	71.41	65.61	77.05
2009	71.87	66.02	77.56
2010	72.65	66.85	78.16
2011	72.6	66.7	78.2
2012	73.41	67.87	78.6
2013	73.94	68.46	79.06
2014	73.82	68.76	78.48
2015	74.2	68.62	79.42
2016	75.05	69.72	79.92
2017	75.51	70.48	80.02
2018	75.68	70.35	80.57
2019	75.75	70.52	80.57

NOA causes of death can be annually examined in fine detail across all causes, age brackets and transition years (1989-2020) thanks to The Russian Fertility and Mortality database of the Centre of Demographic Research at New Economic School in Moscow (Center for Demographic Research, 2021). Using unpublished data from the Russian Federation's Statistical Service (Rosstat), age specific death rates for all causes of death in North Ossetia following the International Classification of Diseases (ICD) categories (WHO, 2010) are available. For a given year and cause of death, the death rate is the number of deaths in an age bracket divided by the number of people in that age bracket times one million. As the percentage distribution of deaths by age bracket is affected by the age distribution of the underlying population, an age specific death rate is needed to go beyond a simpler all-age mortality rate for sound policy recommendations. Further such rates facilitate comparison by age bracket over time and space. These data highly aggregated appear in the Rosstat NOA statistical handbooks (Federal Government Statistical Service for North Caucasus Federal Okrug Federal Government, 2021) which show aggregate causes of death with a marked increase in respiratory deaths in 2020 relative to any year 2012-2019 due to COVID making an understanding of mortality up to the pandemic important to understand how much NOA mortality is being changed by the pandemic.

We examine these data using four time periods covering half a century. The three Soviet Census discrete years of 1970 (January), 1979 (January) and 1989 (mid-year) are the first period which will be used as initial conditions. These years are also important as many older Ossetians and Russians living there believe Soviet times were better (Foltz, 2022) with some support from President Putin himself. The second period, 1989-1999, is a time of great turmoil and technically in the dataset has causes of death classified using the Soviet classification based on the older 9th edition of ICD codes. This period covers the last years of the Soviet era through the recession of

1998. We use this decade to look at overall mortality but not by individual causes of death given the old Soviet era codes. Though the NES dataset begins in 1989, the 1989 data are separate from the Soviet Census data of that year. NES annual data have separate urban and rural series with the annual population data underestimating the Census count in the transition era in NOA (Kaberti *et al*. 2017) but no adjustment is possible.

The third period, 1999-2012, has causes of death categorized in the new Russian codes based on the ICD 10th edition. This period covers the early Putin era through the Great Recession and recovery by the end of 2012. Closer examination of the dataset revealed that in North Ossetia in 2011 and 2012 use of these codes continued though they were supposed to be supplanted by the current codes which expand some categories. The fourth period, 2013-2019, has codes in a slightly expanded category list that can often be directly matched with period three to allow a 1999-2019 detailed comparison of causes of death. The fourth period covers the onset of sanctions and the 2014 Sochi Olympics which infused the entire Caucasus federal district with billions of dollars mostly directed to other regions. The fourth period ends just before the COVID epidemic with the 2020 NES data released while this project was being done. Like all Russian regions, NOA has several broad classifications of causes of death that explain almost all deaths: Neoplasms, Cardiovascular Diseases and Senility (grouped together as senility is often misdiagnosed for older people (Timonin *et al.* 2017), Respiratory diseases, Digestive diseases, External Causes, and Other. Malignant neoplasms (cancer) are the second leading cause of death with many types of cardiovascular/blood circulation diseases in first place with the latter accounting for 2/3 of all deaths in 2010 and growing in importance partly due to longer life expectancy (Badov, 2015) and the delay of the cardiovascular revolution occurring in other countries (Grigoriev *et al.* 2014). The level and growth of male youth mortality is high but has causes of death different from older adults (i.e. not natural causes) and separate from causes lowering infant mortality over the past thirty years.

In the Soviet era, mortality generally increased across the last two decades (1970-1990) except for infants where it fell significantly. Despite rising Soviet era mortality including famous attempts to reverse it such as Gorbachev's anti-alcohol campaign in the late 1980s, many Russians believe the Soviet era was superior to the present including President Putin who claims the breakup of the Soviet Union was a catastrophe and has his own campaigns against mortality including an anti-alcohol campaign like Gorbachev (Brooke and Gans-Morse, 2016). While improvement in medical knowledge should improve mortality since 1991, the Soviet era measures do give a sense of how well North Ossetia was doing in the last two decades of Soviet power and is an important benchmark. In NOA such nostalgia is exacerbated by a medical infrastructure that has stagnated in terms of structures, personnel, and number of hospital beds (Kaberti *et al.* 2017). Mortality is higher than even some Soviet years though the NOA infrastructure is considered to be better than other regions in the North Caucasus (Badov, 2015).

3. Data

During the last thirty years, the mean female death rate is always lower than mean male death rate across age brackets (Table 2) and the urban/rural split (table available upon request from author). Like other parts of Russia, high male mortality in the 30s and 40s makes the mean male rate 5-6 times higher than the female rate though NOA has succeeded in lowering the youth mortality rate in every district over the 1990-2010 period (Badov, 2015). Even in the age brackets of the 50s, 60s and 70s, the male rate remains twice as high. For males only, there are also substantial differences between blue and white collar workers with the former having particularly high mortality (Bessudnov *et al*. 2012).

Table 2. Mean NOA death rate male/female comparison across age brackets 1989-2019

Age Bracket	Females			Males		
	Overall	Urban	Rural	Overall	Urban	Rural
0-1yrs	10141	10216	9999	13876	13421	14834
1-4yrs	459	429	519	647	619	708
5-9yrs	295	324	257	328	355	288
10-14yrs	272	317	205	415	439	373
15-19	378	379	376	1051	1098	940
20-24	623	610	643	1948	1817	2353
25-29	796	837	713	3642	3611	3758
30-34	1088	1098	1070	5179	5376	4812
35-39	1422	1486	1295	7077	7179	6888
40-44	2102	2140	2039	9320	9650	8674
45-49	3154	3300	2815	12900	13054	12650
50-54	4600	4681	4436	17029	17031	17121
55-59	6782	6829	6683	21988	22391	21203
60-64	10783	10947	10435	30203	30187	30206
65-69	17837	18068	17378	41005	41574	40058
70-74	30835	31266	29921	58546	59356	57022
75-79	53209	54601	50214	84847	85197	84366
80-84	93108	95842	87405	123047	125661	118420
85+	176593	185352	163457	196481	201235	188617

From ages 25-75 the transition years exhibit higher male mortality than the 1989 Soviet Census (Table 3). Ages 15-70 and 85+ even have higher male morality than the 1979 Census suggesting no real gain in reducing male morality over several decades except with children and some older groups. Further, males ages 35-50 continue to have higher mortality than the Soviet era even in period four. For females (Table 4), the brackets where the transition mean rate exceeds the 1989 Soviet mean rate tend to be in urban areas with all numbers lower than males. A comparison with the 1979 census is similar with only the oldest age brackets suggesting lower mortality in the Soviet era compared to the second and third time periods. Unlike males, female rates finally fall below Soviet rates in period four consistently across age brackets except for the very old. Infant mortality (age 0-1 in both Tables 3 and 4) plateaus in the early transition but then steadily falls for both sexes illustrating real success in reducing this indicator of overall public health.

Table 3. Mean NOA death rate for males across age brackets and time

	Transition Era								
Ages	1989-1998			1999-2008			2009-2019		
	Overall	Urban	Rural	Overall	Urban	Rural	Overall	Urban	Rural
0-1	19642	18691	21734	12885	12995	12708	9535	9018	10495
1-4	922	822	1127	697	704	685	350	356	348
5-9	394	390	402	413	522	251	190	171	220
10-14	479	501	435	533	616	401	249	222	291
15-19	1355	1383	1287	1180	1343	827	657	617	727
20-24	2415	2124	3471	2162	2201	2069	1328	1190	1594
25-29	4599	4340	5259	4186	4392	3806	2279	2236	2351
30-34	5997	6231	5538	5972	6205	5536	3715	3846	3495
35-39	7796	7989	7435	8244	8344	8067	5361	5385	5320
40-44	10261	10717	9273	10655	11211	9675	7250	7262	7220
45-49	14700	14511	15160	14837	15673	13294	9501	9347	9784
50-54	19054	18505	20328	18927	19158	18452	13464	13758	12996
55-59	24884	25132	24385	23980	24678	22557	17546	17820	17080
60-64	33791	33531	34248	32253	32688	31448	25077	24872	25401
65-69	45701	46867	43485	44060	45161	42392	33960	33502	34820
70-74	64097	65428	61190	63141	64829	60376	49322	48862	50185
75-79	92586	91973	93994	90411	91767	87813	72754	73064	72479
80-84	134592	133767	137145	131224	138298	117416	105117	106804	102310
85+	215147	214719	216552	220098	224887	211302	158042	167475	142597

Table 3. continued

	Soviet Era (Census yr. only)		
Ages	1970 Overall	1979 Overall	1989 Overall
0-1yrs	30652	24260	18592
1-4yrs	882	1211	1220
5-9yrs	291	579	468
10-14yrs	419	463	545
15-19	746	986	1142
20-24	1604	1749	1730
25-29	2571	2376	2823
30-34	3424	4269	3894
35-39	4696	5192	5153
40-44	6341	7850	6888
45-49	7455	9563	9061
50-54	12221	13526	14888
55-59	14875	20129	20306
60-64	24828	24760	27195
65-69	32560	37010	40443
70-74	53352	61419	55015
75-79	68766	89437	92322
80-84	93813	131213	138165
85+	142578	169649	202054

Table 4. Mean death rate for females across age brackets and time

	Transition Era								
Ages	1989-1998			1999-2008			2009-2019		
	Overall	Urban	Rural	Overall	Urban	Rural	Overall	Urban	Rural
0-1yrs	14213	14974	12780	9382	9197	9750	7127	6818	7698
1-4yrs	642	580	767	469	496	422	283	230	381
5-9yrs	346	303	425	407	521	238	148	163	122
10-14yrs	266	236	323	445	610	186	120	124	114
15-19	508	507	513	391	402	374	247	241	254
20-24	794	801	774	624	630	617	468	419	548
25-29	970	988	933	931	1021	753	514	534	476
30-34	1292	1268	1343	1184	1212	1128	814	839	769
35-39	1587	1576	1618	1570	1770	1164	1136	1146	1120
40-44	2314	2258	2493	2370	2546	1993	1664	1662	1669
45-49	3880	3930	3678	3284	3492	2818	2374	2552	2029
50-54	5358	5254	5620	5003	5133	4670	3544	3750	3146
55-59	8080	8166	7873	6968	6848	7262	5433	5596	5074
60-64	13176	13503	12486	11072	11342	10479	8346	8263	8530
65-69	21434	21799	20630	19224	19615	18515	13306	13270	13389
70-74	36014	37046	33666	33790	34316	32868	23439	23240	23837
75-79	58815	61166	53204	57601	59710	53488	44119	43987	44520
80-84	102981	107627	92853	96544	99260	91078	81008	82021	79114
85+	173881	188468	154608	201562	206330	193560	156358	163450	144136

Table 4. continued

Ages	1970 Overall	1979 Overall	1989 Overall
0-1yrs	20875	23626	13900
1-4yrs	1032	1430	725
5-9yrs	233	624	271
10-14yrs	384	261	340
15-19	575	536	417
20-24	551	524	584
25-29	1006	628	845
30-34	1132	1113	1047
35-39	1354	1457	1452
40-44	2087	2255	1995
45-49	3197	2903	3405
50-54	4039	5147	4963
55-59	6472	7207	6758
60-64	9558	9539	12130
65-69	18011	19440	20426
70-74	30526	33377	33375
75-79	46921	52200	56868
80-84	65319	91343	93778
85+	116534	131723	152991

In 1989-1998, urban mortality was higher for female infants and 70+ women. For men with relatively higher rates, rural infant mortality was higher than urban but older brackets show no clear rural/urban differences. In 1999-2008, both male and female urban mortality was higher than 1989. Finally, in the third period mortality falls below 1989, but now rural mortality is higher than urban for both sexes with cardiovascular disease deaths higher in rural than urban areas in 2010 (Badov, 2015) with ischemic heart disease disproportionally to blame. Across NOA in 2010, men and women died about equally from cancer with cancer deaths little changed from the late Soviet era. Women tend to die from cancer more often than men in urban areas while just the opposite happens in rural areas (Badov, 2015). The third leading cause of death in 2010 is from external (not from a disease) causes which include excessive alcohol use, suicide, homicide, and injuries while using transportation. One in ten men die while using transportation while only 3% of women do. From 1985 to 2010, external cause death overall is little changed but within this category the number dying while using transportation is much higher while dying at home is lower. Part of this rotation is from the explosion of car availability relative to the Soviet era and a cavalier attitude toward wearing a seat belt. Six percent of deaths are from digestive diseases in 2010 with men dying twice as much as women in this category with totals higher than in the Soviet era. While respiratory and infectious diseases do not constitute the cause of most deaths, one of them – tuberculosis – continues to be a problem with men dying three times more than women from this regardless of whether they are in an urban or rural area (Badov, 2015).

At a more disaggregated level, one can examine causes of death in more detail where for a given location (urban or rural) and gender most age bracket/year cells are nonzero. Further, we need that cause of death to have at least two groups where this is true so that we can look at the mortality ratio between them. Those categories with a lot of zeros of course represent success at minimizing mortality from that cause. The tables that categorize the causes of death are available upon request.[1] We summarize the content by focusing on the ratio by gender of rural to

[1] An appendix of tables is available upon request. The categories of causes of death that have enough nonzero data across gender, some age brackets and rural/urban location 1999-2019 to do relative comparisons are: stomach cancer, colon cancer, trachea and lung cancer, breast cancer, prostate cancer, acute myocardial infarction and subsequent complications, atherosclerotic heart disease, other forms of chronic ischemic heart disease, other forms of acute ischemic heart disease, other forms of heart disease, intracerebral hemorrhage, cerebral infarction, stroke not specified as hemorrhage or infarction, pneumonia, other chronic obstructive pulmonary disease, fibrosis and cirrhosis of liver, senility, injuries to the head, poisoning, infant respiratory & hemorrhagic disorders & congenital anomalies of the heart.

urban mortality for a given age bracket in four different transition era periods of time. First, the overall 1999-2019 period, second 1999-2008, third the 2009-2014 period prior to sanctions and a significant drop in the price of oil, and fourth the remaining 2015-2019 years available at the time of this study. We include the table on stomach cancer as a cause of death directly in the text (Table 5) to illustrate the descriptive results. For the rural male over urban male ratio, most numbers are close to one which means men over 50 die of stomach cancer about equally in urban and rural areas. While rural men in the 75-79 age bracket in 2015-2019 die of stomach cancer at a much higher rate than urban men (2.32), the ratio reverses to 0.40 for the same period for the 85+ age bracket. With stomach cancer, there is no clear improvement in urban vs rural health for men. Rural males compared to rural females however shows ratios closer to 2 than one with some as high as four indicating rural men have much higher stomach cancer mortality than rural women. Finally, rural women and urban women have ratios close to one indicating little differences for women by location. Therefore, men have higher mortality from stomach cancer which is most prevalent over age 50 in the region.

Table 5. Age-adjusted male/female mortality ratio

Ages	1970	1979	1989	1989-1999	2000-2009	2010-2019
0-1yrs	1.4684	1.0268	1.3376	1.3742	1.4515	1.3776
1-4yrs	0.8547	0.8469	1.6828	1.6838	2.1637	1.2652
5-9yrs	1.2489	0.9279	1.7269	1.1700	1.2582	1.5573
10-14	1.0911	1.7739	1.6029	2.2488	3.2452	2.8008
15-19	1.2974	1.8396	2.7386	2.8187	3.2564	3.1839
20-24	2.9111	3.3378	2.9623	3.4247	3.4045	3.0670
25-29	2.5557	3.7834	3.3408	5.1496	4.9714	4.3307
30-34	3.0247	3.8356	3.7192	4.7678	5.2431	4.6492
35-39	3.4682	3.5635	3.5489	4.7984	5.5538	4.6751
40-44	3.0383	3.4812	3.4526	4.5552	4.4665	4.4614
45-49	2.3319	3.2942	2.6611	3.8222	4.6690	4.0703
50-54	3.0257	2.6279	2.9998	3.6071	3.7425	3.8943
55-59	2.2984	2.7930	3.0047	3.0958	3.4731	3.2364
60-64	2.5976	2.5957	2.2420	2.5487	3.0032	2.9858
65-69	1.8078	1.9038	1.9800	2.1450	2.3282	2.5839
70-74	1.7478	1.8402	1.6484	1.7908	1.8891	2.1437
75-79	1.4656	1.7134	1.6234	1.5713	1.5704	1.6748
80-84	1.4362	1.4365	1.4733	1.3159	1.3545	1.3026
85+	1.2235	1.2879	1.3207	1.2462	1.0738	1.0130

Colon cancer starting at age 60 impacts urban women much more than rural women. In turn, urban males over 60 have higher relative mortality than urban women with little improvement over time. Trachea and lung cancer impacts urban and rural males about equally from age 45 on and across time. Rural males have strikingly higher mortality from this type of cancer relative to rural women perhaps reflecting reduced smoking by rural women still in this remote region unlike other parts of Russia (Ogloblin and Brock, 2011). Starting at age 35, breast cancer impacts urban women more than rural women consistently across age brackets and time.

For acute myocardial infarction and complications, urban males have higher mortality than rural males across all time periods and most age brackets starting at age 40. Rural males have higher rates than rural females especially in the recent years and ages 55-75. Urban males have a similar pattern but starting earlier at age 40. The only age bracket where male and female mortality are similar for this cause of death is 85 and older. Atherosclerotic heart disease follows a similar pattern with urban males having the highest mortality. Other forms of chronic ischemic heart diseases also have higher male mortality, but rural males over 80 have much higher mortality in the early 1999-2008 period while younger (45-64) males have lower relative mortality. This reverses by 2015-2019 with over 80 rural males' now lower and younger ages higher. These trends impact the overall period results with relative male mortality getting higher in rural areas as age increases. Though female mortality is lower absolutely and relative to men, much higher relative rural female mortality 1999-2008 reverses by 2015-2019 to much higher urban female mortality for this type of heart disease.

The category “other forms of acute ischemic heart diseases” shows ever increasing rural male mortality from age 30 up to 85+ in both the overall and first period. The lowering of the ratio in some age brackets by the fourth period suggests some progress in lowering this cause of male death in rural areas over the 20 years. Very high ratios including a few in double digits makes this heart problem especially dangerous for rural males relative to rural females though rural females have much higher mortality than urban females unlike some other heart disease categories. A final category “other forms of heart disease” shows rural males having the highest relative mortality of any gender/location group and from age 30 on relative to urban males much higher rates in the middle ages with little change over time. Rural females have slightly higher mortality than urban females.

Starting at age 40 for men, having a stroke impacts mortality about equally between rural and urban areas. Rural men have higher mortality due to stroke at much higher levels than rural women in middle ages with equality only for the 85+ age group. Older urban women have lower stroke mortality than rural women and by 2015-2019 across all ages starting at age 55. Urban males die from pneumonia at higher rates than rural males across almost all ages starting at 25 and time periods. The only exception is infant mortality due to pneumonia in 2009-2014 when rural mortality was much higher. Female deaths are quite low with little data to compare with men. Liver problems impact rural and urban men about equally which is expected given the drinking is ubiquitous.

Infant respiratory, hemorrhagic disorders, and congenital anomalies of the heart (males only) are mostly worse for male mortality in rural areas over time. For the first two, rural males have higher mortality than rural female infants. Rural female infants have higher mortality for respiratory problems but are about equal to urban female infants for hemorrhagic disorders. Infant mortality remains high despite long term success compared to the 20th century (Gurieva, 2017). Finally, male head injury and poisonings mortality shows about equal rates between urban and rural areas. These two types of “external cause” mortality are prevalent enough to yield age bracket nonzero data going back to age 15 and extending up to 80 years of age suggesting a lot of male mortality across many ages for these two causes which is unusual. We turn now to all-cause mortality aggregate data.

3. Method

Sigma and beta convergence theory used in the growth literature is applied to mortality to see how all-cause age adjusted deaths changed. Convergence in fertility rates in Russia has also been examined in a similar way (Sinitsa, 2018). Sigma convergence is simply a decline in the coefficient of variation (standard deviation divided by mean) over time and, thanks to the detail in the NES database, over age brackets as well with either the year or age bracket held constant. Both types of convergence are compared across four gender/location (ex. rural females) groups. For a given age bracket (ex. infant mortality) a priori we hypothesize lower variation in urban areas where health care is often better and more available. Given the well documented male mortality in many younger age brackets in Russia, variation for males is hypothesized to be lower than for females as well. For a given year, death rates are hypothesized to have greater variation for females than males as females are more likely to have a zero value in middle age brackets than males. Superior urban health care suggests variation will be higher in urban areas relative to rural ones as well suggesting urban females would have the highest variation of any of the four groups. The higher a given group’s income is the lower the chances that the group will be exposed to a wide array of risk factors for poor health outcomes. Over time, variation in general should increase if the health system is lowering middle age mortality for both sexes towards zero and high death rates are increasingly only found in older age brackets like developed countries.

Beta convergence examines performance relative to an initial value over time only. Divergence away from an initial Soviet era year’s level is expected if health care in NOA improves over time. Absolute beta convergence would be found be simply comparing the initial year with logarithmic changes in the death rate over time. Conditional beta convergence includes control variables that might influence mortality. We include both a time trend and life expectancy at birth in a given year to control for improvements in the health system. The time trend like in production functions serves as a proxy for technological progress. The standard beta convergence equation is then:

$$Ln(y_{i,t} - y_{i,0})/T = \beta_0 Trend + \beta_1 Ln(y_{i,0}) + \beta_2 LE_{i,t} + \varepsilon_{i,t} \quad (1)$$

where “y” is the age adjusted death rate with subscript “i” for an age bracket, “t” for a given year and “T” the value of the entire time period. As the initial year is a fixed value on the right-hand side, the constant term is suppressed to avoid collinearity. We expect β0 and β_2 to be negative as lower death rates over 30 years would be expected in general as health systems and medical knowledge improves. If “β_1” is negative, then the death rate is converging towards an initial year’s value. A priori, we expect “β_1” to be positive indicating a divergence down from an initial year’s value controlling for changes in life expectancy at birth and a trend. The three initial years we use are two Soviet census years (1970 and 1989) and one NES year (1990). We look at all-cause mortality for both sexes regardless of location using the two Soviet years and all-cause mortality for both sexes and location (rural vs urban) using 1990.

In the literature, there is support for these hypotheses. For example, across all districts in Russia there is evidence of improvements in lowering the infant mortality rate (Timonin *et al.* 2020). Middle age groups for males are uncertain as the inclusion of the 1990s when their mortality rose could cause divergence towards higher levels of mortality than the Soviet era while middle age females are hypothesized to diverge lower. After 2000, divergence should be lower if male mortality improves. Divergence at older ages defined as 60 and over following a recent study using the NES dataset (Khvan *et al.* 2020) is also expected.

Finally, to examine any narrowing of the gender mortality gap over time, we look at the ratio of age-adjusted male/female mortality rates across time and age brackets (Tables 6) as is done for other countries (Rosella *et al.* 2016). If the ratio is greater than one, male mortality exceeds female mortality and if less than one vice-versa. In North Ossetia like Russia in general, the ratio of age-adjusted all-cause mortality rates illustrates the huge gender mortality gap especially in middle ages across all age groups and five decades. There is very little evidence of female mortality exceeding male mortality in any year and over time such a year is averaged out. Looking at an urban/rural split (table available upon request) over the past post-Soviet thirty years, the high middle age male mortality becomes more like female mortality over age 60 but never enough to drop the ratio well below one.

4. Results

Across age brackets (Table 7), we find the greatest variation with urban females which tends to be higher or close to rural females. Urban females also have higher variation than urban males which in turn have lower variation than rural females except in the youngest brackets. Urban and rural males have similar variation after age 20. We reject the hypothesis of lower male variation due to greater middle age mortality but do find in very young ages much greater urban variation than rural areas for both sexes. Using aggregate death rates that include both urban and rural areas, we find male and female variation is quite similar and declines steadily after age 15. Sigma convergence by age bracket and location therefore reveals better health in urban over rural areas in NOA, but without any gender differential. Better health in urban areas is supported by the literature indicating good health is a consequence of favorable economic status (Suhrcke *et al*. 2007) and vice versa poor economic development generally leads to poor health (Sala-i-Martin, 2005). This health-wealth ‘gradient’ (Deaton, 2002; Marmot, 2004) assumes that there is a gradual relationship between improving health and wealth as health improves with income throughout the income distribution with income higher in urban NOA than rural NOA.

Table 7. Sigma convergence across time (1989-2019) for a given age bracket

Age Bracket	Rural Women	Urban Women	Rural Men	Urban Men	All Women	All Men
0-1yrs	0.363	0.427	0.388	0.394	0.366	0.364
1-4yrs	0.602	0.634	0.622	0.532	0.512	0.489
5-9yrs	0.694	1.417	0.625	1.115	0.938	0.768
10-14yrs	0.887	2.154	0.457	1.004	1.606	0.683
15-19	0.695	0.527	0.435	0.555	0.460	0.434
20-24	0.447	0.450	0.447	0.403	0.385	0.360
25-29	0.511	0.429	0.484	0.385	0.398	0.380
30-34	0.439	0.281	0.306	0.311	0.286	0.294
35-39	0.254	0.277	0.240	0.286	0.231	0.258
40-44	0.346	0.270	0.244	0.276	0.238	0.250
45-49	0.373	0.290	0.239	0.281	0.279	0.254
50-54	0.319	0.195	0.243	0.216	0.211	0.214
55-59	0.274	0.223	0.210	0.216	0.217	0.206
60-64	0.216	0.223	0.177	0.173	0.206	0.165
65-69	0.237	0.227	0.139	0.178	0.221	0.154
70-74	0.195	0.227	0.138	0.160	0.211	0.143
75-79	0.119	0.173	0.163	0.131	0.151	0.130
80-84	0.133	0.136	0.163	0.154	0.129	0.139
85+	0.191	0.121	0.225	0.175	0.140	0.176

Comparing dispersion across age brackets for each year, a striking result is overall male variation regardless of location is unchanged over 50 years (Table 8). The 1979 Soviet era variation is almost exactly the same as the 2015 variation for example. On the other hand, the overall female variation is considerably higher in the transition era with every year exceeding the last Soviet census year of 1989 starting in 1995. NOA mortality improves more for women than men in the transition era. Urban female variation is slightly higher than rural women but they both increase substantially. Urban male variation is slightly higher than rural male variation but both groups are well below either female group. Though we do not have a Soviet era data point for separate urban and rural groups, the 1989 NES year compared to 2019 shows over 30 years little change in male variation while substantial change in female variation regardless of location. One cause is the middle age male mortality not falling to a very low amount near zero as it has for women. Unlike the other type of sigma dispersion, the improved relative health is better by gender not by location.

Table 8. Sigma convergence across age brackets in a given year

Year	Rural Women	Urban Women	Rural Men	Urban Men	All Women	All Men
1970					1.728	1.454
1979					1.757	1.512
1989					1.868	1.611
1989	1.709	1.939	1.546	1.653	1.845	1.612
1990	1.794	1.930	1.518	1.689	1.864	1.623
1991	1.712	1.896	1.619	1.541	1.821	1.567
1992	1.799	1.930	1.591	1.514	1.870	1.550
1993	1.946	2.007	1.634	1.513	1.977	1.556
1994	1.796	1.922	1.574	1.515	1.860	1.533
1995	1.921	1.946	1.461	1.441	1.927	1.443
1996	1.909	1.960	1.462	1.550	1.942	1.514
1997	1.997	1.951	1.411	1.454	1.963	1.439
1998	2.011	1.929	1.494	1.421	1.954	1.445
1999	1.991	2.022	1.646	1.509	2.007	1.550
2000	2.024	2.054	1.415	1.544	2.040	1.502
2001	2.113	2.086	1.629	1.503	2.090	1.541
2002	2.008	2.066	1.575	1.602	2.043	1.590
2003	2.095	2.089	1.507	1.597	2.088	1.564
2004	2.091	1.984	1.500	1.548	2.018	1.533
2005	2.226	2.147	1.601	1.707	2.172	1.674
2006	2.180	2.086	1.622	1.543	2.118	1.569
2007	2.140	2.138	1.738	1.477	2.139	1.555
2008	2.058	2.146	1.537	1.653	2.115	1.614
2009	2.105	2.103	1.549	1.540	2.104	1.542
2010	2.061	2.101	1.511	1.626	2.087	1.588
2011	1.949	2.106	1.560	1.639	2.052	1.610
2012	2.064	2.101	1.518	1.582	2.087	1.559
2013	2.108	2.166	1.466	1.602	2.147	1.554
2014	2.058	2.136	1.522	1.555	2.106	1.542

Table 8. continued

Year	Rural Women	Urban Women	Rural Men	Urban Men	All Women	All Men
2015	2.115	2.131	1.474	1.510	2.124	1.495
2016	1.961	2.232	1.530	1.696	2.133	1.629
2017	2.049	2.157	1.462	1.599	2.116	1.545
2018	2.111	2.252	1.475	1.619	2.201	1.562
2019	2.086	2.181	1.461	1.634	2.142	1.561

Beta divergence is clearly observed when the initial year is 1970 (Table 9). In no age bracket is there a statistically significant and negative coefficient on β_1. Improved technology proxied by a trend term and higher life expectancy at birth exhibit negative coefficients as hypothesized. Lower death rates in 2019 than 1970 are evident indicating downward divergence over half a century. With women, this is the case with two exceptions. In the oldest female brackets (80-84 and 85+) the 1970 death rate is lower than the 2019 rate so while the female 85+ coefficient is insignificant, the 80-84 positive and significant female coefficient indicates worsening of mortality for just this one age bracket over the very long run. For men, only two age brackets (45-49 and 60-64) have higher death rates in 2019 compared to 1970, so mortality has worsened for just these two brackets (upward divergence). To see if 2019 was an exceptional year, we looked at 2015 and found all age brackets 30-60 as well as three older ones all had higher death rates than 1970 suggesting real improvement in male mortality is quite recent in NOA and still a problem on the eve of the pandemic.

Table 9. Conditional beta convergence across age brackets with 1970 as initial year

Ages	**Male**				**Female**			
	Trend	InitialDR	LifeExp.	adj. Rsq	Trend	InitialDR	LifeExp.	adj. Rsq
0-1y	-0.0001	0.013	-0.0012		0.0001	0.0017	-0.0020	
t.stat	-0.18	0.34	**-2.1**	0.95	0.19	0.03	-1.6	0.91
1-4y	-0.0004	0.1336	-0.0022		-0.0001	0.0414	-0.0018	
	-0.86	1.08	-1.85	0.62	-0.15	0.29	-0.75	0.80
5-9y	-0.0013	0.4568	0.0003		-0.0004	0.2076	-0.0038	
	-2.63	**2.81**	0.24	0.35	-0.65	1.01	-1.43	0.35
10-14y	-0.0003	0.1211	-0.0020		0.0010	-0.2499	-0.0074	
	-0.69	0.9	-1.69	0.34	1.07	-0.9	-1.9	0.54
15-19	-0.0004	0.1491	-0.0027		0.0004	-0.0625	-0.0052	
	-1.42	1.88	**-3.64**	0.81	1.01	-0.59	**-3.26**	0.76
20-24	-0.0003	0.0916	-0.0024		0.0003	-0.0460	-0.0051	
	-1.04	1.48	**-3.68**	0.75	0.86	-0.42	**-3.13**	0.47
25-29	-0.0003	0.1010	-0.0032		-0.0001	0.0622	-0.0028	
	-1.54	**2.27**	**-6.28**	0.91	-0.29	0.66	-1.82	0.56
30-34	-0.0002	0.0674	-0.0028		-0.0001	0.0456	-0.0024	
	-1.51	**2.5**	**-8.78**	0.96	-0.24	0.64	**-2.02**	0.39
35-39	-0.0001	0.0326	-0.0027		0.0002	-0.0287	-0.0036	
	-0.51	1.68	**-11.22**	0.98	1.6	-0.79	**-5.76**	0.75
40-44	0.0002	-0.0155	-0.0031		0.0003	-0.0477	-0.0033	
	1.96	-0.83	**-12.95**	0.98	1.29	-0.88	**-3.37**	0.41
45-49	-0.0005	0.1261	-0.0018		-0.0001	0.0453	-0.0029	
	-3.74	**4.58**	**-5.21**	0.97	-0.36	1.03	**-3.39**	0.66
50-54	0.0001	0.0154	-0.0023		-0.0005	0.1350	-0.0009	
	0.07	0.72	**-7.97**	0.95	**-3.74**	**4.64**	-1.64	0.85
55-59	-0.0002	0.0596	-0.0019		-0.0001	0.0476	-0.0023	
	-2.62	**3.69**	**-8.46**	0.98	-0.75	1.5	**-3.41**	0.73
60-64	-0.0002	0.0530	-0.0012		-0.0006	0.1375	-0.0008	
	-3.03	**3.88**	**-6.04**	0.95	**-5.97**	**7.26**	-1.87	0.92
65-69	-0.0003	0.0668	-0.0010		-0.0002	0.0647	-0.0020	
	-4.44	**5.31**	**-5.1**	0.96	**-2.39**	**3.62**	**-4.71**	0.87
70-74	-0.0003	0.0525	-0.0007		-0.0002	0.0586	-0.0019	
	-4.51	**5.31**	**-4.55**	0.93	**-3.34**	**5.14**	**-6.98**	0.94
75-79	-0.0005	0.0879	-0.0002		-0.0002	0.0485	-0.0015	
	-6.13	**6.73**	-0.91	0.94	**-3.16**	**4.75**	**-5.84**	0.95
80-84	-0.0004	0.0803	-0.0005		-0.0005	0.0953	-0.0009	
	-5.29	**5.98**	**-2.47**	0.95	**-6.86**	**8.55**	**-2.93**	0.98
85+	-0.0005	0.0933	-0.0007		0.0002	-0.0105	-0.0030	
	-5.77	**6.53**	**-2.77**	0.96	**2.09**	-0.8	**-8.43**	0.98

Note: Bold indicates significance at 5%

Before concluding that mortality has worsened in a few age groups in the transition era, one must consider any worsening of mortality in the Soviet era after 1970. We therefore reran the beta convergence with 1989 as the initial year (Table 10). With women we again find divergence except for the ages 10-14 bracket where there is statistically significant convergence. As all female death rates are lower in 2019 than 1989 with the 10-14 age bracket much lower, we interpret this as recent years in this age bracket only are close to the 1989 level for an unknown reason. Therefore, the 1989 initial year results support the 1970 initial year results for women with lower mortality in the transition era across age brackets with one exception. For men, the 2019 death rate is lower than 1989 except for the 45-49 age bracket. All brackets are diverging except three – 1-4, 50-54, and 80-84 – with statistically significant convergence. Like the one female age bracket, these three brackets have not improved in the 30 years. Overall, however, male mortality has improved in the transition era relative to the Soviet era especially if one looks at 1989 instead of 1970.

Table 10. Conditional beta convergence across age brackets with 1989 as initial year

Ages	**Male**				**Female**			
	Trend	InitialDR	LifeExp.	ad. Rsq	Trend	InitialDR	LifeExp.	ad. Rsq
0-1y	-0.003	0.553	0.000		0.005	-0.837	-0.024	
t.stat	**-2.57**	**2.78**	-0.08	0.394	**2.08**	-1.96	**-2.53**	0.214
1-4y	0.0191	-4.9627	-0.0444		-0.019	5.6288	0.0568	
	6.84	**-6.83**	**-5.92**	0.732	**-5.05**	**5.18**	**3.61**	0.484
5-9y	-0.005	1.454	0.008		-0.003	1.115	0.002	
	-3.43	**3.47**	**2.22**	0.354	-1.45	1.63	0.26	0.113
10-14y	-0.004	1.247	0.003		0.021	-6.157	-0.073	
	-2.66	**2.79**	0.85	0.252	**6.6**	**-6.64**	**-5.53**	0.729
15-19	-0.003	0.949	-0.004		-0.006	2.137	0.004	
	-2.01	**2.27**	-1.05	0.561	**-3.36**	**3.81**	0.48	0.627
20-24	-0.008	2.105	0.007		-0.003	0.900	-0.006	
	-4.2	**4.4**	1.43	0.616	-1.11	1.4	-0.6	0.379
25-29	0.0015	-0.2484	-0.0137		-0.007	1.9507	0.0140	
	0.89	-0.66	**-3.12**	0.402	**-4.29**	**4.59**	**2.08**	0.520
30-34	-0.008	1.839	0.007		-0.003	0.931	0.003	
	-7.32	**7.68**	**2.31**	0.859	**-2.53**	**2.84**	0.49	0.423
35-39	-0.006	1.366	0.004		-0.004	0.983	0.001	
	-8.87	**9.37**	**2.27**	0.915	**-5.12**	**5.86**	0.44	0.854
40-44	-0.001	0.2118	-0.0076		-0.001	0.1014	-0.0084	
	-0.81	1.22	**-3.45**	0.791	-0.03	0.24	-1.13	0.181
45-49	-0.008	1.748	0.010		-0.003	0.673	-0.0009	
	-5.91	**6.13**	**2.68**	0.734	**-2.67**	**3.14**	-0.23	0.599
50-54	0.003	-0.591	-0.013		-0.002	0.433	0.001	
	4.22	**-3.95**	**-6.29**	0.585	**-2.53**	**2.84**	0.44	0.367
55-59	-0.001	0.070	-0.006		-0.003	0.592	-0.001	
	-0.2	0.54	**-3.26**	0.657	**-3**	**3.54**	-0.35	0.706
60-64	-0.001	0.2883	-0.0018		0.0001	0.0304	-0.0053	
	-2.73	**3.07**	-1.28	0.706	0.09	0.25	**-2**	0.362
65-69	-0.001	0.247	-0.001		0.002	-0.219	-0.012	
	-3.31	**3.67**	-0.97	0.705	1.58	-1.29	**-2.99**	0.279
70-74	-0.003	0.569	0.004		-0.001	0.119	-0.004	
	-8.28	**8.59**	**3.69**	0.816	-1.62	**2.49**	**-3.38**	0.773
75-79	-0.001	0.0896	-0.0005		0.0005	-0.0483	-0.0065	
	-1.55	1.73	-0.64	0.301	1.06	-0.63	-3.27	0.428
80-84	0.003	-0.383	-0.008		-0.004	0.720	0.009	
	2.44	**-2.36**	**-2.89**	0.184	**-7.94**	**8.46**	**4**	0.834
85+	-0.001	0.219	0.0001		0.001	-0.089	-0.011	
	-2.86	**3.07**	0.07	0.440	1.53	-0.99	**-4.23**	0.761

Note: Bold indicates significance at 5%.

Looking only at the transition era, downward divergence across both gender and rural/urban areas is the norm. In urban areas only, male beta divergence happens in the majority of age brackets with only the 1-4, 5-9 and 80-84 age brackets having statistically significant convergence to the 1990 level (Table 11). As all but the 20-24 age bracket have death rates in 2019 lower than the 1990 rate across brackets there is general improvement. For urban women, there is divergence except for the 10-14 and 40-44 age brackets with lower death rates in all brackets in 2019 relative to 1990 indicating improvement over 30 years. In rural areas, results are much more mixed with 5 male age brackets having statistically significant convergence and 10 female brackets showing convergence as well (Table 12). 4 female death rates in 2019 are higher than in 1990 including infants and the oldest 85+ bracket. The fact that even female infant mortality is above 1990 in 2019 suggests rural female mortality has not followed other regions where infant mortality decline is one area where mortality has improved in Russia during the transition. Rural male beta convergence is also statistically significant in 5 age brackets with two of them (10-14 and 40-44) having higher death rates in 2015 and 2019 relative to 1990. For both genders, rural areas in NOA have struggled to move to lower mortality during the transition era though male infant mortality is at least following the cross-regional trend downward over 30 years.

Table 11. Conditional beta convergence across urban age brackets with 1990 as initial year

Ages		**Male**		adj.		**Female**		adj.
	Trend	InitialDR	LifeExp.	Rsq	Trend	InitialDR	LifeExp.	Rsq
0-1y	0.0008	-0.0674	-0.0126		-0.0004	0.1295	-0.0059	
	0.41	-0.19	-1.64	0.16	-0.22	0.39	-0.83	0.16
1-4y	0.0253	-6.3137	-0.0709		-0.0038	1.3063	-0.0074	
	3.7	**-3.82**	**-2.64**	0.50	-0.83	1.03	-0.42	0.17
5-9y	0.0298	-8.1653	-0.1278		-0.0144	4.6927	0.0419	
	3.6	**-3.48**	**-3.94**	0.40	-1.65	1.69	1.22	0.00
10-14y	-0.0314	10.6740	0.0619		0.0168	-4.8674	-0.0655	
	-3.75	**4**	1.88	0.46	**2.49**	**-2.45**	**-2.48**	0.39
15-19	-0.0045	1.4227	-0.0053		-0.0119	3.8092	0.0221	
	-1.91	**2.3**	-0.57	0.61	**-4.31**	**4.62**	**2.04**	0.57
20-24	0.0004	0.0596	-0.0166		-0.0174	5.1888	0.0470	
	0.18	0.1	-1.77	0.41	**-3.73**	**3.86**	**2.56**	0.42
25-29	-0.0033	0.8953	-0.0061		-0.0043	1.2448	0.0027	
	-2.16	**2.67**	-1.01	0.72	**-2.49**	**2.8**	0.4	0.45
30-34	-0.0114	2.5797	0.0225		-0.0128	3.3540	0.0335	
	-6.75	**7.2**	**3.4**	0.83	**-5.28**	**5.48**	**3.53**	0.59
35-39	-0.0089	2.0079	0.0128		-0.0062	1.6861	0.0083	
	-7.71	**8.42**	**2.81**	0.91	**-7.6**	**8.33**	**2.58**	0.91
40-44	-0.0050	1.1397	0.0011		0.0088	-1.9513	-0.0362	
	-5.63	**6.46**	0.31	0.92	**3.5**	**-3.4**	**-3.68**	0.26
45-49	-0.0065	1.3535	0.0090		-0.0130	3.1059	0.0269	
	-6.15	**6.73**	**2.16**	0.86	**-8.96**	**9.53**	**4.73**	0.88
50-54	0.0019	-0.2913	-0.0127		-0.0055	1.1792	0.0133	
	1.37	-1.17	**-2.34**	0.23	**-4.23**	**4.42**	**2.62**	0.47
55-59	-0.0002	0.1029	-0.0071		0.0007	-0.0680	-0.0100	
	-0.24	0.62	-1.92	0.54	0.47	-0.24	-1.75	0.23
60-64	-0.0006	0.1545	-0.0056		-0.0018	0.3881	0.0005	
	-0.63	1	-1.56	0.51	**-2.78**	**3.17**	0.2	0.52
65-69	-0.0056	0.9858	0.0115		-0.0021	0.4204	-0.0001	
	-6.58	**7**	**3.44**	0.78	**-4.09**	**4.73**	-0.07	0.75
70-74	-0.0030	0.5155	0.0045		-0.0010	0.2064	-0.0019	
	-7.06	**7.68**	**2.71**	0.83	**-2.87**	**3.55**	-1.4	0.75
75-79	0.0004	-0.0419	-0.0054		-0.0016	0.3033	-0.0001	
	0.77	-0.47	**-2.37**	0.29	**-3.9**	**4.52**	-0.08	0.76
80-84	0.0040	-0.5813	-0.0157		-0.0049	0.7802	0.0107	
	3.13	**-3.08**	**-3.11**	0.27	**-7.43**	**7.85**	**4.16**	0.79
85+	-0.0021	0.2996	0.0057		-0.0006	0.1230	-0.0027	
	-1.85	1.9	1.31	0.04	-1.1	1.49	-1.22	0.67

Note: Bold indicates significance at 5%.

Table 12. Conditional beta convergence across rural age brackets with 1990 as initial year

Ages	Male			adj.	Female			adj.
	Trend	InitialDR	LifeExp.	Rsq	Trend	InitialDR	LifeExp.	Rsq
0-1y	0.0008	-0.0674	-0.0126		-0.0004	0.1295	-0.0059	
	0.41	-0.19	-1.64	0.16	-0.22	0.39	-0.83	0.16
1-4y	0.0253	-6.3137	-0.0709		-0.0038	1.3063	-0.0074	
	3.7	**-3.82**	**-2.64**	0.50	-0.83	1.03	-0.42	0.17
5-9y	0.0298	-8.1653	-0.1278		-0.0144	4.6927	0.0419	
	3.6	**-3.48**	**-3.94**	0.40	-1.65	1.69	1.22	0.00
10-14y	-0.0314	10.6740	0.0619		0.0168	-4.8674	-0.0655	
	-3.75	**4**	1.88	0.46	**2.49**	**-2.45**	**-2.48**	0.39
15-19	-0.0045	1.4227	-0.0053		-0.0119	3.8092	0.0221	
	-1.91	**2.3**	-0.57	0.61	**-4.31**	**4.62**	**2.04**	0.57
20-24	0.0004	0.0596	-0.0166		-0.0174	5.1888	0.0470	
	0.18	0.1	-1.77	0.41	**-3.73**	**3.86**	**2.56**	0.42
25-29	-0.0033	0.8953	-0.0061		-0.0043	1.2448	0.0027	
	-2.16	**2.67**	-1.01	0.72	**-2.49**	**2.8**	0.4	0.45
30-34	-0.0114	2.5797	0.0225		-0.0128	3.3540	0.0335	
	-6.75	**7.2**	**3.4**	0.83	**-5.28**	**5.48**	**3.53**	0.59
35-39	-0.0089	2.0079	0.0128		-0.0062	1.6861	0.0083	
	-7.71	**8.42**	**2.81**	0.91	**-7.6**	**8.33**	**2.58**	0.91
40-44	-0.0050	1.1397	0.0011		0.0088	-1.9513	-0.0362	
	-5.63	**6.46**	0.31	0.92	**3.5**	**-3.4**	**-3.68**	0.26
45-49	-0.0065	1.3535	0.0090		-0.0130	3.1059	0.0269	
	-6.15	**6.73**	**2.16**	0.86	**-8.96**	**9.53**	**4.73**	0.88
50-54	0.0019	-0.2913	-0.0127		-0.0055	1.1792	0.0133	
	1.37	-1.17	**-2.34**	0.23	**-4.23**	**4.42**	**2.62**	0.47
55-59	-0.0002	0.1029	-0.0071		0.0007	-0.0680	-0.0100	
	-0.24	0.62	-1.92	0.54	0.47	-0.24	-1.75	0.23
60-64	-0.0006	0.1545	-0.0056		-0.0018	0.3881	0.0005	
	-0.63	1	-1.56	0.51	**-2.78**	**3.17**	0.2	0.52
65-69	-0.0056	0.9858	0.0115		-0.0021	0.4204	-0.0001	
	-6.58	**7**	**3.44**	0.78	**-4.09**	**4.73**	-0.07	0.75
70-74	-0.0030	0.5155	0.0045		-0.0010	0.2064	-0.0019	
	-7.06	**7.68**	**2.71**	0.83	**-2.87**	**3.55**	-1.4	0.75
75-79	0.0004	-0.0419	-0.0054		-0.0016	0.3033	-0.0001	
	0.77	-0.47	**-2.37**	0.29	**-3.9**	**4.52**	-0.08	0.76
80-84	0.0040	-0.5813	-0.0157		-0.0049	0.7802	0.0107	
	3.13	**-3.08**	**-3.11**	0.27	**-7.43**	**7.85**	**4.16**	0.79
85+	-0.0021	0.2996	0.0057		-0.0006	0.1230	-0.0027	
	-1.85	1.9	1.31	0.04	-1.1	1.49	-1.22	0.67

Note: Bold indicates significance at 5%.

5. Conclusion

NOA mortality is above both all-Russian and developed country levels. Like Russia, men live much shorter lives than women in both urban and rural areas. Unlike many other Russian regions, gender and location differences have changed little during the transition in part due to an influx of refugees fleeing violence nearby and slow improvement in overall public health for both sexes. While mortality is lower than the Soviet era in general and life expectancy at birth is higher, some evidence is found for some small groups by age bracket and location of little improvement since 1990 in mortality reduction. For men, drinking continues to cause death through liver problems. Men also are dying across age brackets because of external causes that could be addressed by improved road safety and enforcing seat belt regulations. Such external cause death adds to the perennial problems with cancers and heart issues that the transition has failed to overcome. As in other regions, infant mortality and deaths before age 5 have been much reduced but are unlikely to go much lower without major investments in public neonatal and early childhood health. Such investments are critical as the age structure of the region is getting older with many young people leaving contributing to the depopulation problems found in many of Russia's regions.

Of the four groups by gender and location, urban females have the lowest mortality. Sigma convergence provides one way to quantitatively measure improved performance in the future with the goal being to increase male variation perhaps to the level where the female variation is in 2019. Beta convergence found in a few male middle age brackets and one female would disappear with more statistically significant divergence like the other brackets. Fundamental reforms would be indicated by both sexes would having even greater divergence downward than in the past 30 years which would also eliminate any discussion of the Soviet era being better.

As a few causes of death appear to be worse in urban relative to rural areas (ex. pneumonia), policy could focus on why this is so with perhaps some patients being relocated to different medical facilities outside of Vladikavkaz. Further research would include using statistical data from the 8 rural districts with the rural mortality data to examine both rural mortality and rural economic development along with subjective rural poverty versus absolute poverty (Nivorozhkin *et al.* 2010). South Ossetia which is just beginning to make statistical data available through the Rosstat system could be included as well. While the Georgia border with South Ossetia remains mostly closed, South Ossetian public health will remain highly dependent on improvements in North Ossetia. A companion paper comparing NOA with other Caucasus regions' ability to decrease mortality in middle age brackets and push high mortality to much older brackets is another area of research that is understudied.

As mentioned above, the 2020 mortality data that include the pandemic started to be published during this study. All cause deaths and deaths due to respiratory problems are substantially higher than recent years so evidence of a COVID impact is there. As excess mortality deaths are used as the gold standard by demographers to measure COVID fatalities in general and Russia in particular (Cordell, 2021), this study sets the stage for analysis of COVID in NOA. As COVID is falsely believed to have increased global per capita income inequalities when in fact the opposite has occurred plus richer countries have more deaths per capita than poor ones through 2020 (Deaton, 2021), poorer regions such as NOA may have relatively less COVID mortality than Moscow. Regional economic growth may be necessary but not sufficient for reducing mortality with remote regions a better place to be if the pandemic continues.

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