

Supplementary Online Content

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eMethods and eResults

This supplementary material has been provided by the authors to give readers additional information about their work.

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Supplementary Online Content

Household Income, Life Expectancy and Cause Specific Mortality in Norway: 2005-2015

Kinge JM, Modalsli JH, Øverland S, et al.

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eMethods

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36 eMethods

37 **Part I: The measure of household income**

38 The income measure included wage income, self-employment income, capital income, pension income and
39 social benefits. To reflect the standard of living for each household member as accurately as possible, the
40 following adjustments was made: First, income after tax was adjusted to the value of Norwegian Kroner (NOK)
41 in 2015, using the consumer price index. Second, the square root equivalence scale¹ was used to account for the
42 growing needs of a household with each additional member. Third, current income in year of death (year t) was
43 excluded, as individuals who die in year t do not earn full income that year. Fourth, income was aggregated
44 across five years. The primary reason for using this aggregated measure of income, and not income in a single
45 year, was that total income may vary substantially from year to year due to adaptation to tax reforms. There has
46 been two tax reforms in the time span we are studying.^{2,3} Hence, when plotting time trends, the consequences of
47 these reforms would result in spikes in trends due to tax avoidance behavior, had we not aggregated income over
48 several years.

49
50 Equivalized household income for a person in a given year t was estimated by aggregating individual income for
51 five successive years ($t-5, \dots, t-1$), prior to year t ; counting number of household members in the year t ;
52 aggregating individual income for each household member, and finally dividing by the square root of number of
53 household members:
54

$$Equivalised\ household\ income = \frac{\frac{1}{5} \sum_{i=5}^1 household\ income_{t-i}}{\sqrt{household\ members_t}}$$

55
56 Preliminary estimations suggested that the lowest 3% income percentiles consisted of a mixed group of people
57 with frequently zero or negative income. These were excluded. The remaining individuals were assigned
58 percentile ranks from 1 to 100 based on “equivalized household income” relative to all other individuals of the
59 same sex and age each calendar year. Income was for some analyses dichotomized into above and below median,
60 or categorized into quartiles.
61
62

63 **Part II: Methods used in comparisons between Norway and the US**

64 To ensure that any difference in life expectancy, by income percentile, were not due to differences in the
65 compositions of the subpopulations between Norway and the US or the methods used, a number of measures
66 were taken. Below, the steps taken to ensure a comparable subpopulation for use in the US and Norway
67 comparison, and how we have replicated the method used by Chetty et al.⁴ is explained.
68

69 *The population for US Norway comparison*

70 The subpopulation was generated to match the US subpopulation by Chetty et al.⁴ First, as the US estimates
71 were based on the years 2001-2014, this study included data for the same years. The official household identifier
72 was available from 2005. To generate a household identifier prior to 2005, information about marital status,
73 partner identification and mother and father identification was used.
74

75 There was no information about immigration status in the US dataset. Hence, all residents both with and without
76 immigrant background was included in the Norwegian subpopulation in the US comparison analyses.
77

78 The income variable used by Chetty et al.⁴ was based on adjusted gross income plus tax-exempt interest income
79 minus taxable Social Security and disability benefits, for those who filed tax returns. For those who did not file a
80 tax return, household earnings were defined as the sum of all wage earnings and unemployment benefits. Chetty
81 et al.⁴ restricted their analysis to residents who had positive earnings. Eight percent of their subpopulation had
82 zero income and 1% had negative income. To ensure that comparable segment was excluded from the
83 Norwegian population, the study excluded those who had a “pensionable income” equal to zero, two years
84 earlier. Pensionable income was the sum of personal income from wages, personal income from self-
85 employment and unemployment benefits. Therefore, individuals with income consisting solely of e.g. disability
86 benefits and disability insurance two years earlier, were excluded. Seven percent of the Norwegian population
87 lived in households without pensionable income. When Chetty et al.⁴ excluded the 8% with zero income in their
88 data, this group accounted for 32% of deaths in the US. In addition to the 7% with zero pensionable income, we
89 also excluded the 2% with the lowest income. In total, 9% of the total Norwegian population was excluded,
90 which is identical to the percentage excluded from the US population used by Chetty et al.⁴. Thirty one percent
91 of deaths in Norway in the age group 40-63 were in the excluded 9%, which is very similar to 32% in the US
92 subpopulation.⁴ We believe our exclusions based on 0 pensionable income, plus the additional 2% with lowest

93 income, is a good approximation of exclusions made by Chetty et al., with a comparable proportion of the
94 population excluded and with equivalent mortality rates. Chetty et al. do not adjust the income measure for
95 family size, hence a measure of household income, not adjusted for family size was used for this part of the
96 analysis.

97
98 Finally, Chetty et al. measured income for individuals aged 63 years or older at 61 years of age. Because 1999
99 was the earliest year in which income was observed in the US dataset and the mortality data end in 2014,
100 mortality rates were calculated up to 76 years of age. To ensure comparability, the same cohorts as Chetty et al.⁴
101 was included in the Norwegian subpopulation.

102 *Methods for US and Norway comparisons*

103 Chetty et al.⁴ methods was replicated by estimating period life expectancy conditional on income percentile in
104 four steps (eFigure 5):

105
106
107 (1) For individuals aged 62 years or younger, mortality rates were calculated based on income percentile 1-5
108 years earlier.

109
110 (2) Chetty et al.⁴ state that the US rate of retirement increases sharply at 62 years of age. This is similar in
111 Norway, where 62 years is the minimum retirement age for many public and private pension schemes. Income
112 for individuals 63 years and older was measured for the same years as for 63-year-olds; i.e. when the individual
113 was 58-62 years old. This study followed Chetty et al.⁴ and calculated mortality rates up to 76 years of age.

114
115 (3) Mortality rates for ages 77-90 were extrapolated using a Gompertz function estimate based on mortality
116 between age 40 and 76. In a Gompertz model, the logarithm of the mortality rate is linear in age: $\log(m(\text{age})) = \alpha$
117 $+ \beta \text{age}$. To estimate the Gompertz parameters, number of deaths was regressed on age using a generalized linear
118 model (GLM) with a binomial probability distribution, with person years as the binomial denominator, and a log
119 link function in the age group 40-76, by sex and income. Using the Gompertz parameters α and β from this
120 model, mortality rates as estimated at each age 77-90 for each sex and income percentile.

121
122 (4) Sex-specific, but income-independent, mortality rates was used for in all survivors beyond the age of 90,
123 based on official life tables published by Statistics Norway, according to method applied by Chetty et al.⁴ This
124 was done because Gompertz parameters fits less well after the age of 90.

125
126 eFigure 1 shows expected age at death before and after excluding individuals with zero “pensionable income”
127 from the subpopulation. The population living in households with zero “pensionable income” was a high
128 mortality population. Therefore the curve shifted upwards.

129
130 eFigure 4 shows the results from: 1) the main estimations subpopulation, 2011-2015, based on the methods for
131 estimating life expectancy described in the manuscript; 2) the full Norwegian population, 2011-2015, including
132 those with immigrant background based on the methods for estimating life expectancy described in the
133 manuscript; and, 3) the subpopulation used for the US-Norway comparison, based on the methods developed by
134 Chetty et al.⁴ The three different methods and subpopulations resulted in differences in both the level of life
135 expectancy by income and the shape of the association (eFigure 4).

136 **Part III: Sensitivity analyses of life expectancy estimates to alternative income specifications**

137
138 Our baseline estimates of life expectancy by income were estimated by (1) calculating mortality rates for the
139 ages of 40 to 95 years; (2) for those older than 95 years, mortality was assumed constant and set equal to the
140 crude rate for this age group. Mortality rates were calculated based on income percentile 1-5 years earlier.
141 Below, the sensitivity of the results to alternative specifications are assessed.

142 *Sensitivity analysis of life expectancy at 40 years of age (e40) by the measure of income for individuals aged 63* 143 *years or older*

144
145 When assigning individuals to percentile ranks by income after the age of 62, this study assumed that income
146 after the age of 62 was a reasonable proxy for income prior to the age of 62. An important concern is that
147 retirement might lead to a change in income class. As retirement rates increase at age 62, it may lead to structural
148 changes in the composition of the percentiles; an individual in the 5th income percentile age 60, may not be in the
149 5th percentile based on income at age 70.

150
151 This assumption was explored by using income at age 58-62 for individuals aged 63 or older. In order to
152 generate this income measure for the individuals aged 63 and above, income for all individuals in the

153 subpopulation when they were aged 58-62 was needed. This meant that a longer time series with income data
154 was required. For example, to obtain income at age 58-62 for a 95 year old in 2011, information about that
155 persons income from 1973-1977 was needed. The dataset was merged with a different income register that
156 contained "assessed income", available from 1967. Assessed income ("alminnelig inntekt" in Norwegian) is a
157 more crude measure of total income than our main source available from 1993 onwards. In particular, as
158 assessed income forms the basis for taxation, several deductions have been subtracted from individuals' tax
159 filings before the numbers are registered to the tax authorities' computer files, causing variable truncation over
160 time.

161
162 Furthermore, a household identifier was needed, but official household identifier from Statistics Norway was not
163 available prior to 2005. To identify household members prior to 2005 for those who were 63 years and older,
164 spouse identifiers and marital status was used. Hence, in the analyses, a household consisted of a maximum of
165 two persons, for those aged 63 or older.

166
167 To estimate life expectancy, all individuals aged 40 and above was included. Period life expectancy was
168 estimated conditional on income percentiles by (1) calculating mortality rates for the ages of 40 to 62 years; for
169 individuals aged 62 years or younger, mortality rates were calculated based on income percentile 1-5 years
170 earlier using the household identifier available from 2005. (2) For individuals aged 63 or older, mortality rates
171 based on general income at the ages 58-62 was calculated.

172
173 eFigure 2 shows life expectancy at 40 years of age (e40) by the measure of income for individuals aged 63 years
174 or older. The results were very similar: the relationship between e40 and income was essentially invariant to how
175 income was measured.

176
177 *Sensitivity analysis of life expectancy at age 40 by the number of lags of income*

178 This study used the mean income across five years lag to measure income. The primary reason for using this
179 measure of income, and not income in a single year, was that total income may vary substantially from year to
180 year due to adaptation to tax reforms. This would have consequences when plotting time trends. The 1-5 years of
181 lag is different from the definition that Chetty et al.⁴ used, which was income in a single year with two years lag.
182 In eFigure 3 compare the Norwegian results on life expectancy by income when income was from a single year
183 with two years lag. The two series are very similar, which supports Chetty et al.⁴ finding that mortality rates by
184 income are essentially invariant to the number of lags with which income is measured.

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189 **eResults**

190 **eTable 1: Grouping of diseases and their ICD10 codes.**

Cause of death	ICD 10 codes
Infectious diseases	A00-B99
Malignant neoplasms (excl. lung cancer)	C00-C32; C37-C99
Lung cancer	C33-C34
Diabetes	E10-E14
Nervous system diseases	G00-G99
Substance use disorders	F10; F11-F16, F18-F19; X40-X49
Cardiovascular disease	I00-I99
Diseases of the respiratory system (including COPD)	J00-J99
External causes (Injuries excl. suicide and substance use)	V00-V99; W00-W99; X00-X39; X45-X59; X85-X99; Y00-Y86; Y87.1-Y99
Suicide	X60-X84, Y87.0
Ill-defined conditions	R00-R99
All other diseases	Remaining codes

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eTable 2: Life expectancy at the age of 40 by household income percentile.

Income percentile	Men					
	Excluding immigrants (2011-2015)		Including Immigrants (2011-2015)		Subpop comparable to Chetty et al (2001-2014)	
	Person years		Person years=		Person years	
	=5 035 910		5 859 823		= 11 202 681	
	e40	(95 % CI)	e40	(95 % CI)	e40	
1	30.59	(29.55 -31.64)	34.46	(33.53 -35.40)	36.30	
2	31.06	(29.98 -32.13)	33.27	(32.25 -34.29)	36.28	
3	32.17	(31.10 -33.23)	33.37	(32.39 -34.36)	37.05	
4	32.47	(31.40 -33.54)	33.41	(32.40 -34.41)	38.01	
5	33.27	(32.14 -34.40)	33.26	(32.23 -34.29)	38.92	
6	34.56	(33.51 -35.61)	33.84	(32.81 -34.87)	38.71	
7	35.55	(34.54 -36.56)	33.96	(32.95 -34.96)	39.00	
8	36.29	(35.28 -37.30)	35.56	(34.55 -36.57)	39.19	
9	36.87	(35.89 -37.86)	35.83	(34.86 -36.80)	39.32	
10	37.12	(36.13 -38.12)	36.07	(35.08 -37.06)	39.62	
Omit 11-45						
46	42.52	(41.48 -43.55)	41.94	(41.00 -42.87)	42.22	
47	41.75	(40.84 -42.65)	42.39	(41.51 -43.27)	42.54	
48	41.31	(40.35 -42.28)	41.9	(40.94 -42.85)	42.57	
49	42.47	(41.42 -43.52)	41.86	(40.73 -42.98)	43.53	
50	42.02	(40.98 -43.06)	41.99	(41.02 -42.95)	43.45	
51	42.51	(41.51 -43.52)	42	(41.04 -42.97)	42.89	
52	42.34	(41.39 -43.30)	42.35	(41.41 -43.29)	42.99	
53	42.11	(41.16 -43.06)	42.05	(41.12 -42.97)	43.33	
54	42.23	(41.32 -43.14)	42.08	(41.21 -42.95)	43.05	
55	42.44	(41.49 -43.39)	42.41	(41.49 -43.32)	43.21	
Omit 46-90						
91	44.38	(43.38 -45.38)	44.52	(43.57 -45.48)	46.63	
92	44.24	(43.28 -45.20)	44.18	(43.22 -45.13)	46.67	
93	45.06	(43.99 -46.13)	44.88	(43.90 -45.87)	45.91	
94	44.83	(43.90 -45.76)	44.92	(43.97 -45.86)	46.16	
95	44.03	(43.01 -45.05)	43.99	(43.06 -44.93)	45.57	
96	45.07	(44.09 -46.05)	45.19	(44.18 -46.19)	46.46	
97	44.82	(43.82 -45.81)	44.75	(43.80 -45.70)	46.61	
98	44.74	(43.90 -45.59)	44.63	(43.78 -45.48)	46.69	
99	45.18	(44.26 -46.10)	45.41	(44.54 -46.28)	47.44	
100	44.38	(43.38 -45.38)	44.49	(43.48 -45.50)	46.90	

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Income percentile	Women		
	Excluding immigrants	Including immigrants	Subpop comparable to Chetty et al.
	(2011-2015)	(2011-2015)	(2001-2014)
	Person years = 5 343 298	Person years = 6 078 398	Person years = 10 810 063
	e40 (95 % CI)	e40 (95 % CI)	e40
1	37.98(37.06-38.90)	39.48(38.62-40.33)	41.48
2	37.48(36.53-38.43)	39.10(38.25-39.94)	43.27
3	38.52(37.60-39.44)	38.67(37.77-39.56)	43.45
4	39.08(38.14-40.03)	39.28(38.41-40.16)	43.21
5	38.81(37.85-39.76)	39.32(38.42-40.22)	44.20
6	39.69(38.74-40.63)	39.62(38.73-40.52)	44.00
7	39.81(38.86-40.77)	39.84(38.92-40.76)	44.80
8	41.49(40.62-42.36)	40.33(39.45-41.21)	44.55
9	40.99(40.07-41.92)	40.76(39.88-41.64)	45.48
10	41.54(40.66-42.42)	40.67(39.80-41.55)	44.93
Omit 11-45			
46	45.10(44.30-45.90)	45.25(44.49-46.02)	47.22
47	45.38(44.55-46.21)	45.24(44.45-46.02)	48.23
48	44.80(43.99-45.62)	45.16(44.36-45.95)	47.75
49	45.17(44.39-45.95)	44.90(44.13-45.66)	47.21
50	44.62(43.83-45.42)	44.81(44.06-45.56)	46.89
51	44.82(44.01-45.63)	45.51(44.76-46.26)	47.21
52	45.92(45.14-46.71)	45.68(44.91-46.45)	47.78
53	45.63(44.82-46.44)	45.35(44.54-46.17)	48.11
54	45.48(44.70-46.26)	45.85(45.12-46.58)	47.55
55	45.63(44.81-46.45)	45.33(44.51-46.14)	47.08
Omit 46-90			
91	46.97(46.20-47.74)	47.27(46.53-48.01)	49.06
92	47.08(46.33-47.84)	47.40(46.66-48.13)	49.40
93	47.12(46.32-47.91)	47.22(46.46-47.99)	48.73
94	47.24(46.46-48.03)	46.96(46.18-47.75)	50.12
95	47.62(46.88-48.37)	47.99(47.29-48.70)	50.21
96	47.73(47.02-48.45)	47.69(46.99-48.40)	49.96
97	47.59(46.83-48.35)	47.30(46.56-48.03)	49.30
98	46.81(46.02-47.59)	47.08(46.31-47.84)	49.58
99	47.17(46.37-47.96)	47.19(46.43-47.95)	48.96
100	46.40(45.66-47.13)	46.58(45.88-47.28)	49.26

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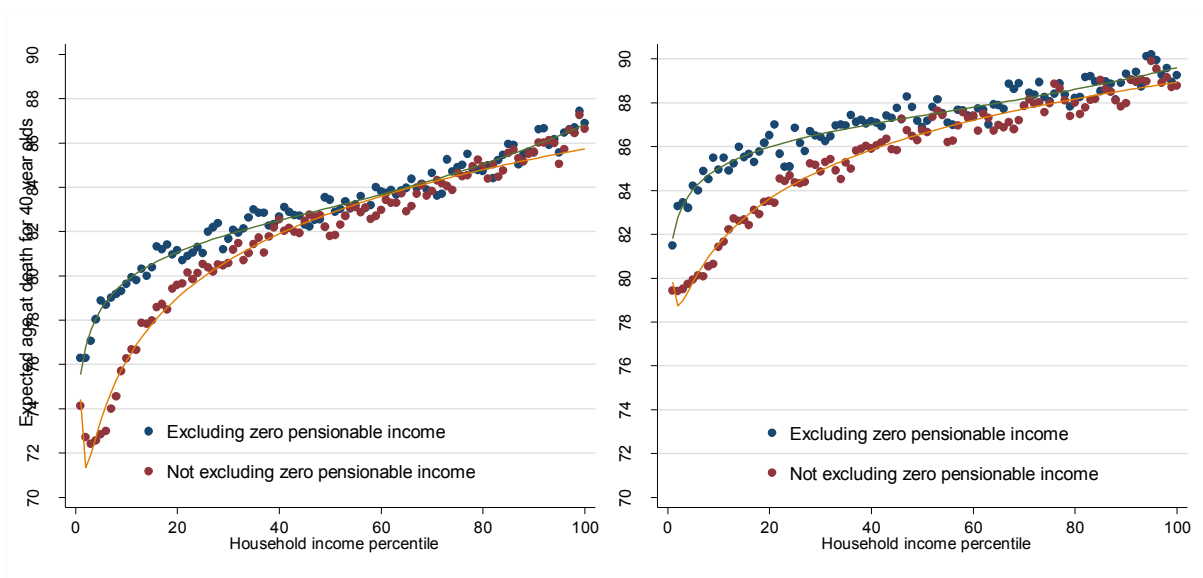
eTable 3: Difference in life expectancy (in years) between the top and bottom income quartiles of income by age in the years 2005-2015.

Men	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Age group											
40	0.5	0.4	0.3	0.4	0.5	0.3	0.5	0.4	0.4	0.4	0.5
45	0.6	0.6	0.7	0.5	0.6	0.5	0.6	0.5	0.5	0.5	0.6
50	0.8	0.8	0.7	0.9	1.0	0.9	0.8	1.0	0.9	0.8	0.8
55	0.9	1.1	1.1	1.0	1.0	1.2	1.1	1.1	1.2	1.0	1.0
60	1.1	1.1	1.1	1.1	1.2	1.3	1.2	1.3	1.1	1.3	1.2
65	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.1	1.2	1.3	1.4
70	0.7	0.6	1.0	0.9	0.9	1.0	0.9	1.0	1.1	1.1	1.1
75	0.4	0.5	0.6	0.5	0.6	0.9	0.8	0.8	0.8	0.8	0.7
80	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6
85	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.3	0.2
90+	-0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Total	6.2	6.5	7.0	7.1	7.5	7.7	7.9	7.9	7.9	8.2	8.3
Women	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Age group											
40	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
45	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.2	0.3	0.4	0.3
50	0.3	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.4
55	0.6	0.4	0.6	0.7	0.6	0.5	0.7	0.6	0.7	0.7	0.6
60	0.6	0.7	0.6	0.7	0.6	0.8	0.8	0.8	0.9	0.8	0.9
65	0.6	0.7	0.6	0.6	0.7	0.8	0.9	0.9	0.9	0.9	0.9
70	0.4	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.8	0.9	0.9
75	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.9	1.0
80	-0.1	0.1	0.1	0.2	0.3	0.5	0.4	0.5	0.6	0.8	0.5
85	-0.2	-0.1	0.1	0.1	0.2	0.3	0.1	0.3	0.2	0.4	0.3
90+	-0.4	-0.2	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.2
Total	2.5	3.5	4.1	4.4	4.8	5.4	5.8	5.8	5.9	6.9	6.2

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211 **eFigure 1: Sensitivity analysis of expected age at death, for the populations**
212 **with and without no “pensionable income”, 2001-2014.**

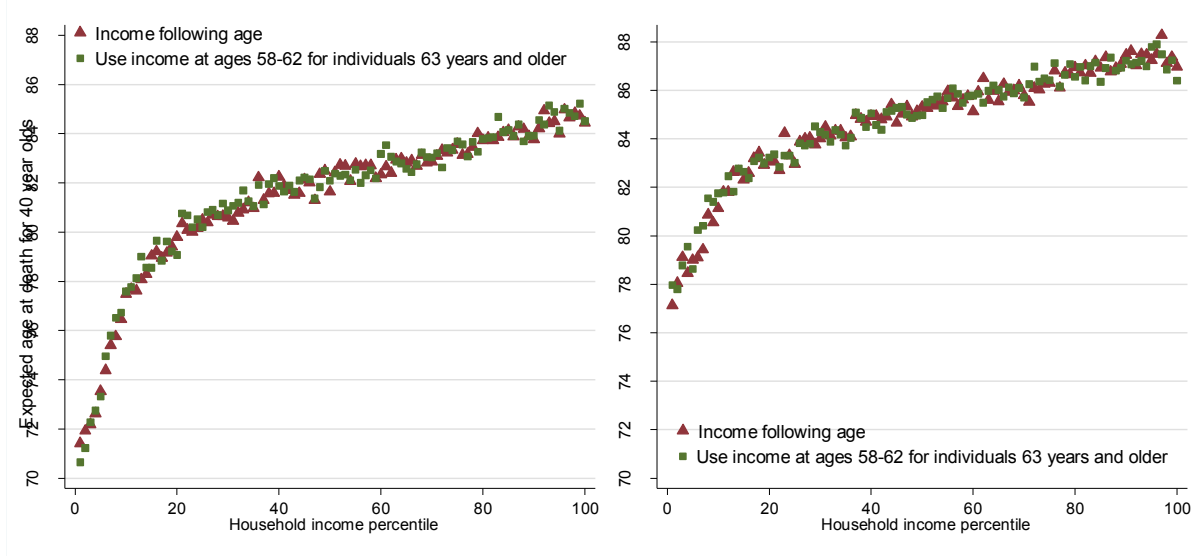
213 **Left: men. Right: women.**



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215 **eFigure 2: Sensitivity analysis of life expectancy by the measure of income for**
216 **individuals aged 63 years or older.**

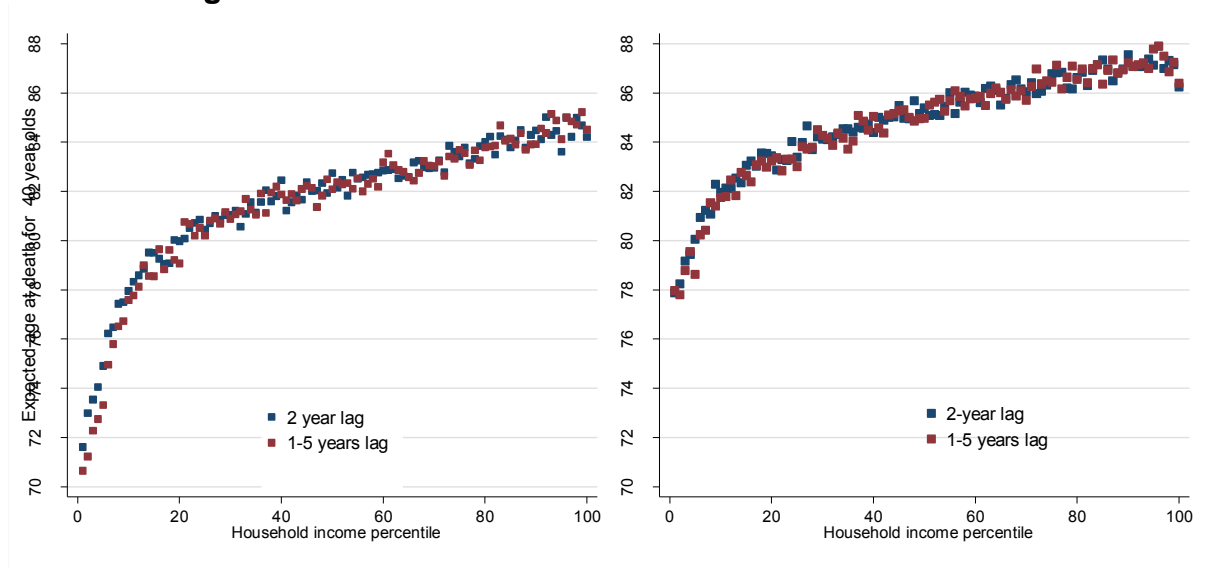
217 **Left: men. Right: women.**



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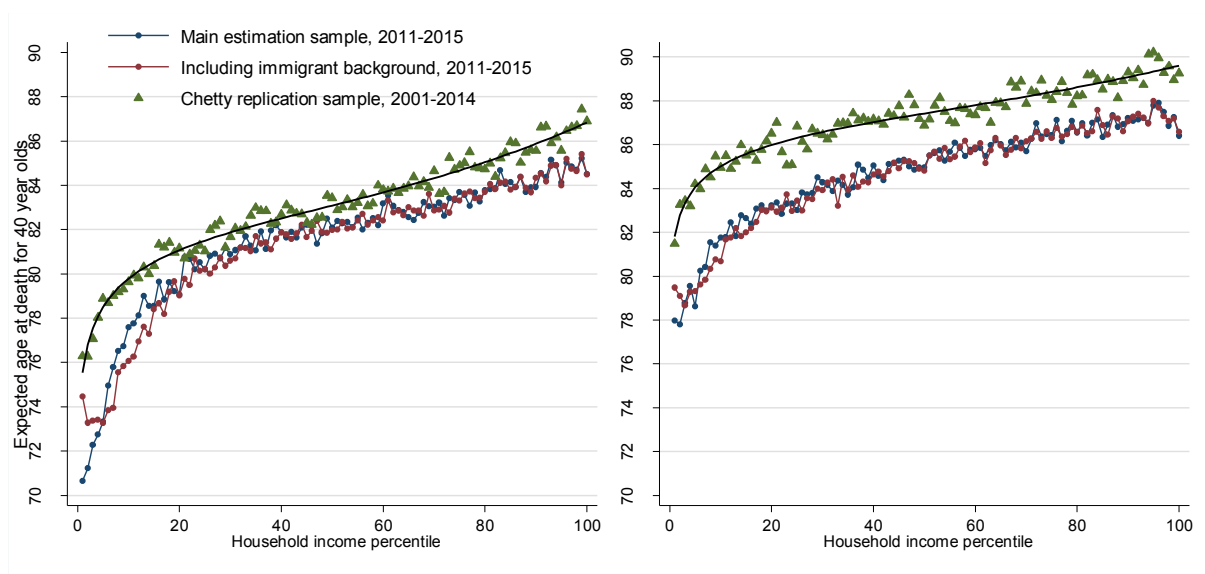
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221 **eFigure 3: Sensitivity analysis of life expectancy by the number of lags of**
 222 **income.**
 223 **Left: men. Right: women.**



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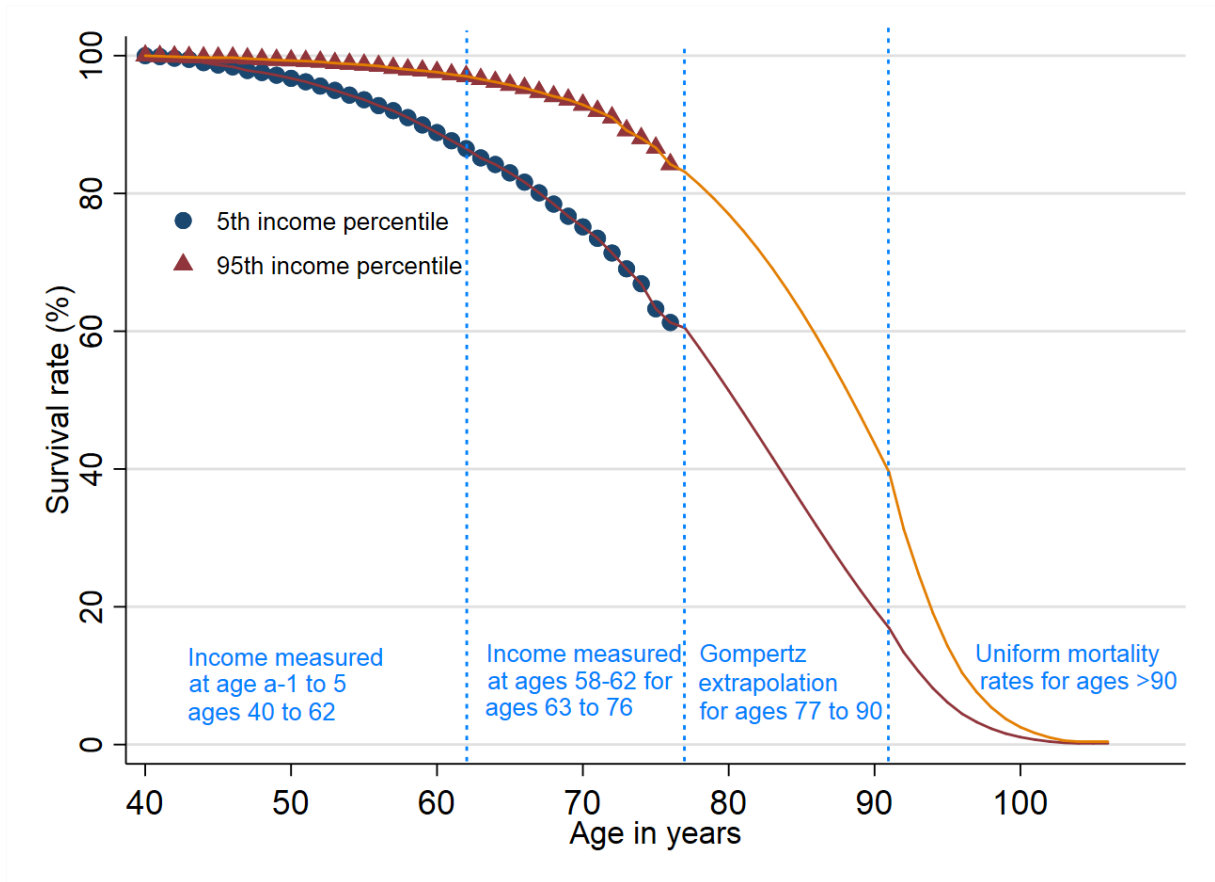
eFigure 4: Life expectancy at birth, by income percentile for the Norwegian population 2011-2015 excluding those with immigrant background (blue), including those with immigrant background (red), and for the subpopulation defined according to Chetty et al. used in comparisons with US estimates (green). Left: men. Right: women.



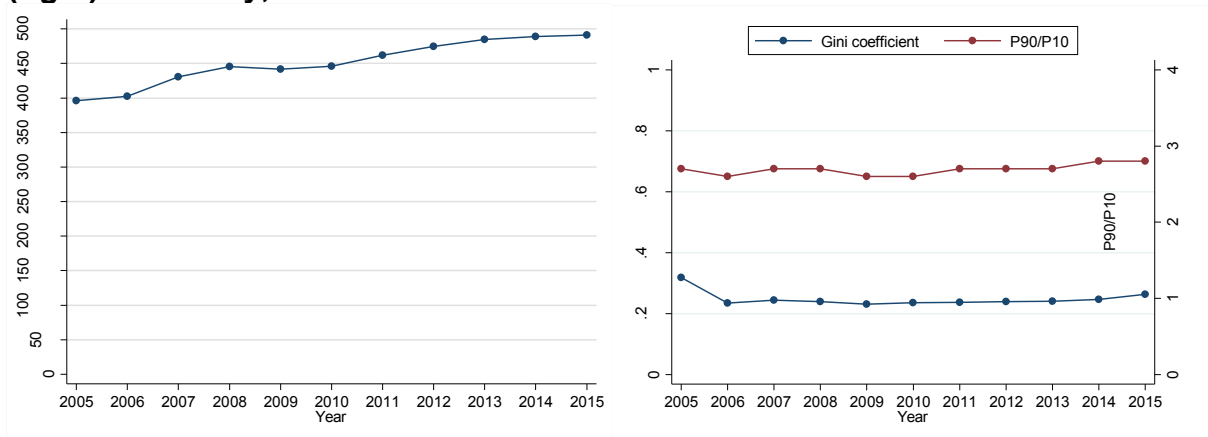
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Life expectancy for the main estimation sample and sample including immigrants is based on actual mortality rates and presented as expected age at death.
 Life expectancy for the Chetty replication sample is estimated by a combination of actual mortality rates (ages 40-76) and forecasted mortality rates (ages 77-90) and uniform sex specific mortality rates (ages 91 and above).

238 **eFigure 5: Survival curves for men in the 5th and 95th income percentiles in the**
 239 **Norwegian subpopulation 2001-2014, similar to the study sample defined by**
 240 **Chetty et al.**



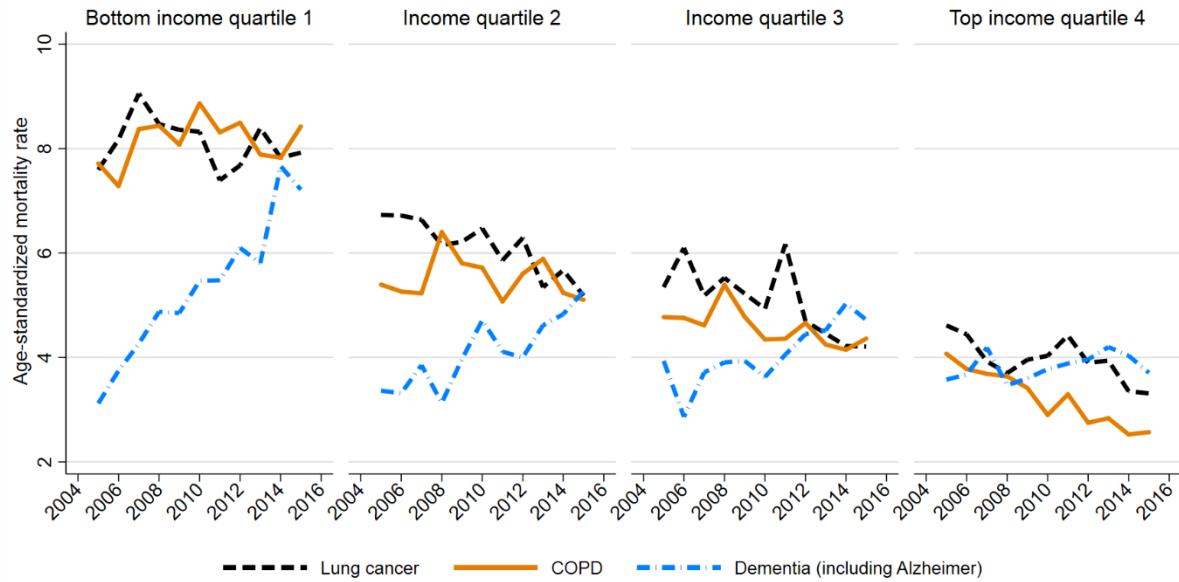
241 **eFigure 6: Median income in constant NOK after tax for all households (left)**
 242 **and measures of income dispersion – the Gini coefficient and P10/P90 ratio**
 243 **(right) in Norway, 2005-2015.**
 244



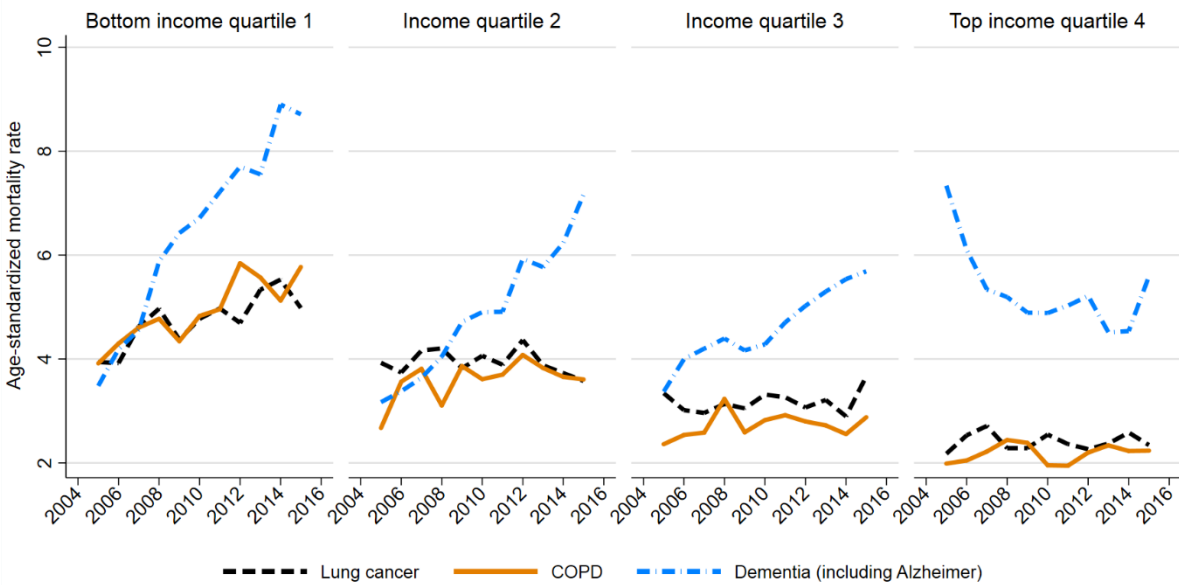
245 Source of data: Statistics Norway
 246 The Gini coefficient is a number between 0 and 1 that measures the degree of inequality in the
 247 distribution of income, where 0 corresponds with perfect equality and 1 corresponds with perfect
 248 inequality.
 249 P90/P10 is the percentile ratio of the 9th and the 1st decile cut-offs.
 250
 251
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253 **eFigure 7. Age-standardized annual mortality rates (deaths per 100 000 person**
 254 **years) for selected causes of death by income quartiles (Q1 to Q4), 2005-2015,**
 255 **for men and women.**

256
 257 **A: Men**



258
 259 **B: Women**



260 Direct age-adjustment. The age-specific death rates was weighted by the proportion of each group in
 261 the mean population in Norway from 2005-2011. Estimates are based on the total Norwegian
 262 population above the age of 40, excluding the lowest 3% income and those with immigrant
 263 background.
 264 Lung cancer, COPD and Dementia (including AD) was chosen ex-post, as these were the causes of
 265 death with the most diverging time trends across income groups.
 266
 267

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