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Income Related Mortality of Lithuanian Seniors in the Light of Covid-19

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Abstract

Main source of income in retirement in Lithuania is from Ist pillar public system, since IInd pillar is still not mature. Lithuania introduced quasi mandatory IInd pillar in 2004. IInd pillar is based on investments in Individual Accounts and participants who at retirement have accumulated sum higher than set threshold need to purchase pension annuity from Centralized Annuity Provider. Projected mortality level and interest rate are two main factors when pricing annuity. It is well known that income is one of mortality predictors other main predictors being age and sex. Since those retirees who are obliged to purchase annuity (annuitants) are wealthier individuals, they are supposed to live longer than average retired person. During last couple of years mortality in Lithuania increased due to Covid-19 pandemics, however, the question is whether pandemics affected all individuals equally or, on the contrary, impact of mortality shock negatively correlated with wealth of individual. Centralized Annuity Provider started its activities in the mid of 2020 when only first wave of pandemics was in force. This may lead to situation when increased number of deaths will be observed in accumulation stage and annuities will be purchased almost exclusively by those who avoided lethal consequences of pandemics. In such case there will be almost nil effect of mortality shock due to Covid-19 to activities of Centralized Annuity Provider. We analyze mortality data of Lithuanian seniors who all receive pension benefits from Ist pillar and some of them receive pension annuities from Centralized Annuity Provider. We compare income related mortality before Covid-19 and in case of Covid-19 pandemics.

Key words: Covid-19, Income related mortality, Pension annuity.

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1 Introduction

It is agreed almost commonly that mortality differs quite significantly by sex and socio-economic status, mostly defined by education, occupation and income, see, for example, [2], [6] and references therein. It is not so clear, however, which attribute (education, occupation or income) has highest influence on mortality. Moreover, all three variables may be interrelated, for example, it is reasonable to expect that individual with higher education level have higher income and will less likely be involved in very hazardous occupation. It is also not so clear what proxy for income should be used since income level may change quite significantly during active career and in retirement compared to active careerer. It is also the question under consideration whether effect of socio-economic variables diminishes with age. Good discussion on mentioned matters may be found in [6]. Authors surveyed more than 50 studies and some results are quite controversial, for example, data from USA showed that influence of socio-economic variables to mortality diminishes with age for men but, on the contrary, gets bigger for women. Data from United Kingdom showed that middle-income women had lowest mortality risk while the gap between high income and low income women was not so big (see [6], graphs and discussion on pages 23-26). Such results suggest that, though in general mortality decreases with higher income levels there may be different patterns of such relationship in different countries and care should be taken when transferring results from one country to another.

The need to evaluate income related mortality of Lithuanian seniors arose when participants of II pension pillar were legally obliged to purchase pension annuity if amount accumulated in Individual account in II pension pillar exceeds specific minimum sum defined by legislation. Such requirement was in power since very onset of II pension pillar in Lithuania, however, since June 1, 2020 annuities are sold only by Centralized Annuity Provider. Up till June 1, 2020 annuities were sold by private companies, so income related mortality tables were not available publicly.

Our paper is organized as follows. Firstly (Section 2) we shortly describe changes in mortality of Lithuanian population since 1990. Some mathematical preliminaries are presented in Section 3. Since main goal of our analysis was to estimate mortality of annuitants and annuities should be purchased by participants of II pension pillar we give short description of II pension pillar in Lithuania in Section 4. Finally we discuss main results and give some concluding remarks in Sections 5 and 6.

2 Mortality in Lithuania

Positive changes in mortality of Lithuanian population started approximately in 1994, that is soon after Lithuania regained independence. This tendency applied to both males and females ([3]), see Figures 1 and 2. ¹

¹Figures and tables in this section are based on data obtained from ([3]).

Figure 1: Life expectancy at birth by calendar year (females)

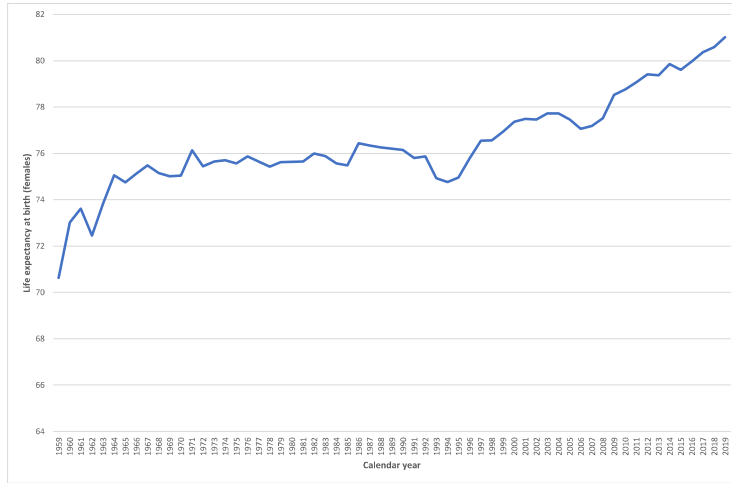
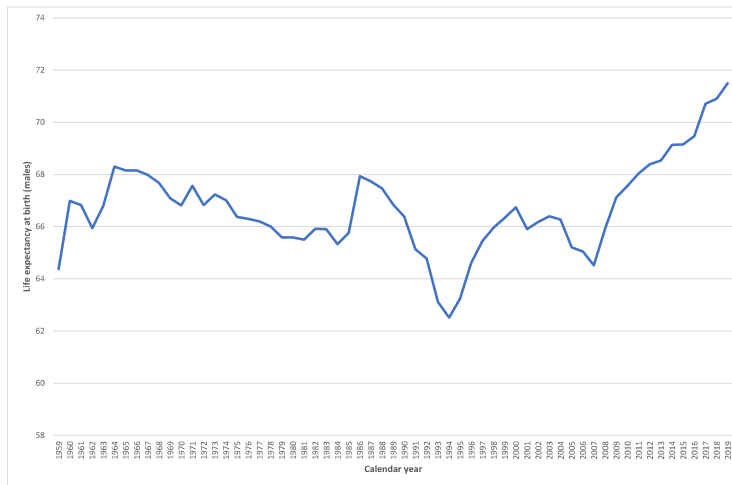


Figure 2: Life expectancy at birth by calendar year (males)



Since we are interested in mortality of senior persons, it is worth looking at changes in life expectancy at age 65 of all population. In Figures 3 and 4 reader may see changes in life expectancy at age 65 from 1990 to 2019. Female life ex-

pectancy at 65 increased quite steadily since 1990 and increase in life expectancy was about 3 years during the period from 1990 to 2019. Male life expectancy at age 65 also increased but there were temporarily pits when life expectancy lowered and total increase in life expectancy since 1990 to 2019 was only about 1.5 years. It was supposed that life expectancy at 65 will continue to increase for both sexes since in 2019 life expectancy was still lower than in many other countries in European Union. For example, in Poland, neighbouring country, life expectancy at age 65 was longer for both sexes with greater improvements since 1990 (see Tables 1 and 2). However, life expectancy improvements were, hopefully, only temporarily stopped due to Covid 19 pandemics.

Figure 3: Life expectancy at age 65 by calendar year (females)*

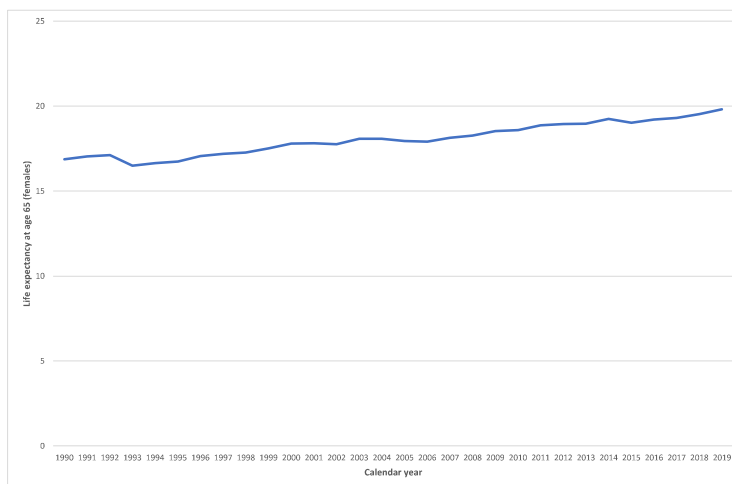


Figure 4: Life expectancy at age 65 by calendar year (males)

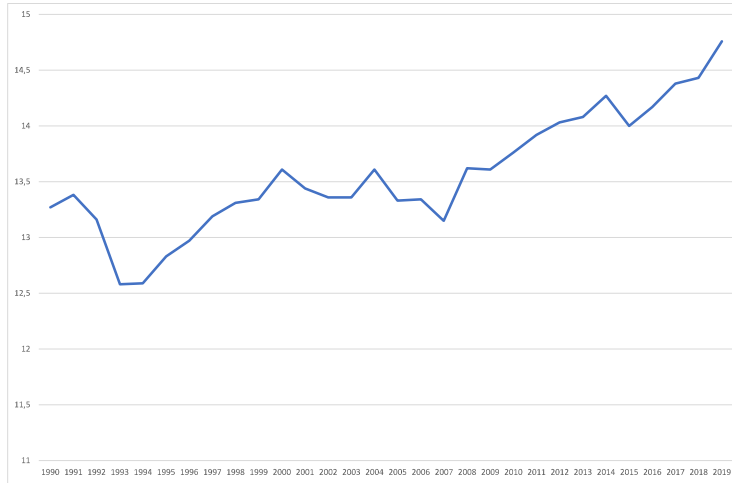


Table 1: Life expectancy at age 65 in some European countries in 2019

	Lithuania	Poland	Italy	Sweden
Females	19.82	20.10	22.54	21.99
Males	14.76	15.97	19.42	19.52

Data provided by Human mortality database ([3])

Table 2: Change in life expectancy at age 65 from 1990 to 2019

	Lithuania	Poland	Italy	Sweden
Females	2.94	3.98	3.65	2.96
Males	1.49	3.56	4.37	4.21

Author's calculations based on data provided by Human mortality database ([3])

It is well known that mortality in the country tends to be quite non homogeneous: females usually have higher life expectancy than men almost at all ages, mortality may depend on living place, e.g. city vs countryside, education, wealth, etc. In the section 5 we analyse mortality of Lithuanian old age pensioners by gender and amount of pension.

3 Some notations and mathematical preliminaries.

Consider a newborn. Her future lifetime is random variable which we will define by T , $T \geq 0$. Alternatively, we may define age at death of this particular newborn. Age at death is also random variable which we will denote by X , $X \geq 0$. We will assume that probability distribution function of random variable X is differentiable and

$$F_X(x) = F(x) = Pr(X \leq x).$$

It is more common to use survival function:

$$S(x) = 1 - F(x) = Pr(X > x).$$

So $S(x)$ describes probability that newborn will attain at least age x (survive until age x).

Consider now person aged x . We will use traditional actuarial notation ${}_t p_x$ to define probability for person aged x to survive t years. Respectively we will use symbol ${}_t q_x$ to define probability for person aged x to die within t years. It is obvious that

$$\begin{aligned} {}_t p_x &= \frac{S(x+t)}{S(x)}; \\ {}_t q_x &= 1 - {}_t p_x = 1 - \frac{S(x+t)}{S(x)} = \frac{S(x) - S(x+t)}{S(x)}. \end{aligned}$$

The instantaneous rate of mortality, so called *force of mortality at age x* , is defined:

$$\mu_x = -\frac{S'(x)}{S(x)}.$$

For practical reasons it is useful to average behaviour of the force of mortality in the interval $(x, x+1]$. In such case *central death rate (central mortality rate)*, which is defined as weighted arithmetic average of force of mortality, is used:

$$m_x = \frac{\int_0^1 S(x+u)\mu_{x+u} du}{\int_0^1 S(x+u) du} = \frac{\int_0^1 {}_u p_x \mu_{x+u} du}{\int_0^1 {}_u p_x du}.$$

Total number of years lived in the interval $(x, x+1]$ by all persons under investigation aged x is called *central exposed-to-risk* and will be denoted by E_x . Using traditional actuarial notation we will define number of deaths in age group $(x, x+1]$ by d_x . Reasonable estimate of central death rate at age x is calculated:

$$m_x = \frac{d_x}{E_x}.$$

Since estimation of central death rate takes into account not only number of person under observation but also years lived, it is considered that central death rate give more accurate estimation of mortality than estimation of probability of mortality q_x . After estimation of central death rate m_x probability of mortality q_x may be obtained using some assumption about distribution of deaths in the interval $(x, x+1]$. We used so-called exponential assumption stating that force

of mortality μ_x is constant in the interval $(x, x + 1]$. In such case $\mu_x = m_x$, $x \in (x, x + 1]$ and

$$q_x = 1 - e^{-\mu_x} = 1 - e^{-m_x}.$$

Denote random variable describing future lifetime of person aged x by T_x . Expected future lifetime of person aged x , $E(T_x)$, is called (**complete**) **expectation of life at age x** and is denoted by 0e_x . It maybe shown that

$${}^0e_x = \int_0^{\infty} {}_s p_x ds.$$

For practical reasons one may consider estimating **curtated expectation of life at age x** which is denoted by e_x and calculated

$$e_x = \sum_{k=1}^{\infty} {}_k p_x.$$

It may be seen from formula above that only full years lived are taken into account when estimating curtate expectation of life (at age x). Relation between complete expectation of life and curtate expectation of life depend on assumption about distribution of deaths in the interval $(x, x + 1]$. Most simple formula which is often used for practical reasons is

$${}^0e_x = e_x + 0.5.$$

For more information interested reader is referred, for example, to [1], [4], [5] and references therein.

4 II pension pillar in Lithuania and Centralized Annuity Provider

II pension pillar in Lithuania was introduced in 2004. It was not II pension pillar in classical sense since usually II pension pillar is usually financed by employer and - in many cases - mandatory. Participation in this pillar was voluntary and only relation to employment was that specific part of social security tax paid by employer on behalf of individual was transferred to Individual account of employee and money in this account were invested in financial markets. More information about history of II pension pillar in Lithuania interested reader may find in [7].

Since introduction in 2004 II pension pillar undergo several major reforms. The last one was introduced in 2019 and came in power on June 1, 2020. Participation in II pension pillar became quasi mandatory, i.e. all active workers not older than 40 years are automatically included into II pension pillar, but they have the right to withdraw during predetermined period (half year). If individual does not withdraw, his/her participation becomes mandatory. Payments into Individual account are no longer made reducing social security tax but are deducted from salary of individual as any other tax. Those participants who at the moment of retirement accumulated more than predetermined minimum sum are obliged to buy pension annuity from Centralized Annuity Provider. Minimum sum was 10.000 Euro during the period of 2020 - 2022, currently

(2023) it is equal to 10.807 Euro. Centralized Annuity Provider is not for profit enterprise, so it is supposed that major part of profit will be distributed to annuitants. It is possible but not mandatory to buy annuity if sum accumulated in Individual account (at retirement) is less than predetermined minimum. There is no legal requirement to purchase annuity immediately at retirement so those participants in II pension pillar who attain official pension age may postpone decision to buy annuity without time limit. In such case money in Individual account are further invested and individual may receive pension from Ist pillar, i.e. there is no requirement to start receiving public pension and annuity at the same time.

5 Main results

We analysed mortality data of Lithuanian old age pensioners. Data was provided by The State Social Insurance Fund Board. Total number of old age pensioners varies about 600 000, exact number depends on the year of analysis. We were interested mainly in how mortality depend on pension level for number of reasons. Firstly, it is well known that wealth of individual and life expectancy are positively correlated. Secondly, only participants of II pension pillar with accumulated amount in the individual account exceeding predefined minimum (10 800 Euro in the year 2023) are obliged to purchase pension annuity. So, mortality of annuitants may differ from mortality of whole population in the country. Despite the fact than pension amount not necessarily is good proxy for individual's wealth, we have chosen pension amount as measure of wealth. This was done for several reasons. Firstly, we had no data which better describe wealth of individual. Secondly, pension is related to former salary of individual, so it may be regarded as metrix of income during active career also. Moreover accumulated sum in Individual account depend also on salary. So we assumed that individuals with higher salaries during working career will receive higher pension and will accumulate bigger amount in their individual account. We assumed that the set of old age pensioners with pensions equal or exceeding 0.6 percentile of pension amount, i.e. 40% of pensioners with highest pensions, will be adequate proxy for mortality of annuitants.

We analysed mortality of pensioners during the period of 2015 - 2019 (base period) and during the years 2020, 2021 and 2022 separately. Base period of 2015 - 2019 may seem too short. However Lithuania introduced Euro instead of national currency Litas at 31 December of 2014, so we assumed that simply change in currency may distort mortality calculations. Moreover as the reader may see from figures 3 and 4 life expectancy increased quite rapidly during last years, so the period of 2015 - 2019 represented the period of lower mortality compared to more long period. The last (but not least) reason when choosing base period was the fact that Centralized Annuity Provider (CAP) started its activities on July 1, 2020, so newest available data was used for analysis.

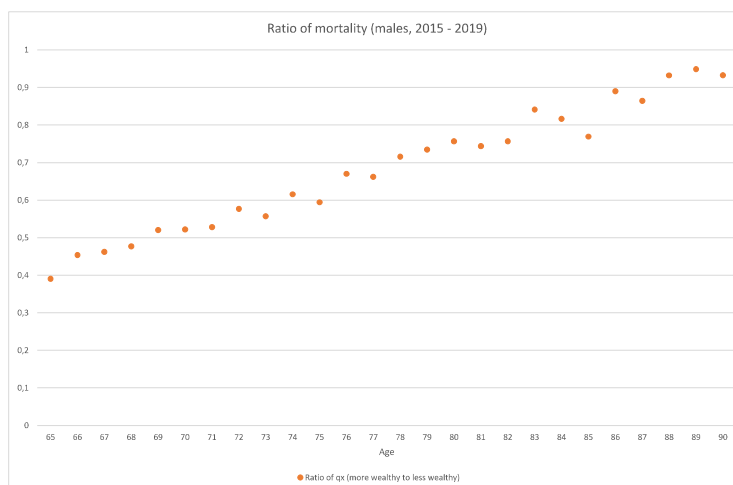
Mortality during 2020, 2021 and 2022 was analysed to evaluate how Covid-19 affected mortality of pensioners. We analysed mortality of males and females as well as of more wealth and less wealthy pensioners separately.

Though official pension age during 2020 - 2022 was lower than 65 both for males and females we have chosen age 65 as starting point of age period under investigation. On the other hand there were quite few deaths after age 90, so to

avoid excess volatility of results we limited age interval to ages 65 through 90.

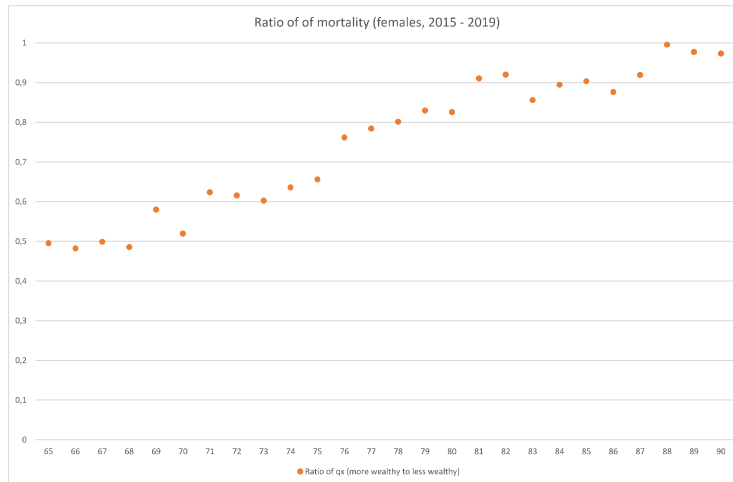
Analysis of mortality during the period of 2015 - 2019 showed that, as expected, females have lower mortality probabilities than males and that there exist positive correlation between wealth and mortality. Probability of death at younger ages (65-67) of more wealthy individuals (both males and females) was slightly more than twice lower compared to less wealthy individuals. This effect, however, diminished with age (see Figures 5 and 6).² The fact that wealth has less impact on mortality at older ages may be explained by the fact that it is more likely that more healthy individuals will live longer, so biological differences (better health) may become more important than socio-economic differences.

Figure 5: Ratio of mortality of more wealthy males compared to less wealthy (2015 - 2019)



²Figures and tables in this section are based on data provided by The State Social Insurance Fund Board of Lithuania.

Figure 6: Ratio of mortality of more wealthy females compared to less wealthy (2015 - 2019)



Though beginning of Covid-19 pandemics in Europe was February - March 2020 and first lock down in Lithuania was declared in mid-March 2020 and lasted until mid June 2020, there were quite little excess deaths during the first half of 2020. Main increase in deaths was observed during the end of 2020 (mainly during October - December), so even great increase in number of deaths during some weeks (there were weeks when number of deaths exceeded average number of deaths within 20 years period during same week by about 50%) not necessarily have the same effect for annual number of deaths. Significantly bigger increase in deaths was observed during 2021 (see figures 7 - 10). Reader should note that ratio 50% : 50% means that number of deaths during specific year (2020 or 2021) was almost equal to 2015-2019 year average; ratio 60% : 40% means that hat number of deaths during specific year (2020 or 2021) exceeded 2015-2019 year average by 50%, etc.

Figure 7: Number of deaths during 2020 versus 2015-2019 average (females)

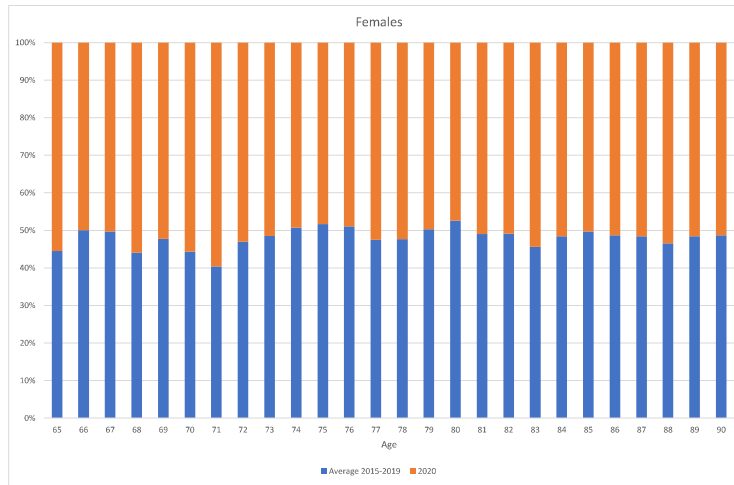


Figure 8: Number of deaths during 2021 versus 2015-2019 average (females)

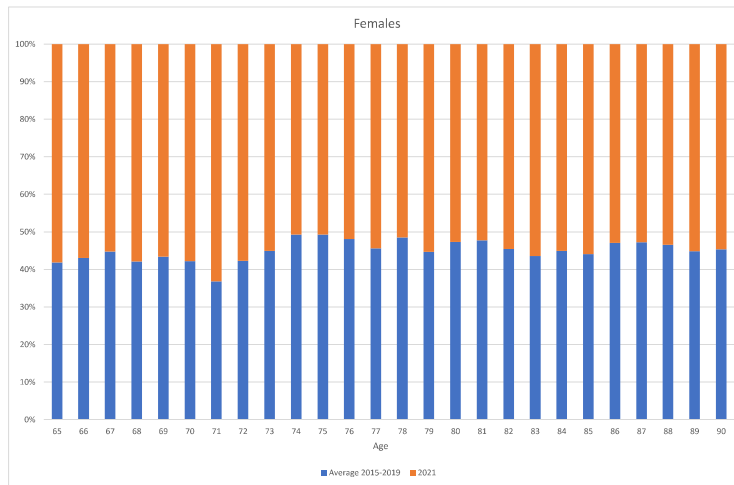


Figure 9: Number of deaths during 2020 versus 2015-2019 average (males)

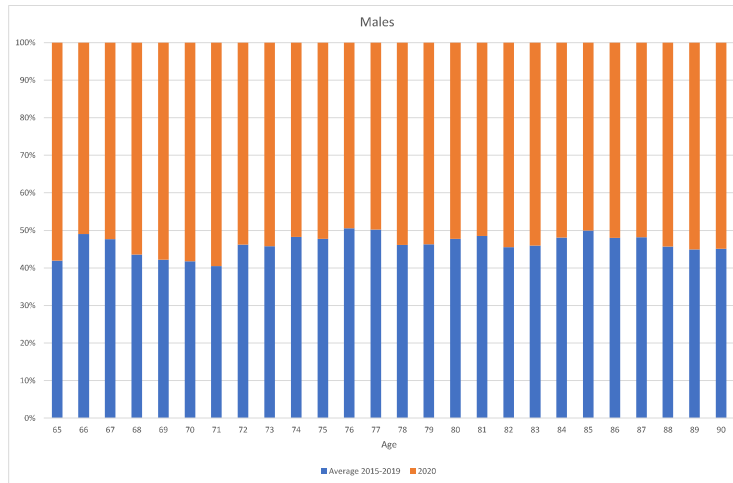
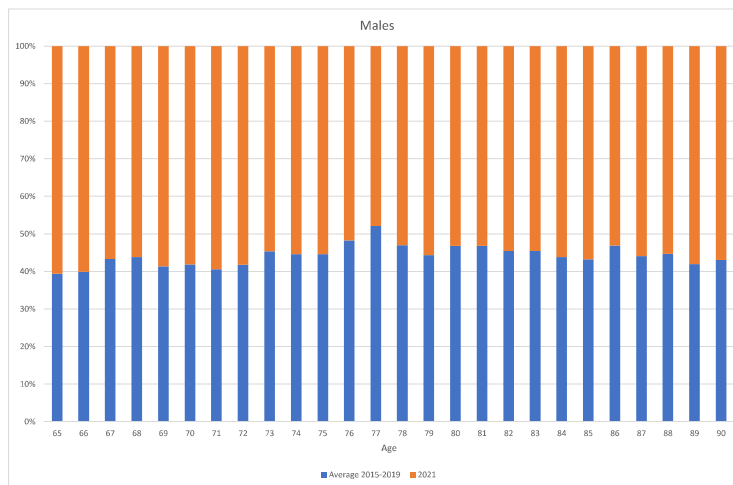


Figure 10: Number of deaths during 2021 versus 2015-2019 average (males)



It is no surprise that changes in mortality due to Covid-19 were more considerable during 2021 than during 2020. Crude mortality probabilities increased more for males compared to females. Both less wealthy men and women suf-

ferred from excess deaths more than more wealth men and women respectively. Though there was no clear trend in excess mortality, it seems that younger pensioners (aged 65 - 80), especially females, suffered more from excess mortality than older persons. Interesting phenomenon may be seen among more wealthy female pensioners: mortality during 2020 was even lower than average mortality during 2015 - 2019. This most probably may be explained by fluctuations caused by not very big amount of data and not changes in mortality due to pandemics alone. It may be seen that, most probably, crude mortality rates started to return to 2015 - 2019 average during 2022 (see Figures 11 - 14).

Figure 11: Ratio of crude mortality rates to average rates during 2015-2019 (less wealthy males)

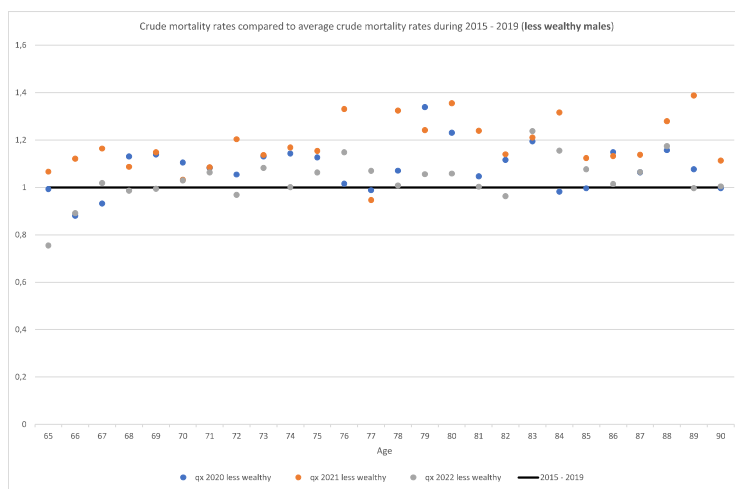


Figure 12: Ratio of crude mortality rates to average rates during 2015-2019 (more wealthy males)

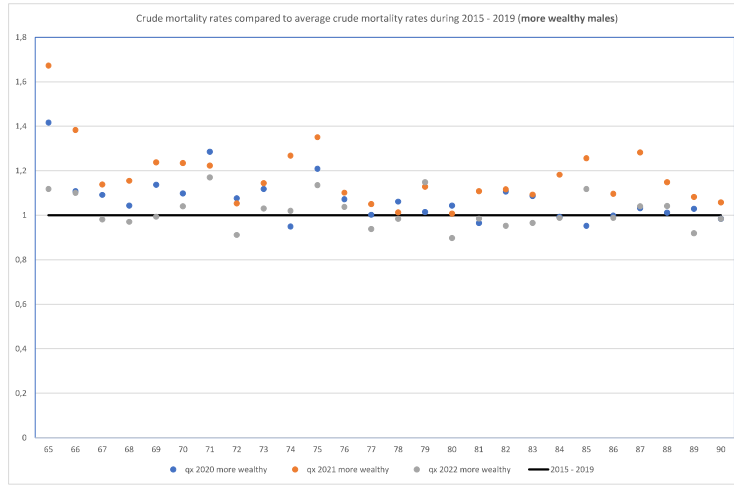


Figure 13: Ratio of crude mortality rates to average rates during 2015-2019 (less wealthy females)

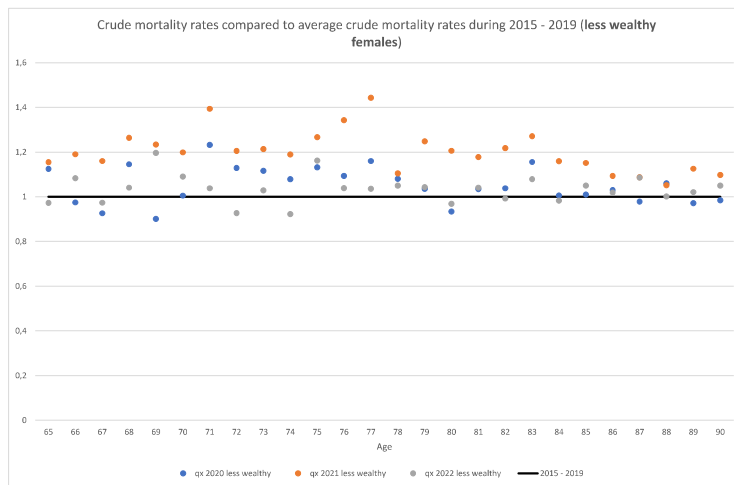
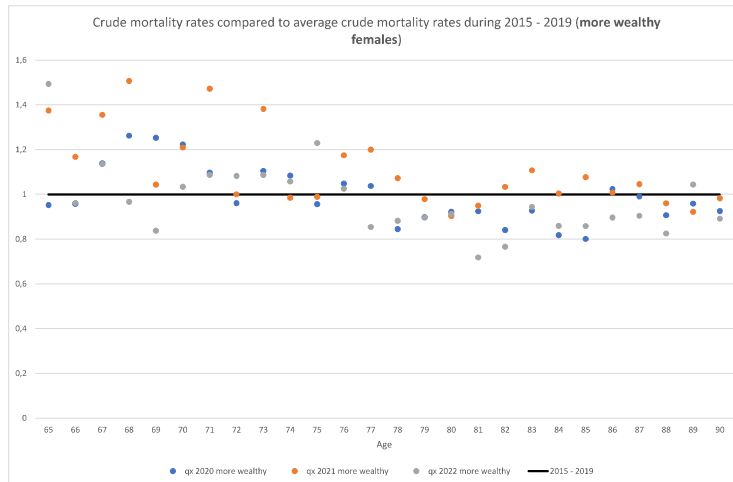


Figure 14: Ratio of crude mortality rates to average rates during 2015-2019 (more wealthy females)



We evaluated expected future lifetime of person aged 65 in age interval 65-90 from crude mortality estimates thus avoiding influence of graduation. Limiting calculations to the age interval 65-90 will allow to avoid impact of extrapolation which is crucial due to the lack of reliable data in older ages. Impact of excess mortality to life expectancy at age 65 is more considerable during 2021 compared to 2020 and it had heavier impact to lower income individuals of both sexes. It seems that life expectancy as well as crude mortality rates started to return to average during 2022 (see tables 3 - 5).

Slight increase in life expectancy of more wealthy females during 2020 is, most probably, due to lack of sufficient amount of data than due to real changes in mortality patterns. This phenomenon is in line with curve of mortality ratios (see Figure 14).

Table 3: Life expectancy at age 65 in age interval 65-90

Period	Males			Females		
	Less wealthy	More wealthy	Average	Less wealthy	More wealthy	Average
2015-2019 average	13.28	16.61	15.19	18.91	20.40	19.36
2020	12.77	16.12	14.63	18.61	20.50	19.19
2021	12.26	15.57	14.06	17.83	20.01	18.50
2022	13.19	16.49	14.90	18.78	20.66	19.31

Table 4: Changes in life expectancy at age 65 (in age interval 65-90) during 2020 - 2022 compared to 2015-2019 average, in years

Period	Males			Females		
	Less wealthy	More wealthy	Average	Less wealthy	More wealthy	Average
2020	-0.51	-0.49	-0.56	-0.30	0.10	-0.17
2021	-1.02	-1.04	-1.13	-1.08	-0.39	-0.86
2022	-0.09	-0.12	-0.29	-0.18	0.26	-0.05

Table 5: Percentage changes in LE at age 65 (in age interval 65-90) during 2020 - 2022 compared to 2015-2019 average

Period	Males			Females		
	Less wealthy	More wealthy	Average	Less wealthy	More wealthy	Average
2020	-3.84%	-2.95%	-3.69%	-1.59%	0.49%	-0.88%
2021	-7.68%	-6.26%	-7.44%	-5.71%	-1.91%	-4.44%
2022	-0.68%	-0.72%	-1.91%	-0.95%	1.27%	-0.26%

6 Concluding Remarks.

Our analysis showed that impact of Covid-19 to mortality of Lithuanian seniors depended on sex as well as socio economic group. Less wealthy males suffered from pandemics most while more wealthy females suffered least.

Impact of Covid-19 to annuity portfolio depend on the type of fund and legal requirements to purchase pension annuity. Our analysis showed that mature portfolio with mandatory participation (when all pensioners are legally obliged to buy annuities) could benefit from pandemics. Lower positive impact may be seen to mature portfolios with optional participation since more wealthy individuals will buy annuity more likely than those with lower income, especially if this bias in purchasing practice was reflected in pricing assumptions (see, for example, [2]). New portfolio, even with (quasi) mandatory participation, like the case of Centralised Annuity Provider in Lithuania, may experience nil to negative impact on mortality since individuals who are supposed to buy annuity may postpone their decision or not buy annuity at all in case of illness or poor health, e.g. due to consequences of long Covid.

Most probably death rates started to return to average during 2022, so impact of pandemics on annuity portfolio, most probably will be of short term nature and will not continue into the future.

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