The association between parity, CVD mortality, and CVD risk factors among Norwegian women and men

ABSTRACT

Background: Several studies have shown that women and men with two children have lower mortality than the childless, but there is less certainty about mortality, including CVD mortality, at higher parities, and meager knowledge about factors underlying the parity-mortality relationship.

Methods: The association between parity and CVD mortality was analysed by estimating discrete-time hazard models for women and men aged 40-80 in 1975-2015. Register data covering the entire Norwegian population were used, and the models included a larger number of relevant sociodemographic control variables than in many previous studies. To analyse the relationship between parity and seven CVD risk factors, logistic models including the same variables as the mortality models were estimated from the CONOR collection of health surveys, linked to the register data.

Results: Men (but not women) who had four or more children had higher mortality from CVD than those with two, although this excess mortality was not observed for the heart disease sub-group. Overweight, possibly in part a result of less physical activity, seems to play a role in this. All CVD risk factors except smoking and alcohol may contribute to the relatively high CVD mortality among childless.

Conclusions: Childbearing is related to a number of well-known CVD risk factors, and becoming a parent or having an additional child is, on the whole, associated with lower – or at least not higher - CVD mortality in Norway. However, for men family sizes beyond three children are associated with increased CVD mortality, with risks of overweight one possible pathway.

SUMMARY BOXES

What is already known on this subject?

Several studies have shown that women and men with two children have lower mortality than the childless. However, there is less certainty about mortality, including CVD mortality, at higher parities and not much knowledge about the factors that contribute to the parity-mortality relationship.

What this study adds.

The study has confirmed the high CVD mortality among the childless and shown that this is consistent with patterns in some well-known CVD risk factors. Having an additional child is associated with lower – or at least not higher - CVD mortality in Norway, except that among men who already have three children, further childbearing is linked to increased CVD mortality, possibly because of higher risk of overweight or physical inactivity.

Women's and men's mortality may be influenced by their number of children. Among women, one reason is that pregnancy involves biological changes with implications for certain disease risks.[1-4] Additionally, having children may affect mothers' and fathers' lifestyle and availability of support. The relationships between number of children and all-cause mortality shown in earlier studies probably reflect such biological and social pathways plus uncontrolled joint determinants of fertility and mortality. It has typically been concluded in these investigations that the childless and, to lesser extent, one-child parents have higher mortality than two-child parents.[5,6] However, there is less certainty about the association between mortality and higher parities. Recent meta-analyses have shown an upturn of all-cause mortality as parity exceeds two[7,8], but in some investigations based on large data sets such a pattern has not appeared (see details below).

In this study, the focus is on mortality from cardiovascular diseases (CVD), which constitutes a large part of all-cause mortality. Earlier investigations have shown that CVD mortality is higher among childless than two-child parents, while the picture at the higher parities is more blurred, although there is more support for a high-parity disadvantage with respect to CVD mortality than all-cause mortality (see below). Using register data that cover the entire Norwegian population, we estimate models for CVD mortality for both women and men (and some similar models for all-cause mortality for comparison), and control better for sociodemographic determinants of fertility than in many previous studies. In particular, we take into account re-partnering, the education of the spouse (if any) and place of residence. We also control for age at first birth, which has often not been done although it is strongly linked to parity. Unlike earlier studies of parity and CVD mortality, we distinguish between four types of CVD: ischemic heart diseases (IHD), other heart diseases, stroke, and all others.

In order to shed light on the underlying mechanisms we estimate relationships between childbearing and seven well-known CVD risk factors[9] reported in health surveys linked to the register data. Three of them may be considered as behavioural factors (smoking, alcohol use, physical inactivity), while four are health conditions (overweight, cholesterol level, hypertension, diabetes) which may be partly a result of these or other types of behaviours, but which, for women, may also be influenced by childbearing through more direct biological pathways (see below).

DATA AND METHODS

Data

Everyone who has lived in Norway at any time after 1964 has been assigned a personal identification number (PIN) and been included in the Norwegian Population Register. The same PIN is used in other registers, which makes it possible to link them to each other. We extracted the following information from the Population Register for each person born between 1935 and 1975: sex, year of birth, year of death (if applicable), marital status and municipality of residence (if living in the country) at the beginning of each year between 1975 and 2015 (the last year with complete data), year of birth of all live born children for whom the person is registered as the father or mother, and PINs of spouses. The reason for the 1935 limit was that the birth histories are not complete for older cohorts. Individuals born outside Norway were, for simplicity, excluded (which had no impact on the key estimates).

We considered only the ages above 40, as there are few CVD deaths at lower ages. Thus, the first year included in the mortality analysis was 1975, when the 1935 cohort attained age 40.

For each person in the selected cohorts, information was added from the Cause-of-Death Register. The highest educational level attained at the beginning of the years 1971 and 1981-2015 was added from the Education Database (operated by Statistics Norway).

The analysis of CVD risk factors was based on the CONOR collection of nine regional health surveys conducted during the years 1994-2003 among individuals older than 18 years [10]. The following eight (out of 19) counties were represented: Akershus, Oslo, Hedmark, Oppland, Hordaland, Nord-Trøndelag, Troms, and Finnmark. In total, there were about 180,000 respondents in these surveys, but all CVD risk factors were not measured for all of them (see Table 2).

Ethical approval for the use of these data has been obtained from the Regional Committees for Medical and Health Research Ethics and the data owners.

Mortality model

Discrete-time hazard models for the odds of dying were estimated. For each individual, a series of one-year observation intervals was constructed. The first was the year when the person turned 40. The last year was 2015, the year of death, or the last year the person lived in Norway, whatever occurred first (and given the 1935 cohort limit, the age was thus never higher than 80). Logistic models for the odds of dying were estimated from the one-year observations, after having excluded years when the person lived temporarily abroad. In total, there were 21.1 million one-year observations and 78,119 deaths among women and 21.5 million one-year observations and 124,261 deaths among men. In the cause-specific analysis, logistic models for the odds of dying from a specific cause were estimated from the same one-year observations (see note in Table 1 about an alternative model). All variables were time-varying and referred to the situation at the beginning of the respective one-year observation interval, except that education in 1971 was included for the 1975-1980 observations.

Logistic models for cardiovascular risk factors

Logistic models for seven CVD risk factors reported in the health surveys were also estimated. We included the same variables as in the mortality models, and applied the same restriction about being born in Norway after 1935 and older than 40.

RESULTS

Estimates from mortality models

As shown in Appendix tables A1 and A2, inclusion of marital status reduces the all-cause mortality disadvantage associated with childlessness. Furthermore, the high-parity disadvantage becomes weaker, or an advantage appears, when the number of co-parents is taken into account. Controlling for age at first birth has a similar impact, in addition to making the disadvantage for one-child parents clearer.

According to the most complex model (7), all-cause mortality declines with parity for both sexes, except that the differences between the two highest parity levels are not significant (Table 1). However, when age at first birth is not controlled for (model 6), men with four or more children appear to have higher mortality than two-child fathers. The mortality disadvantage for the childless is more pronounced for women than men.

(Table 1 about here)

At low parities, the pattern in the CVD mortality is similar to that in all-cause mortality. However, compared with two-child mothers, women with three children have significantly lower CVD mortality only when age at first birth is controlled for, and women with four or more children have the same CVD mortality (while a higher mortality appears when age at first birth and number of co-parents are not controlled for). Among men, CVD mortality is higher at parity four or higher than at parity two according to all models and, as for all-cause mortality, the differences in CVD mortality across the lowest parity levels are smaller than among women. Thus, CVD mortality is, on the whole, more negatively related to parity among women than men. (In contrast to the pattern in the CVD mortality, mortality from other non-violent causes is significantly lower among both women and men with four or more children than among two-child parents; not shown in tables).

Table 1 also shows relationships between parity and mortality from four types of CVD. Mortality is generally highest for the childless, although the magnitude of their disadvantage varies (being largest for 'other heart diseases'). Among women, having four or more children rather than two is not associated with a higher chance of dying from any of the four causes. However, 12-15% higher mortality from stroke and 'other CVDs' appears for men with four or more children than for those with two when age at first birth is controlled for.

CVD risk factors

High parity is associated with relatively low probability of smoking, while the probability is high among one-child parents (Table 2). However, smoking is not more common among the childless than those with two children. Compared to those with two children, men (but not women) who are childless or have one child have lower probability of drinking alcohol more than once a week, while the relationship between alcohol use and parity is negative for both women and men with two or more children. The association between parity and physical inactivity is almost U-shaped, the exception being that childless women are not more inactive than two-child mothers. Also the association between parity and overweight is U-shaped, except among men if overweight is defined as BMI above 25.

Childless women and one-child mothers have higher probability of moderately elevated total cholesterol level than two-child mothers. Among men, this probability is raised for those with one child and there are indications in this direction ($p < 0.10$) for the childless, while it is lower above parity two (although only with $p<0.10$ at the highest parity). Hypertension is more common among women and men who are childless or have one child than among two-child parents. The chance of having diabetes is relatively high among the childless of both sexes, but otherwise not related to parity.

(Table 2)

DISCUSSION

The parity-mortality association in the light of existing literature

Earlier studies have provided mixed evidence about the association between parity and mortality. For example, while some authors have reported an all-cause mortality disadvantage for women with many children[11-14], such a pattern has not appeared in other investigations[15-17]. In studies including both sexes, Tamakoshi et al.[18] found higher mortality among both women and men with many children, while Jaffe et al.[19] and Barclay et al.[6] saw such a pattern only for men. In contrast, no differences across parities were seen for women and men with two or more children in a Finnish register analysis[20], and a Norwegian register study of a relatively young population (and therefore including fewer CVD deaths than some of the other studies) did not show particularly high mortality among high-parity men, but low mortality among high-parity women[5]. Our results accord with the latter study: According to models including joint determinants of childbearing and mortality that are often not taken into account, women and men with three or more children have slightly lower all-cause mortality than two-child parents (see also Table 3 which summarizes findings). Without control for number of co-parents and age at first birth, women with four or more children would not appear to have an advantage, and men at this parity would have an outright disadvantage.

(Table 3 about here)

However, the pattern at the highest parities is different when it comes to CVD mortality: Women with four or more children have as high chance of dying from CVD as those with two, while men at that parity level have raised CVD mortality. When four separate groups of CVD are considered, an excess mortality for men with four or more children does not appear for IHD and other heart diseases, only for stroke and other types of CVD. Such an association between high parity and high CVD mortality for men did not appear in the earlier Norwegian study, except when age at first birth was not taken into account[5], which it is very reasonable to do. (In addition to being strongly linked to high completed fertility it may have a strong effect on cardiovascular mortality and disease risks[21] and be an indicator of social characteristics with such effects.) A Finnish study showed the same pattern[20], while a Swedish investigation that did not control for age at first birth showed relatively high CVD mortality at high parity for both sexes[6]. Furthermore, some studies of only one of the sexes have indicated a positive association between high parity and CVD mortality.[11,12,22]. A relatively high CVD mortality for those with fewer than two children has also been reported[5,6,20,22], although a disadvantage for one-child parents has not always shown up in the smaller studies[11,12].

Results from investigations of CVD incidence or prevalence have been rather diverse. A high-parity disadvantage has been shown in some investigations – for the only sex that has been analysed[17,23-25], for both sexes[21,26-29], or only for women[30-32] - but has not

appeared in other studies[33,34]. In fact, there has not even been full agreement about a disadvantage for the childless.[21,23,24,27,28,30-34]

Note that the estimates shown in the main tables are from models controlling for current marital status, which has an ambiguous position in the causal chain: It is to some extent influenced by earlier childbearing, but also reflects an earlier life situation of importance for childbearing. However, the estimates were not fundamentally changed when marital status was left out. Unfortunately, it was not possible to control for informal cohabitation, so one reason for the higher mortality among childless than parents may be that the latter are more likely to have a partner, which – (almost) like having a spouse - is linked to low mortality.[35]

The role played by CVD risk factors

We considered three 'behavioural' risk factors measured almost in the middle of the period covered by the mortality analysis: daily smoking, high alcohol consumption (which is likely to have a clearer adverse effect than abstention[36]), and no heavy physical activity. Physical inactivity is linked to overweight, which is considered an important CVD risk factor[37,38], but it may have effect above and beyond that[39,40]. In addition to overweight, we considered the three following health conditions: diabetes (associated with overweight, but believed to affect CVD independently of that[38,41]), moderately elevated total cholesterol level[9,42], and hypertension[9,43].

Assuming that these CVD risk factors actually affect mortality adversely, our estimates suggest that differences in their distributions contribute to the relatively high CVD mortality among the childless, at least for one of the sexes, with two exceptions: While smoking is more common among one-child than two-child parents, that is not the case for the childless. Furthermore, childless women do not have particularly high alcohol consumption, and childless men drink less than two-child fathers. On the other side of the scale, less smoking and lower alcohol consumption apparently contribute to reduce CVD mortality among both four-child fathers and (possibly to larger extent according to the point estimates) four-child mothers. However, these advantages are counteracted by the patterns in physical inactivity and overweight, and among men these appear to be dominating.

Some of these risk factor patterns differ from those reported in earlier studies, most of which have been based on much smaller surveys. In particular, the lack of a positive relationship between childlessness and alcohol use and smoking does not fit well with studies showing (at least temporary) effects of having a child [44-47]. Also, some investigations have shown *positive* associations between higher parity and smoking[27,48,49] or no association[50], while alcohol use, as in our study, was found to decrease with higher parity, although only among women[27]. Furthermore, one investigation concluded that childless people were *more* physically active than parents, but that there was no relationship with the number of children[51], while other evidence suggests, like ours, that higher parity is linked with inactivity for both sexes[48,49] or only among women[27]. A positive association between higher parity and overweight, such as in our analysis, has been reported more consistently[27,52], although with some sex differences[48], and there are also studies showing – as ours - a high chance of overweight among the childless[53]. In studies where

hypertension and cholesterol have been considered, no relationships with parity have appeared except for a linear trend in HDL cholesterol among women[27,48,54]. One of these studies[27] showed, like another one [3], an increase in diabetes across parity among women.

Possible underlying mechanisms

Going one step further back in the causal chain, parity differences in the behavioural factors considered here, as well as in others such as diet and stress[54], may reflect a variety of social pathways operating in different directions. On the one hand, children may exert social control on behavior[47,55] and provide emotional and practical support[56,57], with potentially beneficial implications for the parents' health behaviour. On the other hand, there may also be less favourable effects. In particular, earnings may be strongly reduced as a result of childrearing[58], while expenses are high, and the parents may be under intense time pressure. This may, for example, lead to less healthy food intake and reduce the parents' physical activity.

The behavioural factors operate through overweight, diabetes, cholesterol, hypertension and other more proximate risk factors. Additionally, for women, biological effects of pregnancies have been suggested. These include accumulation of abdominal fat, increased insulin resistance and diabetes risk, elevated risk of hypertension and atherosclerosis, and higher levels of circulating lipids[3,59-66]. Also, there may be long-term effects on CVD mortality of complications during pregnancy[67-69]. The fact that the association between parity and CVD mortality is nevertheless more negative among women than men, according to our study, may reflect that the social pathways contribute differently. There are indications in this direction with respect to smoking and alcohol use, and there may also be other behavioural risk factors, not considered here, that are more negatively related to higher parity among women than men. Alternatively, perhaps the biological effects are actually rather weak or even operate in a direction opposite to that suggested in earlier literature.

Finally, the results also reflect unobserved confounders. For example, some of the childless may be less attractive as mates because of certain characteristics or behaviours, and having many children may indicate a strong economic situation, the mother being less career oriented or having poor work opportunities, living in a rural area with low housing costs, or having values that include a positive attitude to a home-oriented lifestyle or a negative attitude to abortion. Such factors may also affect CVD risks, or be linked to factors with such impact. This contribution from confounding may also vary between the sexes.

Conclusion

According to models where age at first birth and other relevant sociodemographic factors are controlled for, the main pattern is that CVD (and all-cause) mortality in Norway goes down with increasing parity or, at the highest levels, remains almost unchanged. A number of well-known CVD risk factors may contribute to this negative association. However, there is one exception: For men who already have three children, the disadvantages caused by – or at least

associated with – further childbearing more than outweigh the advantages. This may be linked to a higher chance of overweight, partly because of less physical activity.

COMPETING INTERESTS

None declared

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(* means: will be omitted after review if only 40 references are allowed)

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Table 1. Effects (odds ratios with CI) of number of children on mortality in discrete-time hazard models for women and men of age 40-80 in 1975-2015 and born in Norway in 1935 or later.

All-cause mortality

	Women			Men		
	Number of deaths	Model 6	Model 7	Number of deaths	Model 6	Model 7
Number of children						
0	11745	1.69**** (1.65-1.74)		29708	1.48**** (1.45-1.51)	
1	11311	1.33**** (1.30-1.37)	1.39**** (1.36-1.43)	15744	1.19**** (1.17-1.22)	1.26**** (1.24-1.29)
2	26321	1	1	38041	1	1
3	18220	0.95**** (0.94-0.97)	0.93**** (0.91-0.94)	26018	0.99 (0.98-1.01)	0.96**** (0.94-0.98)
4+	10522	0.96*** (0.94-0.99)	0.91**** (0.89-0.94)	14750	1.04**** (1.02-1.06)	0.97*** (0.95-0.99)

CVD mortality

	Women			Men		
	Number of deaths	Model 6	Model 7	Number of deaths	Model 6	Model 7
Number of children						
0	1953	1.84**** (1.72-1.97)		8158	1.47**** (1.41-1.53)	
1	1753	1.35**** (1.28-1.43)	1.44**** (1.35-1.53)	4094	1.16**** (1.12-1.20)	1.20**** (1.16-1.25)
2	3882	1	1	10228	1	1
3	2892	0.97 (0.92-1.02)	0.94*** (0.89-0.98)	7304	1.02 (0.99-1.05)	0.99 (0.96-1.03)
4+	1996	1.04 (0.99-1.10)	0.98 (0.93-1.04)	4423	1.11**** (1.07-1.15)	1.05*** (1.01-1.09)

Mortality from IHD

	Women				Men			
	Number of deaths	Model 6		Model 7	Number of deaths	Model 6		Model 7
Number of children								
0	787	1.83****	(1.65-2.03)		4599	1.39****	(1.32-1.47)	
1	727	1.35****	(1.23-1.47)	1.43**** (1.30-1.57)	2443	1.14****	(1.09-1.19)	1.17**** (1.12-1.23)
2	1619	1		1	6235	1		1
3	1176	0.93*	(0.86-1.00)	0.89*** (0.83-0.96)	4482	1.02	(0.98-1.06)	0.99 (0.96-1.03)
4+	849	1.02	(0.93-1.11)	0.94 (0.86-1.03)	2685	1.09****	(1.04-1.14)	1.03 (0.98-1.08)

Mortality from other HD

	Women				Men			
	Number of deaths	Model 6		Model 7	Number of deaths	Model 6		Model 7
Number of children								
0	432	2.04****	(1.76-2.37)		1456	1.79****	(1.62-1.98)	
1	336	1.46****	(1.28-1.67)	1.54**** (1.34-1.77)	639	1.27****	(1.16-1.40)	1.34**** (1.22-1.48)
2	671	1		1	1437	1		1
3	466	0.90*	(0.80-1.01)	0.88** (0.78-1.00)	1022	1.02	(0.94-1.10)	0.98 (0.91-1.07)
4+	347	1.04	(0.91-1.20)	1.01 (0.88-1.17)	602	1.08	(0.98-1.20)	1.02 (0.92-1.13)

Mortality from stroke

	Women				Men			
Number of children	Number of deaths	Model 6		Model 7	Number of deaths	Model 6		Model 7
0	548	1.87****	(1.65-2.11)		1306	1.45****	(1.31-1.61)	
1	486	1.29****	(1.16-1.44)	1.39**** (1.24-1.55)	615	1.15***	(1.05-1.27)	1.19**** (1.08-1.32)
2	1142	1		1	1532	1		1
3	874	1.02	(0.94-1.12)	0.99 (0.91-1.09)	1098	1.03	(0.95-1.12)	1.02 (0.94-1.10)
4+	555	1.06	(0.96-1.18)	1.02 (0.91-1.14)	675	1.14***	(1.04-1.26)	1.12** (1.02-1.24)

Mortality from other CVD

	Women				Men			
Number of children	Number of deaths	Model 6		Model 7	Number of deaths	Model 6		Model 7
0	186	1.48****	(1.21-1.82)		797	1.49****	(1.31-1.69)	
1	204	1.35****	(1.14-1.60)	1.45**** (1.22-1.73)	397	1.12*	(1.00-1.26)	1.21*** (1.07-1.36)
2	450	1		1	1024	1		1
3	376	1.07	(0.93-1.23)	1.03 (0.90-1.19)	702	1.01	(0.92-1.11)	0.97 (0.88-1.07)
4+	245	1.07	(0.91-1.26)	1.01 (0.85-1.19)	461	1.24****	(1.10-1.40)	1.15** (1.02-1.29)

Notes:
Model 6: Estimated for all women or men and includes controls for age (5-year categories, except the highest which includes 75-80), year (5-year categories except the highest which includes 2010-15), education (unknown, primary, lower secondary, upper secondary, lower tertiary, higher tertiary), place of residence (19 counties of residence combined with whether the municipality of residence is a city), marital status (never-married, married, divorced/separated, widowed, other), spouse's education (same categories as own education), whether two or more co-parents (1 if have at least two children and there are at least two different co-parents, otherwise 0)
Model 7: Estimated for parous women or men and includes the same variables as Model 6 plus age at first birth (<18, > 38 and three-year groups between these).
Multinomial logistic models where the various alternative causes of death were the possible outcomes along with 'no death' as the 'reference outcome' gave essentially identical results. ICD-10, ICD-9 and ICD-8 codes used to categorize CVD: All CVD: I00-I99, 390-459; IHD: I20-I25; 410-414; Other HD: I26-I52; 415-429; Stroke: I60-I69, 430-438
*p<0.10; **p<0.05; ***p<0.01; ****p<0.001

Table 2. Effects (odds ratios with CI) of number of children on various cardiovascular risk factors measured in health surveys between 1994 and 2003, in logistic models for women and men who were born in Norway in 1935 or later and at the time of surveys were older than 40.

Currently smoke daily

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.05 (0.96-1.14)		1.04 (0.95-1.14)	
1	1.28**** (1.20-1.37)	1.43**** (1.34-1.54)	1.15**** (1.07-1.23)	1.26**** (1.17-1.36)
2	1	1	1	1
3	0.89**** (0.85-0.94)	0.83**** (0.79-0.87)	0.90**** (0.85-0.95)	0.85**** (0.81-0.90)
4+	0.82**** (0.77-0.88)	0.72**** (0.67-0.77)	0.91** (0.84-0.98)	0.83**** (0.77-0.90)
Number of respondents:	44681	40655	40551	34672
% smoking:	36.2	36.3	33.3	32.8

Alcohol intake at least once a week

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.08 (0.98-1.18)		0.76**** (0.70-0.82)	
1	0.96 (0.90-1.04)	1.03 (0.96-1.11)	0.91** (0.85-0.98)	0.99 (0.92-1.07)
2	1	1	1	1
3	0.79**** (0.75-0.84)	0.77**** (0.72-0.81)	0.83**** (0.79-0.88)	0.80**** (0.75-0.84)
4+	0.54**** (0.45-0.59)	0.50**** (0.46-0.55)	0.66**** (0.61-0.71)	0.61**** (0.56-0.66)
Number of respondents:	41697	37977	38869	33350
% with alcohol intake at least once a week:	31.8	31.2	46.0	46.8

No heavy (defined as “sweating or out of breath”) physical activity in leisure time, including time spent going to work, last year

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	0.96 (0.87-1.05)		1.24**** (1.14-1.36)	
1	1.17**** (1.09-1.26)	1.11*** (1.03-1.20)	1.16**** (1.07-1.25)	1.16**** (1.07-1.26)
2	1	1	1	1
3	1.07** (1.01-1.13)	1.08*** (1.02-1.14)	1.00 (0.94-1.06)	0.99 (0.93-1.02)
4+	1.25**** (1.16-1.34)	1.27**** (1.17-1.36)	1.13*** (1.04-1.24)	1.12*** (1.03-1.23)
Number of respondents:	38359	34764	36662	31398
% with no heavy physical activity:	38.8	39.3	28.8	28.2

BMI > 25

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.18**** (1.08-1.28)		1.02 (0.94-1.11)	
1	1.10*** (1.03-1.18)	1.09** (1.01-1.16)	1.03 (0.96-1.11)	1.08** (1.00-1.16)
2	1	1	1	1
3	1.07*** (1.02-1.12)	1.07*** (1.02-1.12)	0.99 (0.94-1.04)	0.96 (0.91-1.08)
4+	1.32**** (1.24-1.41)	1.31**** (1.22-1.40)	1.07* (0.99-1.16)	1.01 (0.93-1.09)
Number of respondents:	44912	40882	40703	34831
% with BMI > 25:	48.9	49.0	66.6	67.0

BMI > 30

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.50**** (1.35-1.68)		1.44**** (1.30-1.60)	
1	1.26**** (1.15-1.38)	1.24**** (1.12-1.36)	1.16** (1.06-1.27)	1.23**** (1.11-1.35)
2	1	1	1	1
3	1.09** (1.02-1.17)	1.09** (1.02-1.17)	1.03 (0.95-1.10)	1.00 (0.93-1.08)
4+	1.32**** (1.21-1.49)	1.32**** (1.21-1.44)	1.19**** (1.08-1.31)	1.13** (1.02-1.24)
Number of respondents:	44912	40882	40703	34831
% with BMI > 30:	15.2	14.9	15.8	15.0

Having moderately elevated total cholesterol (>6.5 mmol/l)

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.26**** (1.14-1.40)		1.08* (0.99-1.17)	
1	1.21**** (1.12-1.31)	1.23**** (1.13-1.34)	1.06 (0.98-1.14)	1.10** (1.01-1.18)
2	1	1	1	1
3	0.99 (0.93-1.05)	0.97 (0.91-1.03)	0.94** (0.89-0.99)	0.95*** (0.88-0.98)
4+	1.08** (1.01-1.17)	1.04 (0.97-1.17)	0.96 (0.88-1.04)	0.93* (0.86-1.01)
Number of respondents:	44961	40920	40713	34825
% with moderately elevated cholesterol:	24.7	24.7	28.7	28.6

Systolic blood pressure (averaged over two measurements) > 140

	Women (Model 6)	Parous women (Model 7)	Men (Model 6)	Parous men (Model 7)
Number of children				
0	1.24**** (1.11-1.37)		1.18**** (1.09-1.29)	
1	1.09* (1.00-1.19)	1.16**** (1.06-1.26)	1.06 (0.98-1.14)	1.12*** (1.04-1.21)
2	1	1	1	1
3	0.99 (0.93-1.05)	0.98 (0.92-1.04)	1.01 (0.96-1.07)	1.00 (0.94-1.05)
4+	0.97 (0.90-1.05)	0.96 (0.89-1.04)	1.08* (0.99-1.16)	1.05 (0.97-1.14)
Number of respondents:	45000	40941	40732	34836
% with blood pressure > 140:	22.7	22.6	32.8	32.5

Having diabetes

	Women (Model 6)		Parous women (Model 7)		Men (Model 6)		Parous men (Model 7)	
Number of children								
0	1.48**	(1.10-2.00)			1.70****	(1.32-2.19)		
1	1.31**	(1.02-1.69)	1.30*	(1.00-1.70)	1.07	(0.85-1.36)	1.14	(0.89-1.46)
2	1		1		1		1	
3	0.85	(0.69-1.04)	0.85	(0.69-1.05)	0.98	(0.82-1.19)	0.96	(0.80-1.16)
4+	1.16	(0.92-1.46)	1.16	(0.91-1.47)	1.08	(0.85-1.38)	1.03	(0.80-1.32)
Number of respondents:	44441		40452		40410		34581	
% with diabetes:	1.6		1.5		2.2		2.0	

Notes:
Models 6 and 7: Variables as described in Table 1 except that there are only 8 counties of residence.
*p<0.10; **p<0.05; ***p<0.01; ****p<0.001

Table 3. Effects of childlessness and high parity (4+) on mortality and risk factors, significant at 5% level (or 10% level).

	Childlessness		High parity (4+)	
	Women	Men	Women	Men
Mortality from				
All causes	+	+	-	-
All CVD	+	+		+
IHD	+	+		
Other HD	+	+		
Stroke	+	+		+
Other CVD	+	+		+
			Women	Men
Risk factors				
Smoke daily			-	-
High alcohol consumption		-	-	-
Physical inactivity		+	+	+
Overweight, BMI > 25	+		+	
BMI > 30	+	+	+	+
Elevated cholesterol	+	(+)		(-)
Hypertension	+	+		
Diabetes	+	+		

Notes:
Signs for childlessness indicate differences between childless and two-child parents according to estimates from Model 6 in Tables 1 and 2. Signs for high parity indicate differences between parents with four or more children and two-child parents according to estimates from Model 7 in Tables 1 and 2.

Appendix Table A1. Effects (odds ratios with CI) of number of children on all-cause mortality in discrete-time hazard models for women and men of age 40-80 in 1975--2015 and born in Norway in 1935 or later.

Women	Number of deaths	Model 1	Model 2	Model 3	Model 4	Model 5
Number of children						
0	11745	1.90**** (1.86-1.95)	1.88**** (1.84-1.92)	1.86**** (1.82-1.90)	1.66**** (1.62-1.71)	1.65**** (1.61-1.69)
1	11311	1.43**** (1.40-1.46)	1.40**** (1.37-1.43)	1.39**** (1.36-1.42)	1.31**** (1.28-1.34)	1.30**** (1.27-1.33)
2	26321	1	1	1	1	1
3	18220	0.97*** (0.95-0.99)	0.95**** (0.93-0.97)	0.97*** (0.95-0.99)	0.97*** (0.95-0.99)	0.97**** (0.95-0.99)
4+	10522	1.06**** (1.04-1.09)	0.98 (0.96-1.01)	1.02 (0.99-1.04)	1.00 (0.98-1.03)	0.99 (0.97-1.01)
Control for:						
Age, year		x	x	x	x	x
Education			x	x	x	x
Region of residence				x	x	x
Marital status					x	x
Spouse's education						x

	Women with 1+ child	
	Model 6	Model 7
Number of children		
0	1.69**** (1.65-1.74)	
1	1.33**** (1.30-1.37)	1.39**** (1.36-1.43)
2	1	1
3	0.95**** (0.94-0.97)	0.93**** (0.91-0.94)
4+	0.96*** (0.94-0.99)	0.91**** (0.89-0.94)
Control for:		
Age, year	x	x
Education	x	x
Region of residence	x	x
Marital status	x	x
Spouse's education	x	x
Whether 2+ co-parents	x	x
Age at first birth		x

Men	Number of deaths	Model 1	Model 2	Model 3	Model 4	Model 5
Number of children						
0	29708	2.18**** (2.15-2.22)	1.94**** (1.91-1.97)	1.93**** (1.90-1.96)	1.48**** (1.44-1.51)	1.47**** (1.44-1.50)
1	15774	1.40**** (1.37-1.42)	1.33**** (1.30-1.35)	1.31**** (1.29-1.34)	1.19**** (1.17-1.22)	1.18**** (1.16-1.20)
2	38041	1	1	1	1	1
3	26018	0.99 (0.98-1.01)	0.98** (0.97-1.00)	1.00 (0.98-1.02)	1.01 (0.99-1.03)	1.01 (0.99-1.02)
4+	14750	1.13**** (1.11-1.15)	1.07**** (1.05-1.09)	1.10**** (1.07-1.12)	1.08**** (1.06-1.10)	1.07**** (1.05-1.09)
Control for:						
Age, year		x	x	x	x	x
Education			x	x	x	x
Region of residence				x	x	x
Marital status					x	x
Spouse's education						x

	Men with 1+ child	
	Model 6	Model 7
Number of children		
0	1.48**** (1.45-1.51)	
1	1.19**** (1.17-1.22)	1.26**** (1.24-1.29)
2	1	1
3	0.99 (0.98-1.01)	0.96**** (0.94-0.98)
4+	1.04**** (1.02-1.06)	0.97*** (0.95-0.99)
Control for:		
Age, year	x	x
Education	x	x
Region of residence	x	x
Marital status	x	x
Spouse's education	x	x
Whether 2+ co-parents	x	x
Age at first birth		x

Notes:
Categorization of variables described in Table 1. *p<0.10; **p<0.05; ***p<0.01; ****p<0.001

Appendix Table A2. Effects (odds ratios with CI) of number of children on CVD mortality in discrete-time hazard models for women and men of age 40-80 in 1975-2015 and born in Norway in 1935 or later.

Women	Number of deaths	Model 1	Model 2	Model 3	Model 4	Model 5
Number of children						
0	1953	2.12**** (2.01-2.24)	2.14**** (2.02-2.26)	2.12**** (2.01-2.24)	1.82**** (1.71-1.94)	1.79**** (1.68-1.92)
1	1753	1.50**** (1.42-1.59)	1.46**** (1.38-1.54)	1.44**** (1.36-1.53)	1.34**** (1.26-1.42)	1.32**** (1.25-1.40)
2	3882	1	1	1	1	1
3	2890	1.00 (0.96-1.05)	0.98 (0.93-1.02)	0.99 (0.94-1.04)	0.99 (0.94-1.04)	0.98 (0.94-1.03)
4+	1996	1.24**** (1.17-1.31)	1.11**** (1.05-1.17)	1.13**** (1.06-1.19)	1.10*** (1.04-1.16)	1.07** (1.02-1.14)
Control for:						
Age, year		x	x	x	x	x
Education			x	x	x	x
Region of residence				x	x	x
Marital status					x	x
Spouse's education						x

	Women, with 1+ child	
	Model 6	Model 7
Number of children		
0	1.84**** (1.72-1.97)	
1	1.35**** (1.28-1.43)	1.44**** (1.35-1.53)
2	1	1
3	0.97 (0.92-1.02)	0.94*** (0.89-0.98)
4+	1.04 (0.99-1.10)	0.98 (0.93-1.04)
Control for:		
Age, year	x	x
Education	x	x
Region of residence	x	x
Marital status	x	x
Spouse's education	x	x
Whether 2+ co-parents	x	x
Age at first birth		x

Men	Number of deaths	Model 1	Model 2	Model 3	Model 4	Model 5
Number of children						
0	8158	2.23**** (2.16-2.29)	1.97**** (1.92-2.03)	1.96**** (1.91-2.02)	1.47**** (1.41-1.53)	1.46**** (1.41-1.52)
1	4094	1.36**** (1.31-1.41)	1.29**** (1.24-1.34)	1.28**** (1.23-1.32)	1.16**** (1.12-1.21)	1.15**** (1.11-1.20)
2	10228	1	1	1	1	1
3	7304	1.02 (0.99-1.05)	1.01 (0.98-1.04)	1.02 (0.99-1.06)	1.03** (1.00-1.06)	1.03* (1.00-1.06)
4+	4423	1.21**** (1.17-1.26)	1.14**** (1.10-1.18)	1.16**** (1.11-1.20)	1.14**** (1.10-1.19)	1.13**** (1.09-1.17)
Control for:						
Age, year		x	x	x	x	x
Education			x	x	x	x
Region of residence				x	x	x
Marital status					x	x
Spouse's education						x

	Men with 1+ child	
	Model 6	Model 7
Number of children		
0	1.47**** (1.41-1.53)	
1	1.16**** (1.12-1.20)	1.20**** (1.16-1.25)
2	1	1
3	1.02 (0.99-1.05)	0.99 (0.96-1.03)
4+	1.11**** (1.07-1.15)	1.05*** (1.01-1.09)
Control for:		
Age, year	x	x
Education	x	x
Region of residence	x	x
Marital status	x	x
Spouse's education	x	x
Whether 2+ co-parents	x	x
Age at first birth		x

Notes:
Categorization of variables described in Table 1. *p<0.10; **p<0.05; ***p<0.01; ****p<0.001