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Examining the Dutch Disability Trends in the Nineteen-nineties: Age, Period, and Cohort Effects

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Abstract
The paper focuses on changes in the prevalence of disability at older ages in the Netherlands during the nineteen-nineties. Disability is characterized by two self-reported indicators of mild and severe disability and two self-reported and objective measures of functional limitations. Age, period, and cohort (APC) factors are potential determinants of disability at older ages. Understanding the role of APC factors is crucial to get insight into current and future disability trends. To reach this objective, we had to deal with the well-known identification problem -- namely year of birth plus age equals calendar year of measurement. The identification problem is tackled by modeling cohort and period effects using lifetime macro-indicators. This approach -- innovative in analyses on disability trends – also explains mechanisms underlying period and cohort effects. Analyses are conducted using data from the Longitudinal Aging Study Amsterdam. We produce evidence of increasing trends in functional limitations and disability at all ages above 60 and for both genders. These are largely caused by adverse period effects due to restrictions in acute and home care services. In addition, we find evidence of cohort effects -- mainly because of differences in exposure to tuberculosis mortality in year of birth – on functional status and disability. This holds more specifically for females.

Keywords: Trends in Disability, Trends in Functional Limitations, Cohort effects, Period effects, Netherlands.

JEL classification: I12, J14 and C33

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1 Introduction

Evaluating trends in disability at older ages is an important public health issue as the burden of disability is highly associated with the well-being of older populations, with the total needs for and use of health care services, and eventually with mortality. The evidence on disability trends at older ages is mixed and contradictory. Manton, Stallard & Corder (1997) showed that the proportion of males and of females without disability was higher in younger cohorts at all ages in the nineteen-nineties in the United States. A decreasing risk of disability was also established at ages 75, 80, and 85 between 1989 and 1999 in Finland (Pitkala, Valvanna, Kulp, Stranberg & Tilvis 2001). Robine (1994) showed some decrease in the prevalence in disability for ages 65 to 84 and for age 85+ in the nineteen-eighties in France. On the other hand, an increase in (severe) disability rates has been shown in Australia for individuals aged 50 and above between 1981 and 1998 (Davis, Beer, Gligora & Thorn 2001). The proportion of disabled adults in private households in Great Britain was much higher in 1996/97 than in 1985 (Grundy, Ahlburg, Ali, Breeze & Sloggett 1999). With respect to the Netherlands, Hoeymans, Feskens, van den Bos & Kromhout (1997) showed that the functional status of Dutch men aged 65-85 deteriorated between 1990 and 1995. Perenboom, van Herten & Staats (2000) produced evidence of an increase in the prevalence of mild disability for Dutch individuals aged 65 years and over between 1989 and 1998 – with larger increases for females than for males.

In the studies cited, disability was defined in various ways, hampering interpretation of differences between studies. To correctly assess disability trends, disability status needs to be comprehensively characterized. Verbrugge and Jette (1994) developed a hierarchical model in which functional losses induce disability problems. Functional losses restrict the ability, e.g., to move, bend, grasp, or see, whereas disability is defined as the inability to perform daily activities mostly linked at older ages with personal care, domestic chores, or social activities. Changes in disability and functional limitations prevalence rates may have different causes and, consequently, different potential policy implications (Manton, Corder & Stallard 1993). Therefore, both measures of functional and disability status were included in our analyses. Furthermore, the ways in which individuals report their health problems may be influenced by changes in social conditions. Therefore, in addition to self-reports, an objective measure of functional limitations was included in the study as well. By including this set of measures, we aimed at covering the main dimensions of disability at older ages and at obtaining a comprehensive picture of the Dutch trends in disability in the nineteen-nineties.

The prevalence of health disorders at older ages is clearly related to the aging of the individual (age effects). Cohort effects relate to the impact of macro conditions that different birth-cohorts have experienced during their life course and that may affect health status at older ages. For instance, the prevalence of chronic diseases at older ages is related to the socio-economic and living conditions as well as to exposure to infectious diseases in early life and young adulthood (Blackwell, Hayward, & Crimmins 2001; van de Mheen, Stronks, Looman & Mackenbach 1998; Manton et al. 1997). Period effects refer to macro conditions that affect health status of all cohorts at the time of occurrence[1]. For example, the current availability and quality of health care facilities may affect the average disability status of the population. Consequently, age, period, and cohort (APC) factors should be included in analyses on disability trends. Understanding the role of APC factors is not only crucial to get insight into current disability trends and observed differences across countries. It also helps in knowing whether the observed trends will continue in the future, depending on the aging of the population and on whether the observed macro-conditions will be repeated or altered in the future. The present study focuses on evaluating current disability trends and on the role of APC factors in explaining them. To reach this objective, we had to deal with the well-known identification problem – namely year of birth plus age equals calendar year of measurement (the linearity constraint).

The large majority of APC analyses on health trends use dummies to proxy the APC effects and impose some restrictions on the parameters to remove the linearity constraint. For example, they ignore a priori period or cohort effects (e.g. Alwin and McCammon 2001; Kunst and Mackenbach 1997) or estimate successively three two-factors models in each of which one effect is ignored (e.g. Hoeymans et al. 1997a). However, ignoring a factor that should be included in the analyses contaminates the estimation of the remaining parameters (see Portrait, Alessie, and Deeg 2002 for more details) .

In the current study, we followed a different approach and disentangled the APC effects using a modeling method that is extensively described in Portrait et al. (2002) and in references mentioned in this paper. The identification problem was tackled by modeling cohort and/or period effects using better proxies for the underlying processes (Nydegger 1981; Heckman & Robb 1985; Deeg 1989). To be more specific, the dummies for year of birth and timing of interview – that usually characterize the cohort and period effects – were replaced by macro-indicators. A first set of indicators – referred to as cohort variables – characterized the hygienic and socio-economic conditions during infancy or adulthood that may affect disability at older ages. A second set of indicators – labeled as period variables – described the living conditions during the study period that may affect disability status.

The modeling method has two advantages: to handle the identification problem and to reveal some of the mechanisms that lead to cohort and period effects. So far, the modeling approach is innovative in analyses on disability trends and has been seldom applied in analyses on health trends. One major exception is the study of Monden, Kraaykamp & De Graaf (2003). The authors examined cohort and period effects in self-reported health and chronic diseases in the period 1974-1998 for Dutch individuals aged 25-74. They produced evidence of adverse period effects and of cohort effects due to different exposures to infant mortality. Our study differs from theirs in several aspects. First, we examined self-reported and objective disability trends. Second, we concentrated on older ages and on the nineteen-nineties. Third, longitudinal data were used, which allow the correction for time-constant unobserved characteristics. Fourth, we included a variety of statistical checks to assess the validity of our results; particularly, we tested whether the cohort and period effects were correctly modeled (see section 4). Finally, Monden et al. (2003) only included infant mortality to proxy cohort effects and did not explain period effects. We explained both cohort and period effects using a large set of macro-indicators. The Netherlands faced large restrictions in care services during the nineteen-nineties (see e.g. Portrait 2000). Assessment of the effects of these restrictions was highly relevant. Therefore the included period variables are focused on the availability of formal and informal care services.

The modeling approach was applied to each measure of disability status included in the study. The analyses were corrected for a set of demographic and socio-economic variables to investigate how the observed APC effects were affected by individual characteristics. Evidence that APC effects are, partly or fully, explained by current demographic and socio-economic characteristics, would provide additional information for the projections of the future disability status at older ages, and, hence, the concurrent (long-term) health care costs.

2 Data

The analyses were conducted using data from the Longitudinal Aging Study Amsterdam (LASA), an ongoing multidisciplinary research project (Deeg & Westendorp de Serière 1994; Deeg, Beekman, Kriegsman & Westendorp de Serière 1998). The LASA study follows over time a representative sample of 3,107 non-institutionalized and institutionalized individuals aged 55-85 at baseline. There is no refreshment sample. Three waves – held in 1992-93, 1995-96 (2,302 respondents aged 58-88), and 1998-99 (1,852 respondents aged 61-91) – were available at the time of this study (in total 7,261 cases). The dataset provides extensive information on the physical, emotional, cognitive, and social functioning of older individuals and also on a large set of variables that may affect functioning.

3 Measures

Disability measures In the LASA study, functional limitations are measured by two indicators. First, *self-reports of functional limitations* (FL) (van Sonsbeek 1988) assess the ability of respondents to cut one's own toenails, walk up and down a 15-steps staircase without stopping, and make use of private or public transport. In the LASA pilot study, nine items were used to measure functional ability and the three selected items were the most consistent ones to describe functional ability (Smits, Deeg, Jonker 1997; Kriegsman et al. 1997). The score takes on value 0, 1, 2 when an activity is performed without any difficulty, with difficulty or only with help respectively. A score equal to 3 is given to the respondent when the activity can not be performed. In the current study, the total score was obtained by summing the three activity scores (range: 0-9).

Second, *performance tests* measure the time needed to perform three daily activities (Gulranik 1994; Penninx, Deeg, van Eijk, Beekman, & Gulranik 2000): to put on and take off a cardigan, to walk 10 meters, and to sit down and stand up 5 times from a kitchen chair. A score equal to 1, 2, 3, and 4 was allocated to respondents who completed the activity within the first, second, third, and fourth quartile of time in seconds, respectively. A score equal to 5 was given to respondents who could not perform the activity. The total score was also obtained by summing the three unit scores (range: 3-15).

Mild and severe disability are assessed by asking the respondents whether health problems slightly or severely limit their normal daily activities. We converted this three-categories disability variable into two binary indicators. The first variable indicated whether a respondent suffered from mild or severe disability problems (i.e. total disability) versus no disability problems. The second variable indicated whether a respondent suffered from severe disability problems versus no or mild disability problems[2].

Demographic and socio-economic covariates We included: gender (1 = "male", 2 = "female"), attained education level of the respondent (three dummies ranging from "elementary education or less" till "high vocational, college, or university education"), household real net monthly income in 1,000 Euro, occupational prestige of the longest job according to Sixma and Ultee (1983) (ranging from 0 = "never had job" till 87 = "high prestige"), place of residence (three dummies for "West", "North-East", and "South"), degree of urbanization of the municipality in which the respondent lived (categorical variable ranging from 1 = "low" till 10 ="high"), partner status (0 ="no partner", 1 = "partner"), and whether the respondent experienced a significant event during childhood (war, poverty, death of the parents, divorce, drinking problems of one of the parents) (0 = "no", 1 = "yes").

Age, Cohort, and Period variables Age effects were characterized by means of piecewise linear splines (with 4 knots, namely 62.9, 69.4, 76.6, and 83.8 years of age). A spline characterization was used instead of age dummies because it was very flexible and saved degrees of freedom in the estimation of the parameters. Period effects were first proxied by six dummies, namely the calendar years during which respondents were interviewed.

Fourteen macro-variables were used to explain cohort and period differences at older ages. The macro-data are from Statistics Netherlands (2003).

With respect to cohort variables, we included five indicators measured in the year of birth of the respondent, namely:
- the infant mortality characterized by the number of survivors out of a population of 100.000 newborns after one year of life,
- the number of deaths due to infectious diseases and tuberculosis per 100.000 individuals,
- the average attained education level of fathers, and
- the fertility rate.

We also included:
- the number of children in primary school when the respondent was 7 years old,
- the average attained education level of cohorts born in the year of birth of the respondent, and
- the real Gross National Product (G.N.P.) per capita at the age of entrance to the job market (set at age 20).

Six period variables were included, namely:
- the number of hospital beds per 1,000 inhabitants,
- the average number of nursing days in hospitals per inhabitant,
- the number of persons aged 65 and above in residential homes (*1,000)
- the number of nursing days in nursing homes per inhabitant aged 65 and above,
- the number of workers in home care organizations per individual aged 65 and above, and
- the proportion of middle-aged females participating to the labor market (working middle-aged females are an essential source of informal care for older individuals).

4 Identification method

The data of the three waves were pooled together and regression techniques were used to obtain the effect of age, cohort, and period on disability measures. For a detailed presentation of the identification method, see Portrait et al. (2002). Briefly, the linearity constraint was first removed by replacing the C cohort dummies (characterizing the years of birth of the respondent) by K_c cohort variables. In preliminary analyses, the four disability models – in which age effects were modeled by a linear spline and period effects by calendar dummies – were estimated including step-wise all cohort variables[3] described in section 3. We examined the joint significance of the cohort variables using a χ^2-test and the variables that had jointly the highest explanatory power were included in the final models. Examination of the parameters of the period dummies gave insight into the direction of the period effects. Note that the cohort variables may reflect a trend in a factor that was not included in the models. Therefore, the associations found between disability status and cohort variables may be "spurious". We addressed the "spurious regression" problem by adding the quadratic "year of birth" terms to the models (to correct for the remaining trends) and examined whether the cohort variables still (partly) explained the disability outcome. Once the cohort variables were selected, the P period dummies were replaced by K_p period variables, using an approach similar to the one used for the cohort variables.

Finally, we re-estimated the four models including age effects, C cohort dummies and the K_p period variables to validate the results on cohort effects. Cohort effects were found when the C cohort dummies were jointly statistically significant.

We tested whether the cohort and period effects were correctly specified adding an arbitrary set of (C-K_c-1) cohort dummies and of (P-K_p -1) period dummies successively to the models including cohort and period variables. The joint significance of the additional dummies was tested using a χ^2-test. If the model was correctly specified, the parameters of the added (cohort and period) dummies were not significantly different from 0.

Longitudinal data sets – especially on older individuals – are likely to suffer from attrition due to mortality or frailty. Therefore, an initially random sample may end up as a selective sample where the relatively healthy individuals are over- or under-represented – even after we control for observed explanatory variables. See Deeg, van Tilburg, Smit, & de Leeuw (2002) for the characteristics of attrition in the LASA data set. Our analyses were corrected for selective attrition by including two selection variables called Mill ratio's (Wooldridge 1995), the first one for attrition between wave I and II, the second for attrition between wave II and III.

Unobserved factors such as genetic vulnerability or lifestyle might induce a correlation between the disability outcome and its determinants, which may lead to an incorrect representation of the data. We corrected for the impact of unobserved individual effects using a panel data random effects technique that canceled out the possible correlation between the unobserved factors and the determinants by including the individual-specific averages over time of the time-varying variables (Mundlak 1978). The averages over time – when insignificant – were excluded from the final models. STATA was used to perform the calculations.

5 Results

5.1 Preliminary analyses

Table 1 describes baseline health, demographic, and socio-economic variables. Approximately 42% of our respondents reported functional limitations, 35% had a performance score greater or equal to 9 and can be called "objectively limited", 20% reported mild disability, and 12%, severe disability. Table 2 shows the trends in cohort variables between 1908 and 1937 (years of birth of the respondents): decreasing infant mortality, a steady decline of the number of deaths due to tuberculosis and infectious diseases with the exception of the years around the first World War, a slight increase of the average education level of the father and of the children, a drop in the fertility rate, and a relatively stable G.N.P. at age 20 from 1907 till 1925 that rose afterwards. Table 3 reports on the period macro-variables. It shows a decreasing availability of care services during the nineteen-nineties and an increasing middle-aged female labor participation.

< Insert Tables 1, 2, and 3 about here. >

5.2 Graphical approach

To get a better understanding of the data, we first performed a graphical analysis. Figures 1 and 2 display the prevalence of functional limitations and disability at the three waves for 10 cohort categories of 3-year span. At each line, the average year of birth of the cohort followed is shown. For instance, at the first line, 36 refers to individuals born between 1935 and 1937, and who were aged 55-57 at wave I, 58-60 at wave II, and 61-63 at wave III. On each line, the cohort factor is held constant, and the trends that we see are age-period effects. The vertical difference between lines measures the cohort-period effect (the age factor is held constant).

A clear age-period effect (increasing exponentially with age) was disclosed for self-reported functional limitations and disability: on each line, the average FL and total disability scores were higher in wave III than wave I at all ages, whereas the prevalence of severe disability only increased from age 65. Regarding the performance test, the picture was more complex as the average scores in wave II were lower than in wave I at all ages (till 80) and for all cohorts. This can be explained by a "practice effect" (see for instance Hoeymans, Wouters, Feskens & van den Bos 1997b; Tager, Swanson & Satariano 1998). Respondents at wave II knew the content of the tests and were more prepared to perform them. In wave III, they performed worse than in wave II which corresponded to an age-period effect.

No systematic cohort-period effects for self-reported functional limitations and severe disability were disclosed as the ordering of the scores in the three waves changed as age increased. On the other hand, the figures showed cohort-period effects for objective functional status and total disability, with more recent cohorts reaching higher scores than older cohorts at each age. Clearly, a graphical approach is not very helpful to disentangle the APC effects. In the next section, the results of our modeling approach are presented.

< Insert Figures 1 and 2 about here. >

5.3 Modeling approach

Table 4 displays the results for the four health measures of the APC analyses including cohort and period variables. Table 5 reports the χ^2-statistics of the joint significance of the selection, age, period, and cohort parameters. Table 6 reports the χ^2-statistics to test whether the cohort and period effects were correctly specified.

< Insert Tables 4, 5, and 6 about here. >

Both selection variables were negative in all models (showing that respondents who remained in the LASA study were on average healthier than the drop-outs) and jointly statistically significant, except for severe disability.

Age effects Strongly significant increasing age effect were found for functional limitations (after approximately age 70, see Tables 4 and 5): the older the individuals were, the more functional limitations they reported and the poorer the performance test was. With respect to disability, the analyses indicated the existence of age effects as well. Figure 3 shows the age patterns after correction for the differences in scales of the four disability measures: the age effect was the strongest for the self-reported functional status and the weakest for total disability.

< Insert Figure 3 about here. >

Cohort effects Two variables explained the cohort effects (Tables 4 and 5). Note that the variable "quadratic year of birth" was not significant in any model (in other words there is no remaining trend) and was excluded from the final specifications. First, the more deaths caused by tuberculosis during the first year of life, the poorer the performance test was and the more often total disability was reported. Second, favorable economic conditions at age 20 had a positive effect on objective functional status at older ages. Trends in tuberculosis mortality and G.N.P. at age 20 were not linear for the successive birth cohorts (with e.g. cohorts born in the period around the first world war facing higher tuberculosis mortality than others, see Table 2). Therefore, the observed cohort effects in the nineteen-nineties were not systematic. Regarding self-reported functional limitations and severe disability, the cohort variable with the highest explanatory power was the "tuberculosis" variable, which however did not reach significance. All other cohort variables had a lower explanatory power. Therefore, cohort effects did not appear to be relevant here. Estimation of a model including age effects, a full set of cohort dummies and period variables confirmed the absence of cohort effects for self-reports on functional status and severe disability since the cohort dummies were not jointly significant ($\chi^2(29) = 29.29$ and 1.12, respectively)[4]. We could accept the hypothesis of correct modeling of the cohort effects in all models (Table 6).

Following the work of Monden et al. (2003), we tested whether these results were valid for both sexes. We re-estimated the four models adding interaction terms for gender and the cohort variables[3,5]. In model (1), the absence of cohort effects appeared to hold only for males: the interaction coefficient (T-value equal to 7.08) indicated that females who experienced poor hygienic conditions during infancy reported significantly more functional limitations at older ages. Regarding the performance test, only the interaction coefficient associated with tuberculosis was significant (T-value equal to 2.90): females who faced poor hygienic conditions in infancy performed less well on the performance test than males. The cohort effect for total disability appeared to be stronger for females than for males. However, no gender effect was found for severe disability.

Finally, we calculated the magnitude of the cohort effects on functional status and disability. First, examining the effect of being born in a period with low versus high tuberculosis mortality (i.e. 1937 versus 1918) yielded on average an augmentation equal to 0.62 of the self-reported functional score, 1.24 of the performance score, 0.12 of the total disability score, and 0.06 of the severe disability score. These are strong increases given the range of each variable and given that the average scores equaled 1.67, 7.54, 0.36, and 0.14 for the four disability measures respectively. Second, examining the effect on the performance test of entering the job market in poor versus good economic conditions (with low G.N.P. per capita, e.g. 1933, versus high G.N.P. per capita, e.g. 1957) resulted on average in a decrease of the performance score equal to 0.63.

Period effects First, estimation of the four models including age splines, the cohort variables and a full set of period dummies – the first one excluded to avoid perfect correlation – showed significant, almost linearly, increasing trends in self-reported functional limitations, in total disability, and in severe disability (Table 7)[3,5]. Regarding the performance test, "practice effects" complicated the interpretation of the dummy coefficients. All respondents of wave II performed the test for the second time. Consequently, we could not separate the period from the "practice effects" at wave II. For this reason, we refrained from modeling the period effects. Re-estimation of model (2) including wave dummies instead of year dummies helped understanding the period effects. The coefficient associated with wave III was significant and positive (Table 4). This produced evidence of an increasing trend. The second wave coefficient was not significantly different from zero, which may indicate that favorable "practice effects" and adverse period effects compensated each other. Possibly the increasing trend between the first and the third wave was underestimated because of "practice effects" at wave II.

< Insert Table 7 about here. >

Second, we found that two variables explained the period effects (Table 4). Note that the quadratic "year of interview" variable was statistically significant only model 1 and was therefore excluded from the other disability models. First, restrictions in the availability of acute care facilities increased the probability of objective functional limitations and of disability. Second, restrictions in home care services significantly increased the probability of self-reported functional limitations. We could not find any significant effects of the supply reductions in informal and institutional care. The quadratic "year of interview" was significant and negative in model (1), indicating a decreasing trend after correction for the impact of the restrictions in health care. Unlike for cohort effects, no gender effects were found for the period effects. Note that we could accept the hypothesis of correct modeling of the period effects in all models (Table 6).

Finally, we quantified the effect on health measures of the restrictions in health care facilities between 1992 and 1998. This amounted on average to an increase equal to 0.60, 0.17, and 0.07 of the scores on self-reported functional limitations, total disability, and severe disability respectively. These effects are of the same size as the maximum cohort effects.

Demographic and socio-economic variables Females reported significantly more functional limitations and total disability than males, but performed better on the performance test (coefficient significant at a 10% level). We did not find any gender effect for severe disability. Currently having a partner decreased the probability of self-reported functional limitations only. Furthermore, we found strong socioeconomic effects in all models. First, medium educated respondents were favored compared to lower educated individuals with respect to functional status and total disability. Second, high education positively affected total and severe disability. In addition, a positive effect of having a higher income was demonstrated in all models. This was an effect of average income and no additional effect of variation of income at each wave was shown. Furthermore, respondents whose longest job had a high prestige reported less functional limitations at older ages than others. No significant job prestige effect was found in other models. Additionally, disability was not affected by the region in which the respondents lived. However, somewhat contradictory regional effects on functional status emerged : respondents in the North-East of the Netherlands reported more functional limitations but had better performance test scores than respondents in the

West. We could not find any "urbanization" effects and therefore excluded this variable from the final analyses. Finally, having experienced a significant event during childhood significantly increased the probability of functional limitations and disability at older ages.

The observed age, gender, cohort, and period effects were explained only to a limited extent by the individual demographic and socio-economic variables. We re-estimated the four models without demographic and socio-economic variables. In these four models, cohort and period effects remained similar. However, evidence of slightly more increasing age effects emerged. For self-reported functional status, the age effects were from approximately age 62, i.e. somewhat earlier than in the model including demographic and socio-economic variables. The differences between genders were to some extent explained by the demographic and socio-economic variables since, as in contrast to model (2), females had poorer performance tests than males in the model excluding demographic and socio-economic characteristics. The other gender effects remained similar.

Total period and cohort effects Figure 4 shows the total impact on functional status and disability of the (adverse) period and (unsystematic) cohort effects for individuals with specific ages and gender and with average demographic and socio-economic characteristics. Figure 4 is based on estimation results of Table 4.

< Insert Figure 4 about here. >

Clearly, the prevalence of functional limitations and disability increased in the nineteen-nineties at all ages and for both genders. Taking into account the differences in scales of the health measures, the prevalence of total disability showed the sharpest increase, followed by severe disability, self-reports on functional limitations, and objective functional limitations. Finally, the rise in prevalence in the period 1992-1999 appeared to be somewhat larger at age 80 than at age 70, and somewhat larger at age 70 than at age 60.

6 Discussion and conclusion

The purpose of our study was to assess trends in disability in the older Dutch population in the nineteen-nineties, and to explain these trends in terms of age, period, and cohort effects. To reach these objectives, we used a graphical and a modeling approach, and compared the results of both approaches. The increasing age-period trends shown in figures 1 and 2 were confirmed by our analyses. The figures did not demonstrate any systematic cohort-period effects for self-reports on functional limitations and severe disability. Our analyses, however, produced evidence of no cohort effects and increasing period effects. One explanation can be that the graphs were not corrected for gender and selective attrition. An informal check for this was to estimate models (1) and (4) in which first the selection variables and then also the gender variables were excluded. After the exclusion of gender, the period dummies showed unsystematic period effects, with some positive and some negative parameters. This was consistent with the graphical results.

Figures 1 and 2 displayed rising period-cohort effects for the performance test and for total disability. The analyses showed increasing period effects and unsystematic cohort effects. This seems to indicate that the adverse period effects dominated the favorable cohort effects. In sum, it can be stated that the graphical and analytical results nicely confirmed as well as complemented each other.

A first conclusion from this study is that the prevalence of functional limitations and disability increased at all ages between 60 and 80 and for both genders during the nineteen-nineties. A second conclusion is that the trends in self-reported functional limitations and disability were partly due to adverse period effects. We were also able to show adverse period effects for objective functional status even though we could not explain them due to the impossibility of disentangling the period from the potential "practice effects". The period effects for self-reports on functional limitations and disability were explained by restrictions in acute care facilities (indicated by the average number of days in hospitals) and home care services (indicated by the average number of home care workers for individuals aged 65 and above). We could not find any effect of restrictions in institutional care facilities and informal care. One explanation may be that individuals experience (higher levels of) functional limitations and disability as they are waiting for, e.g., surgeries. Patients may also be discharged from hospitals earlier which may result in a deterioration of their self-reported functional and disability status. When they are at home, hospital care can not be fully compensated by home care services, which may lead to a further decline in functional status. Disability was not further affected by restrictions in home or informal care services. Furthermore, our results showed a decreasing trend in self-reported functional limitations after taking into account the impact of the restrictions in acute and home care facilities. In other words, had there been no restrictions in health care services, self-reported functional limitations in the Netherlands would show a downward trend. Finally, both genders appeared to be equally affected by the adverse period effects.

A third conclusion from our study concerns a cohort effect. Our results indicated that childhood exposure to poor hygienic conditions (measured by tuberculosis mortality in year of birth) increased the probability of objective functional limitations and of total disability at older ages. Additionally, exposure to poor economic conditions at the entrance on the job market further increased the probability of objective functional limitations at advanced ages. Poor socio-economic conditions (indicated by average education level of fathers and respondents, fertility rate, and level of G.N.P.) did not appear to affect trends in self-reports in functional limitations and disability. However, poor hygienic and socio-economic conditions are likely to be correlated. Given the trends in childhood exposure to tuberculosis and in G.N.P. at age 20, more recent cohorts will have less functional limitations and less total disability than older cohorts (with the exception of the cohorts born around the first world war), all other things being equal. The fact that childhood exposure to tuberculosis mortality explained more than childhood exposure to all infectious diseases or to high infant mortality needs some explanation. We suggest that tuberculosis mortality was more directly associated with hygienic conditions, housing conditions, and general public health and wealth, and that all of these factors affected functional and disability status at older ages (van de Mheen et al. 1998, Blackwell et al. 2001). Finally, only objective functional limitations were affected by the macro-economic conditions when the respondent most likely entered the labor market. It could be that, in poor economic conditions, there are more highly physically demanding jobs and more work injuries. These may result more directly in a lower objective functional status at older ages than in lower self-reported functional and disability status.

An important finding is that the period and cohort effects on trends in functional limitations and disability were substantial and that they were not explained by the included demographic and socio-economic variables. Individual behaviour at older ages did not seem to moderate the negative consequences of childhood experiences and of the current macro-conditions.

A fourth conclusion concerns age effects. We found steeper age effects for functional limitations than for disability. One explanation may be that functional limitations are more sensitive to physical decline than disability and that assessment of disability is more directly related to what a person expects to do at a given age. The U-shape age effects for disability – noteworthy also present in the raw data – might be unexpected. However, this may indicate that, at similar objective health status, younger elderly individuals might report worse disability status than older elderly individuals because of higher expectations. With aging, the expectations may become more in concordance with the objective health status.

Our results confirmed and extended the work of Perenboom et al. (2000) and of Hoeymans et al. (1997a) which demonstrated an increase in the prevalence of mild disability for individuals aged 65 years and over between 1989 and 1998 and a deterioration of the functional status of Dutch men aged 65-85 between 1990 and 1995. Our conclusions are also consistent with and extend those of Monden et al. (2003) who explained the unfavorable trends in self-reported health and in chronic diseases by a decrease in infant mortality (for females) and by adverse – but unspecified – period effects.

Several limitations of the study should be mentioned. The main issue is the difficulty to obtain data on all past and current macro-circumstances that may affect disability at older ages. Especially with older individuals, historical data over a long period of time are required to construct cohort variables and these data are not always available. However, we could accept the hypothesis of correct modeling of the cohort effects in all models. Concerning period effects, other macro-conditions than the ones included in this study – such as economic prosperity, the quality of public health care, increased awareness or expectations regarding health status – may affect disability status as well. However, our focus was on the effect of restrictions in health care facilities faced in the Netherlands in the nineteen-nineties. Note moreover that we tested whether we were able to explain all period effects and this hypothesis was not rejected in all four models. Nevertheless, for self-reports on functional limitations, the quadratic "year of interview" variable was negative and significant, showing that there were positive trends that we were not able to explain in the current study.

A second limitation to the study is the restricted set of individual characteristics. In future research, risk factors for morbidity and disability such as smoking, drinking, body mass index, physical exercise could be explicitly included. In our study, such factors were taken into account by correcting the analyses for unobserved characteristics. However, if these individual characteristics show APC effects, explicit assessment will offer additional instruments to project the health status at older ages, and consequently the associated health care needs.

The main conclusion of our study is that the increased prevalence in functional limitations and disability that the Netherlands experienced during the nineteen-nineties was mainly caused by adverse period effects due to restrictions in acute and home care facilities. Interventions seem therefore required to limit the restrictions of care services and the concurrent consequences for the disability status of the older population. The increasing trends are weakened by favorable cohort effects caused by a decreased exposure to tuberculosis mortality in year of birth (for the most recent cohorts). The most important contributions of the study are that most of these conclusions were shown to be valid for an extensive set of self-reported and objective disability measures, that we investigated the role of a large set of macro-conditions and that we included a variety of statistical checks to assess the validity of our results.

Footnotes

[1]: Because period effects affect the entire population, only period effects that occur during the sample period can be identified. Indeed, affected and non-affected cases are needed to measure the impact of an event. The period effects that took place before the sample period are not identifiable and are actually confounded in the cohort effects.

[2]: To assess chronic disability, the respondent is asked whether health problems limited daily activities for a period longer than 3 months. Preliminary analyses showed no marked difference in trends for total and chronic disability and, as a consequence, we did not pursue our analyses on chronic disability any further.

[3]: Results available from the authors.

[4]: The "tuberculosis" cohort variable should however be included in models (1) and (4) since the age and period parameters of Table 3 slightly differed from the ones of models excluding the "tuberculosis" cohort variable.

[5]: The remaining coefficients were to a large extent similar to the ones reported in Table 3.

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Table 1: Baseline characteristics: Health, Demographic and Socioeconomic factors

Variables	Outcome	(%)
Number of respondents*		2,766
Self-reports on FL	Score = 0	58.8
	$1 \leq$ Score ≤ 3	25.5
	$4 \leq$ Score ≤ 6	8.9
	$7 \leq$ Score ≤ 9	6.8
Performance test	$3 \leq$ Score ≤ 5	28.7
	$6 \leq$ Score ≤ 8	36.0
	$9 \leq$ Score ≤ 11	23.4
	$12 \leq$ Score ≤ 15	11.9
Total disability	Score = 1	31.1
Severe disability	Score = 1	11.8
Age	[55-60)	11.7
	[60-65)	16.4
	[65-70)	17.2
	[70-75)	15.8
	[75-80)	18.7
	[80-85]	20.2
Year of birth	1908-12	18.2
	1913-17	18.5
	1918-22	15.1
	1923-27	15.8
	1928-32	16.7
	1933-37	15.7
Year of interview	1992	33.9
	1993	66.1
Female	Score = 2	51.2
Attained education level	Elementary or less	44.1
	Medium	41.9
	High	14.0
Net monthly income (in Euro)	< 625	22.3
	625-852	22.4
	853-1080	16.7
	1081-1477	18.9
	1478-1932	10.4
	> 1933	9.5
Occupational prestige longest job	Mean (Score from 0 till 82)	27.2
Place of residence	North-East	30.7
	South	23.9
	West	45.4
No partner	Score = 0	33.5
No significant event during childhood	Score = 0	72.4

*: After exclusion of missing values.

Table 2: Cohort macro-indicators

Year of birth	Survivors at one year of age per 100,000	Nb. deaths infectious diseases per 100,000	Nb. deaths tuberculosis per 100,000	Average education fathers*	Average education children*	Nb children primary school (x1,000)	Fertility rate	Real GNP per capita in Euro at age 20 **
1908	85,845	246.5	164.0	2.61	3.15	1010.9	4.1	4,358
1909	87,740	227.5	164.0	2.38	3.12	1025.3	4.0	4,449
1910	86,317	221.0	156.9	2.53	3.45	1039.7	3.9	4,337
1911	85,081	229.2	157.0	2.27	2.92	1056.8	3.8	3,938
1912	89,200	212.2	144.0	2.18	3.21	1073.9	3.8	3,552
1913	88,595	202.4	142.0	2.90	2.89	1091.0	3.9	3,441
1914	90,549	202.4	140.0	2.61	3.52	1108.1	3.9	3,396
1915	89,333	208.4	144.1	2.40	3.34	1125.2	3.6	3,415
1916	89,146	235.5	167.0	2.41	3.13	1134.2	3.6	3,474
1917	89,238	243.0	182.0	2.64	3.03	1143.2	3.6	3,789
1918	88,106	290.9	203.0	2.38	3.35	1152.2	3.5	3,836
1919	92,173	258.0	174.0	2.55	3.40	1161.2	3.4	4,143
1920	90,699	195.8	146.9	2.34	3.41	1170.2	3.9	4,012
1921	91,951	180.3	127.0	2.41	3.31	1177.0	3.8	3,900
1922	92,167	160.2	113.7	2.49	3.25	1183.8	3.5	3,804
1923	94,203	150.1	104.8	2.67	3.52	1190.7	3.6	4,077
1924	93,170	144.1	106.5	2.65	3.62	1197.5	3.4	3,969
1925	94,842	139.2	98.7	2.80	3.26	1204.3	3.3	3,880
1926	93,206	144.0	96.2	2.51	3.43	1235.7	3.2	3,510
1927	95,125	141.8	94.3	2.80	3.43	1267.1	3.1	3,936
1928	93,573	125.7	83.8	2.75	3.39	1298.4	3.1	4,327
1929	95,280	124.5	85.6	2.74	3.70	1329.8	3.0	4,538
1930	94,316	113.1	74.7	2.45	3.90	1361.2	3.0	4,438
1931	94,643	103.9	72.7	2.89	3.78	1359.4	2.9	4,527
1932	94,896	94.5	64.4	2.64	3.98	1357.6	2.8	4,691
1933	95,161	85.1	59.8	2.67	3.65	1355.7	2.7	4,952
1934	95,359	81.0	54.5	2.94	3.80	1353.9	2.6	5,211
1935	96,539	75.3	52.4	2.77	3.80	1352.1	2.6	5,771
1936	95,620	73.6	50.0	3.00	3.88	1353.0	2.5	5,860
1937	95,806	66.9	47.9	2.61	4.07	1357.5	2.5	6,018

*: calculation based on an education indicator with scores ranging from 1 (primary education not completed) till 9 (university 2nd grade).

**: real GNP measured in 1.0 Euro with 1990 as base year.

Table 3: Period macro-indicators

Indicators	1992	1993	1995	1996	1998	1999
Nb hospital beds per 1,000 inhabitants	4.2	4.1	3.9	3.8	3.7	3.6
Nb nursing days in hospitals per 1,000 inhabitants	1.1	1.08	1.02	1.0	0.94	0.88
Total number of residential home dwellers	127	124	119	117	108	107
Number nursing days in nursing homes per 65+	9.62	9.66	9.75	9.76	9.70	9.57
Number of home care workers per 65+	0.025	0.025	0.024	0.023	0.023	0.023
% working middle-aged females	34.76	34.81	41.44	42.31	45.8	47.07

Table 4: Estimation results

	Model 1 Self-reported FL		Model 2 Performance test		Model 3 Total Disability		Model 4 Severe Disability	
	Par.	T-val.	Par.	T-val.	Par.	T-val.	Par.	T-val.
Constant	19.933	5.74	10.324	3.64	2.192	4.65	1.107	3.41
Selection variable I	-1.163	-4.03	-0.479	-1.33	0.012	0.30	-0.019	-0.98
Selection variable II	-0.993	-2.44	-1.022	-2.29	-0.141	-1.87	-0.073	-1.26
Age spline								
[55,62.9)	0.003	0.19	-0.032	-0.80	-0.020	-3.01	-0.011	-2.55
[62.9,69.4)	0.028	1.42	0.017	0.56	0.003	0.81	-0.000	-0.31
[69.4, 76.6)	0.089	3.78	0.106	3.69	0.006	1.33	0.005	1.46
[76.6,83.8)	0.211	9.75	0.212	9.10	0.004	1.16	0.003	1.01
[83.8, 92)	0.363	6.15	0.205	3.91	0.013	1.47	0.016	2.04
Cohort variables								
Death tuberculosis	0.004	1.45	0.009	3.28	0.001	2.23	0.001	1.34
Real G.N.P. at age 20			-0.123	-2.16				
Period variables								
Hosp. nursing days	-8.780	-2.37			-0.796	-4.79	-0.338	-2.59
Home care workers	-4.072	-3.28						
(year of interview)^2	-0.024	-2.36						
Wave II/Pract. dummy			0.116	0.74				
Wave III			0.735	3.52				
Dem. & Soc-eco. Variables								
Female	0.502	6.25	-0.170	-1.72	0.029	2.18	-0.005	-0.39
Partner status	-0.218	-2.36	-0.171	-1.56	0.027	0.80	-0.010	-0.82
Medium Education	-0.275	-3.05	-0.300	-2.92	-0.036	-2.04	-0.012	-1.23
High Education	-0.217	-1.63	-0.192	-1.20	-0.086	-3.13	-0.037	-2.11
Real income	0.050	0.74	0.022	0.20	-0.012	-0.52	0.007	0.41
$\overline{\text{Real income}}$	-0.680	-6.01	-0.915	-5.70	-0.070	-2.37	-0.073	-3.35
Prestige	-0.005	-2.38	-0.003	-1.25	0.000	0.38	0.000	0.55
North-East	0.153	1.76	-0.339	-3.42	-0.003	-0.18	-0.013	-1.10
South	0.093	0.97	-0.099	-0.89	-0.019	-1.02	0.005	0.36
Childhood event	0.298	3.44	0.285	2.94	0.080	4.65	0.050	4.17
R^2	0.280		0.273		0.049		0.037	
Number of observations	6,276		6,184		6,408		6,408	

Table 5: χ^2-values for joint significance of the APC parameters

	Self-reported FL	Performance test	Total Disability	Severe Disability
Selection parameters	*16.7*	*6.0*	*9.5*	2.0
Age parameters	*206.2*	*174.3*	*21.5*	*25.1*
Period parameters	*19.7*	*84.7*	*19.1*	*6.7*
Cohort parameters	2.1	*10.4*	*3.3*	1.8

(Figures in italic are significant at 1%)

Table 6: χ^2-values for the joint significance of additional cohort and period dummies

	Self-reported FL	Performance test	Total Disability	Severe Disability
Cohort dummies	$\chi^2_{(28)} = 30.7$	$\chi^2_{(26)} = 25.9$	$\chi^2_{(28)} = 22.2$	$\chi^2_{(28)} = 30.4$
	(0.33)	(0.47)	(0.77)	(0.34)
Period dummies	$\chi^2_{(2)} = 5.3$	n.a.	$\chi^2_{(4)} = 2.8$	$\chi^2_{(4)} = 6.8$
	(0.08)		(0.60)	(0.15)

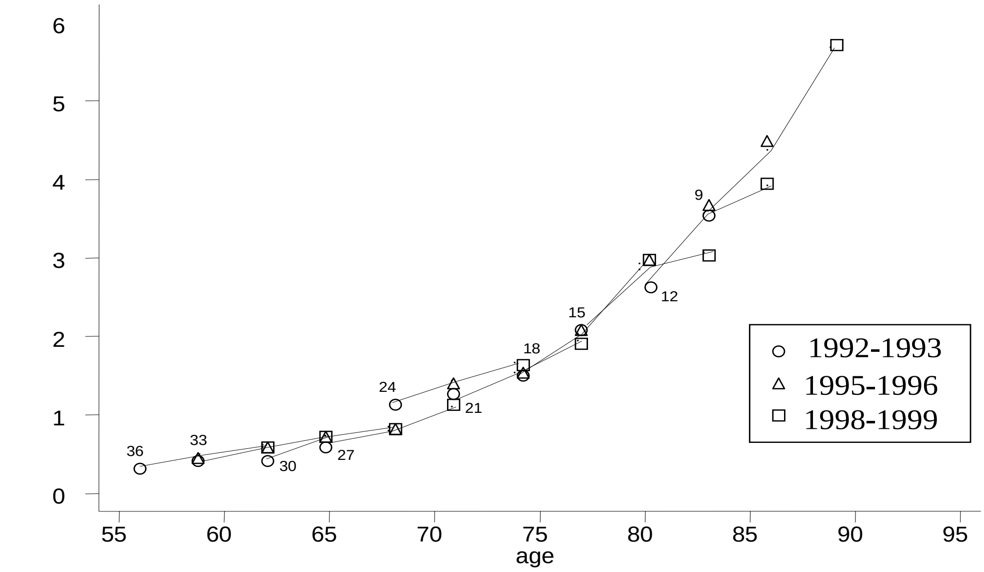
(Figures in brackets are the probabilities of acceptance of $H0$: models are correctly specified.)

Table 7: Estimation results with cohort variables and period dummies (Excerpt)

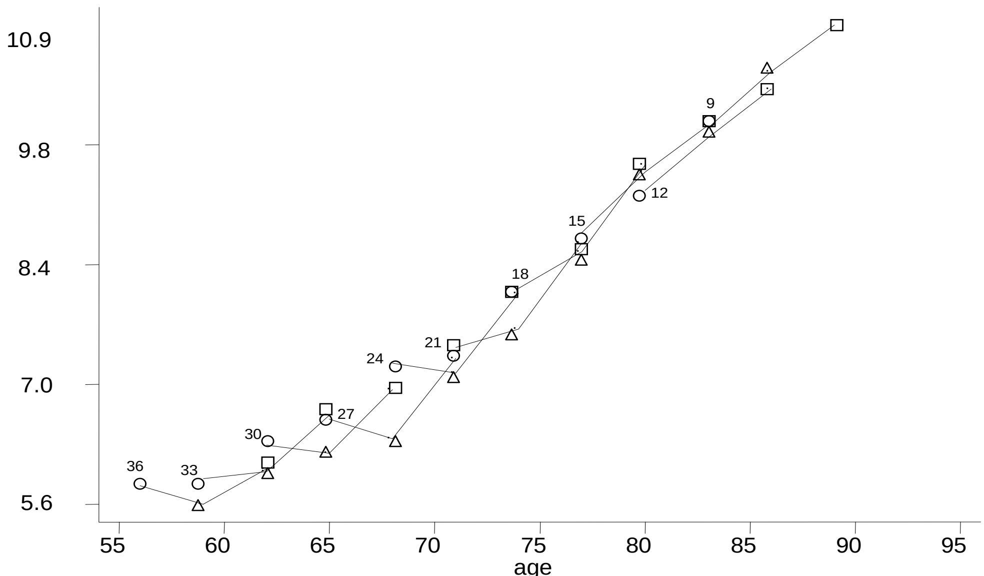
	Self-reported FL	Performance test	Total Disability	Severe Disability
Period dummy 1993	0.161 (1.9)	-0.735 (-6.9)	0.007 (0.4)	0.014 (1.1)
Period dummy 1995	0.450 (3.2)	-0.439 (-2.4)	0.086 (2.6)	0.033 (1.3)
Period dummy 1996	0.692 (4.5)	-0.358 (-1.9)	0.108 (3.2)	0.056 (2.2)
Period dummy 1998	0.220 (1.3)	0.090 (0.4)	0.127 (3.3)	0.008 (0.3)
Period dummy 1999	0.602 (3.0)	0.292 (1.2)	0.165 (4.2)	0.062 (2.2)
Joint significance	$\chi^2(5) = 25.6$	$\chi^2(5) = 84.7$	$\chi^2(5) = 21.4$	$\chi^2(5) = 12.5$

(T-value into brackets)

Figure 1: Functional limitations



Age / Period / Cohort effects in self-reports on functional limitations



Age / Period / Cohort effects in performance test

Figure 2: Disability status

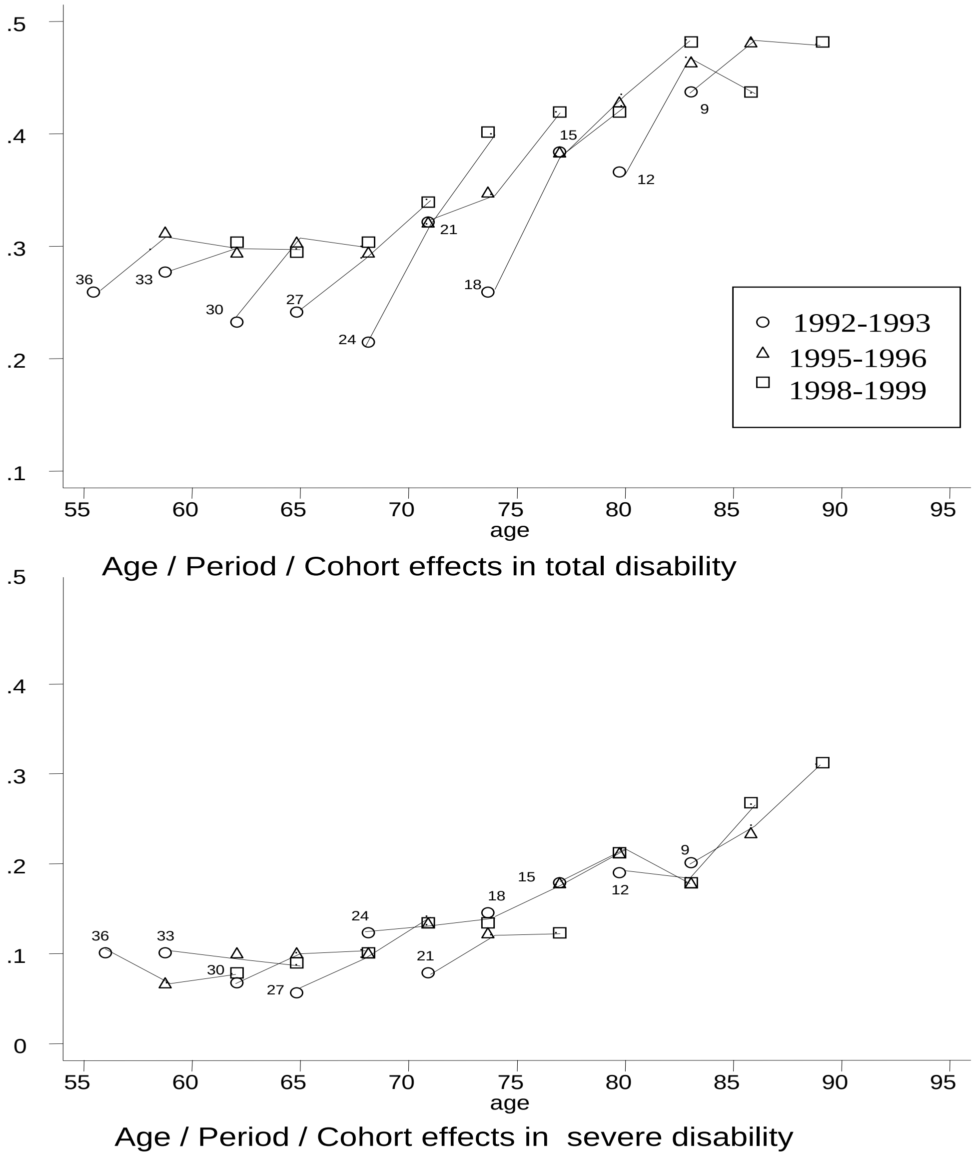


Figure 3: Age profile

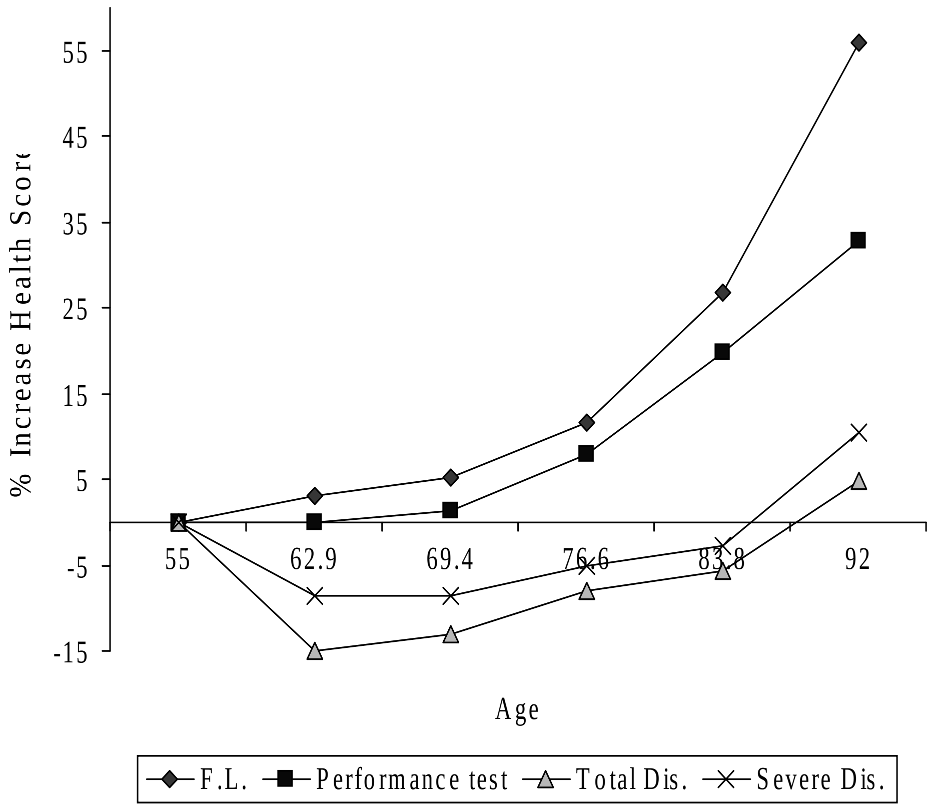


Figure 4: Total effect