Aging in disguise: age, period and cohort effects in mobility and edentulousness over three decades

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Abstract By corroborating cross-sectional with longitudinal analyses, this study illustrates how cohort effects can confound trends over age and time. Mobility (walking difficulties) and edentulousness (toothlessness) were studied from 1968 to 2002 in a nationally representative panel aged 18–75 (5 waves, $n \approx 5,000$) and ages 77+ at later waves (2 waves, $n \approx 500$). Three analyses were done: cross-sectional 10-year age group differences in 5 waves, time-lag differences between waves (shifts across time) for age groups, and within-cohort differences between waves for 10-year birth cohorts followed over time. Complementary age-period-cohort models using logistic regression analysis evaluated differences. Both mobility and edentulousness have earlier been shown to be strongly related to age cross-sectionally. For mobility, cross-sectional and longitudinal analyses showed large changes, whereas time-lag analysis indicated no or marginal changes. Both cross-sectional and longitudinal results showed an exponential curvilinear age dependency for mobility limitations, with limitations becoming more usual in older ages. In contrast, cross-sectional and time-lag analyses of edentulousness showed large differences, whereas longitudinal analysis indicated no or marginal changes. Rates of edentulousness became increasingly lower for successively later cohorts in a curvilinear fashion. These patterns demonstrate that age effects

dominated mobility, whereas cohort effects dominated edentulousness. Age-period-cohort models confirmed these findings. The cohort effect of edentulousness implies that the cohorts' movement through time gives a false impression of age and period effects in cross-sectional data.

Keywords Sweden · Edentulism · Dental health · Disability · Lower body function · Walking difficulties

Introduction

Most nations conduct surveys of the population on a regular basis to monitor different aspects of health and health-related risk factors over time and age. Health trends in the elderly population are of particular concern in regard to social policy and resource distribution (Freedman et al. 2002; Parker et al. 2005; Robine and Michel 2004). Epidemiological data over time help in understanding the effects of the aging process itself, of change during a studied time period, and of belonging to a specific generation, i.e., whether observed changes may be classified as due to age, period, or cohort effects. This study uses cross-sectional and longitudinal analyses to illustrate how cohort effects can confound descriptions of age and overtime trends.

A cohort refers to a group of people sharing similar social and cultural circumstances during a longer or a shorter time period (Ryder 1965). Most studies use the concept of birth cohorts, e.g., all the persons born in a specific year or within a 5- or 10-year time span. Cohort effects may be because of historical differences in the social or physical environment during childhood or young adulthood, or to differences in the structure or size of a cohort, e.g., baby-boomers differ from previous and later cohorts partly due to their greater numbers.

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Although cohorts may differ from each other because of different influences previous to the study, period effects reflect events and influences during a studied time period. This can include dramatic events in the physical and social environment such as famine or war but may also include more subtle changes, for example, shifting gender roles or changes in social policy.

Age effects are due to biological, psychological and behavioral processes connected with growing up and becoming older. Age effects are usually seen as indicators of the biological aging processes leading to impaired capacity (Dannefer 1984).

There are three basic study designs for examining development (Glenn 1977; Palmore 1978; Schaie and Willis 2002). First, cross-sectional designs make it possible to examine age differences in the distribution of a phenomenon. It will however remain unclear whether these differences are due to age or cohort effects. Second, with repeated waves of a survey it is possible to examine the changes between two or more measurements within the same age groups over a period of time, something Schaie (1965) called time-lag analysis. Such a design based on repeated cross-sectional surveys confounds period and cohort effects. Third, longitudinal designs enable researchers to follow birth cohorts over a period of time as they age. The age changes in a longitudinal design will confound age with period effects.

It can be difficult to disentangle age, period, and cohort effects (Donaldson and Horn 1992; Glenn 1977), but sometimes interpretations are evident (Palmore 1978). For example, if longitudinal and cross-sectional descriptions of the age-relatedness of a health condition agree, the most likely explanation is that only age effects are present, i.e., that period and cohort effects are negligible.

To exemplify the phenomena of age, period, and cohort effects, this study considers two age-dependent conditions: mobility and edentulousness. Mobility, i.e., walking limitations, is often used to reflect functional limitations or disability, and edentulousness, i.e., having no or very few teeth, is a common measure of dental health status.

Both edentulousness and the rate of walking limitations show clear gradual increases with age when analyzed cross-sectionally in a population (Ahacic et al. 1998, 2000). To what extent cohort differences, such as changes in childhood conditions (Macintyre 1997), influence this cross-sectional age-relatedness remains unclear. Comprehensive longitudinal descriptions are lacking. Edentulousness has decreased considerably over the past decades in many countries (Ahacic et al. 1998; Ainamo and Osterberg 1992; Osterberg et al. 2000; Suominen-Taipale et al. 1999; Truin et al. 1993; Vrbic 1995), while for walking limitations there is less agreement between studies (Freedman et al. 2002; Parker et al. 2005; Robine and Michel 2004).

Walking limitations and edentulousness are two phenomena common in old age. By comparing the patterns of effects in these two conditions, we may better understand which factors can be important in the development of a condition in the population over time. Do cross-sectional and longitudinal depictions of prevalence rates reveal similar pictures for walking limitations and edentulousness? What interpretations regarding age, period, and cohort effects can be made on the basis of these patterns?

Materials and methods

The Level of Living Surveys, LNU (Erikson and Åberg 1987), were conducted in 1968, 1974, 1981, 1991, and 2000. In 1968 the sample consisted of approximately 6,000 randomly selected persons between the ages of 15 and 75. When the survey was repeated in 1974, everyone from the 1968 sample who was living in Sweden and less than 76 years old was included. In 1974 and at each successive wave, a sample of younger persons and newly arrived immigrants were added to maintain representativity. The ceiling of 75 years was maintained but the lower age limit was raised from 15 to 18 in 1991. Thus, all waves were nationally representative of the adult population at the time of the survey. The surveys were carried out in collaboration with Statistics Sweden, and professional interviewers conducted the interviews. Between 1968 and 2000 the response rate fell from 90.6 to 76.6%. The number of respondents decreased from 5,654 to 5,126.

The SWEOLD study originates from the LNU. It consists of two cross-sectional nationally representative surveys of people aged 77 to 98 living in Sweden interviewed in 1992 and 2002 (Lundberg and Thorslund 1996). Response rates were 95.4 and 88.5% (Parker et al. 2005). The two waves for this study contain all those persons aged 77+ who had been eligible for at least one Level of Living Survey. They were interviewed in their homes or institutions, and subjects who could not be interviewed directly (11.9 and 12.8%) were interviewed by proxy.

Mobility was based on a single self-reported item concerning difficulties with walking 100 m. Possible answers were yes or no. Dental health was measured by the question: Which of the following statements best describes your teeth? The respondent was shown a card with the response alternatives: 1. No teeth or roots only; 2. Dentures, complete or partial; 3. Own teeth, in poor condition: many missing etc.; 4. Own teeth: many fillings, crowns or bridges; 5. Own teeth, in good condition; no or few fillings. “Edentulous” refers to response alternatives 1–3.

Analysis

Sometimes it is possible to infer the presence of age, period, and cohort effects by using the three kinds of designs (the cross-sectional, the repeated cross-sectional, i.e., the time-lag analysis, and the longitudinal) simultaneously (Palmore 1978). No effects would result in no measurable changes in any design. Second, when there is only one kind of effect, two of the designs will show a coinciding pattern and the third design will indicate no change. Thus, if a phenomenon is affected by age but not by period or cohort, then cross-sectional and longitudinal designs will indicate a similar age-related change, whereas a time-lag analysis will indicate negligible changes. When only period effects are present, a time-lag analysis and the longitudinal design will indicate a coinciding pattern of change over the time period, whereas the cross-sectional design will indicate no changes. Similarly, when only cohort effects are present, the cross-sectional design and a time-lag analysis will show a coinciding pattern of cohort differences, whereas the longitudinal design will indicate no change.

When all three designs indicate change, two or three effects are present. In order to separate effects, the so-called age-period-cohort regression models are called for (Holford 2006; Robertson et al. 1999).

This study examines (1) cross-sectional 10-year age group differences at five points in time: 1968, 1974, 1981, 1991/1992 and 2000/2002, (2) time-lag differences between waves (shifts across time) for 10-year age groups, and (3) longitudinal within-cohort changes between waves for 10-year birth cohort panels followed over age and time. A total of six different graphic descriptions are possible, as change in all three designs can be described in two alternative ways, e.g., longitudinal changes may be described either over calendar time or over age.

The irregular intervals between waves truncated some cohorts in some waves; these data were disregarded in the graphs (for the 1965–1974 cohort in the 1998 and 1991 waves, the 1955–1964 cohort in 1974, the 1945–1954 cohort in 1968, and the 1925–1934 cohort in 2002). Similarly, data on the oldest 10-year cohorts in the later waves were disregarded because of the upper age limit and the high mortality in the oldest ages (the 1895–1904 cohort in 1974 and 2002, and the 1892–1894 cohort in 1974 and later).

The irregular intervals also made it necessary to approximate most of the data points for the graphs of the cohort differences by age. These approximations were based on the curves describing the age differences in the longitudinal design, i.e., estimates for the specific ages were taken from the Excel spreadsheet used for the longitudinal age curves.

We also estimated age-period-cohort models with logistic regressions using the SAS statistical software (SAS Institute 1994). All observations from the seven waves

were collapsed into one data set. The results from two models are presented, with mobility limitations and edentulousness as outcome variables. Both outcomes were modeled with age, period, and cohort as independent variables. To reach a better model fit the model of mobility limitations also included the two-way interaction terms between cohorts and time periods, whereas the model of edentulousness only included the three main effects. The plots did not give us reason to believe that there were any interactions between the main effects in the model for edentulousness and pseudo R² was also reasonably high. Together this suggested that modeling the main effects only was sufficient to show that a one-effect solution represented an adequate description for edentulousness, something which was not true for mobility limitations. Age refers to the age at observation and period to survey year. Birth year was used to group people in 10-year birth cohorts. When plots for age and birth year suggested a curvilinear relationship with the outcome, curvilinear assumptions were used in regression models to estimate effects rather than categorical values, i.e., 10-year cohorts or age groups. The increases in odds for the curvilinear estimates are given for a 10-year interval. Quadratic terms were introduced in both models, and in the model for mobility limitations the quadratic term for age was significant and therefore kept in the presented model. McKelvey and Zavoina pseudo R² give a fair estimate of the model fit (DeMaris 2002).

Controls for truncated cohorts (dummy variables for the cohorts in the waves enumerated above) and age groups below age 18 (dummies for these ages in the 1968, 1974, and 1981 wave) were used when necessary in models.

Results

Walking limitations

Figure 1 shows the rates of walking limitations. The age differences based on the cross-sectional and the longitudinal designs are in the first row, the differences over the time period based on the time-lag analysis and the longitudinal design are in the second row, and the differences between cohorts based on the cross-sectional design and time-lag analysis are in the third row. Headings show the design and the effects that the curve confounds.

Figure 1a shows age differences by period, indicating age or cohort effects; i.e., the figure plots the prevalence by age in each survey. All curves show rates that increases with age. At age 40 the curves start to bend upward. Rates are higher for successively older age groups, indicating a curvilinear relationship for each wave. In short, the curves show cross-sectional age relatedness for walking limitations in all survey waves.

Fig. 1 Percent with walking limitations. Cross-sectional, longitudinal, and time-lag analysis of age, period, and cohort patterns

Figure 1b shows age differences by birth cohorts, indicating age or period effects; the figure plots the prevalence by age in each cohort. For example, the 1955–1964 cohort is followed from an average age of 21 years to age 40. Together the curves of the different cohorts show a curvilinear age-related increase in rates of walking limitations. As in the earlier figure, the increase in rates become evident after age 40, at which point the curves bend upwards, reaching more than 60% at age 90.

Figure 1c shows period differences by age, indicating period or cohort effects; i.e., the figure plots the prevalence by period (calendar time) for each age group. Over the whole period from 1968 to 2002, the curves indicate

successively lower rates of mobility limitations, evident foremost among the oldest age groups with the highest rates. In the youngest age groups with negligible rates, variation over time is less evident.

The figure also indicates that the trend differed between waves. Rates decreased between 1968 and 1991, as reported earlier (Ahacic et al. 2000). Between the last two waves the rates of limitations largely remain at the same level or increase somewhat (Parker et al. 2005).

Figure 1d shows the period differences by cohort, indicating period or age effects; i.e., the figure plots the prevalence by time period in each 10-year cohort. These curves are similar to the longitudinal age differences in Fig. 1b, except that

within-cohort changes have been distributed over time instead of over age. Between the years 1968 and 1974, rates of walking limitations increased, foremost in the 1905–1914, 1915–1924, and 1935–1944 cohorts, and less in younger cohorts. From 1974 to 1981 rates continued to increase. Between 1981 and 1991, the increases in rates are less obvious. During the 1990s rates again increased in all cohorts.

Figure 1e shows the cohort differences by period, indicating cohort or age effects; i.e., the figure plots the prevalence by cohort in each survey. These data showing between-cohort differences are similar to the cross-sectional age differences in Fig. 1a, but reversed and distributed over cohorts instead of age. All curves show rates that become successively lower for later-born cohorts.

The last figure, Fig. 1f, shows cohort differences by age, indicating cohort or period effects; i.e., the figure plots the prevalence by birth cohort at each age. The curves for older ages lie above curves for younger ages, indicating higher rates. In general, later-born cohorts seem to have lower or about the same rates as earlier cohorts at corresponding ages. There are some exceptions: at age 80 the 1915–1924 cohort may have had a higher rate than the earlier 1905–1914 cohort, and there are also some indications of increased rates between the last cohorts among younger ages.

Edentulousness

Figure 2 depicts rates of edentulousness over age, time period and cohorts. Figure 2a shows the age differences by survey year, indicating age or cohort effects. In all waves the percentage of edentulous people increases with age. Rates are successively higher in successively older age groups, indicating a curvilinear relationship for each wave. In this figure, edentulousness shows a pattern similar to walking limitations.

Figure 2b shows the age differences by cohort, indicating age or period effects. Compared to walking limitations two things stand out. Firstly, older cohorts have higher rates of edentulousness. Secondly, the curves run horizontally and parallel at different levels showing that the percent of edentulous people in each cohort stays more or less the same. Consequently, longitudinal analysis of edentulousness does not show any clear age dependency as walking difficulties do.

Figure 2c shows period differences by age, indicating period or cohort effects. The figure shows how rates of edentulousness have fallen between 1968 and 2000/2002 in all age groups.

The period differences by cohort are in Fig. 2d. The within-cohort changes indicate that the rates of edentulousness the cohorts started out with in 1968 stayed more or less stable over the time period.

The cohort differences by period, indicating cohort or age effects, (in Fig. 2e) show that the rates of edentulousness

become successively lower for later-born cohorts. The same pattern is seen in all survey waves. Together the curves of the different waves show consistent curvilinear cohort dependency.

The last figure, Fig. 2f, shows the cohort differences by age, indicating cohort or period effects. In each age the successively later cohorts show lower rates. Together the curves demonstrate a curvilinear cohort dependency, coinciding with the cohort dependency shown by the earlier figure (Fig. 2e).

Age, period, and cohort effects

The age effect component appears in cross-sectional age differences (Figs. 1a and 2a) and in longitudinal age differences (Figs. 1b and 2b). If period and cohort effects are negligible these figures will indicate the same trend, as seen for walking limitations. Similarly, cross-sectional (Fig. 2e) and time-lag (Fig. 2f) cohort differences agreed for edentulousness, which suggests only that cohort effects were present.

These effects were further evaluated with logistic regression models (Tables 1, 2) that estimate age, period, and cohort differences simultaneously.

Table 1 shows the model for mobility limitations, and OR's for age are found in the first two rows. Two terms for age are used. The first term indicates that as age increases the odds for mobility limitations increases, whereas the second (quadratic) term for age indicates a curvilinear form, i.e., that increases of odds with age become larger in older age.

Differences between cohorts are also found, with the 1935–1944 cohort as reference category (OR 1.0). In comparison to the 1935–1944 cohort, later-born cohorts have higher odds for mobility limitations, whereas earlier-born cohorts have lower odds (with the exception of the two oldest cohorts, which do not differ significantly).

The columns to the right show the relative odds for mobility limitations in earlier survey waves in comparison to the latest wave 2000/2002, the reference category. For example, the 1895–1904 cohort was included in 1968 and 1992 and odds were 3.32 times higher in 1968 compared to in 1992 for this cohort. The ORs indicate that odds were significantly higher in earlier waves for some cohorts (the 1895–1904, 1905–1914, 1915–1924, and 1925–1934 cohorts), whereas for other cohorts (the 1935–1944, 1945–1954, 1955–1964 cohorts) odds did not differ between waves. Cohorts only included once, as the 1892–1894 cohort in 1968, show only a reference value (OR 1.0), because there are no waves to compare odds with.

Including only the main effects of period and cohort (besides age) in this model would have averaged the OR for earlier waves over the cohorts, but would also have provided a poorer description of the observed changes. While

Fig. 2 Percent edentulous peoples. Cross-sectional, longitudinal, and time-lag analysis of age, period, and cohort patterns

the 1935–1944 cohort's period improvement was not significant (OR 1.38), earlier-born cohorts showed a successively larger period improvement.

Since the model included the interaction terms, which allowed the ORs for earlier waves to vary across cohorts, the between-cohort differences in the first column only estimate the OR between cohorts for the year of reference, that is 2000/2002 mostly (i.e., for all but the 1892–1894 and 1895–1904 cohorts).

Between-cohort ORs apart from in 2000/2002 (the reference category for all but the two 1892–1894 and 1895–1904 cohorts) are not presented in the table and need to be estimated separately. For example, odds for the 1925–1934 cohort are 2.82 times higher in 1968 than 2000/2002, for

the reference category 1935–1944 cohort odds are 1.38 times higher. In 2000/2002 OR is 0.64 for the 1925–1934 cohort in comparison to the reference cohort, in 1968 the corresponding odds ratio is $(2.82 \times 0.64) / (1.38 \times 1.0) = 1.31$. Similarly, ORs in 1968 for the 1915–1924, 1905–1914, 1895–1904, and 1892–1894 cohorts are 1.18, 1.57, 1.01, and 0.99, respectively.

Since there were no pronounced differences at baseline, the model indicates no particular cohort effects. The estimated period effects (or ORs between 1968 and 2000/2002) differed between cohorts, which indicates that the period effects varied by cohort. In short, the model indicates significant period effects (which benefited earlier-born cohorts more) besides age effects, but no clear cohort effects.

Table 1 Logistic regression modeling odds ratios for mobility limitations in the adult Swedish population between 1968 and 2002, for age, different birth cohorts, and at different times (survey waves) for these cohorts

		OR	Time period (survey wave) by cohort ^a				
			1968 OR	1974 OR	1981 OR	1991/1992 OR	2000/2002 OR
Age							
Linear ^b	1.26						
Quadratic ^c	1.10 ^{***}						
Cohort ^d							
1892–1894	1.37	1.0					
1895–1904	0.42	3.32 [*]			1.0		
1905–1914	0.28 ^{**}	7.76 ^{***}	5.98 ^{***}	3.94 ^{***}	1.35	1.0	
1915–1924	0.60 [*]	2.73 ^{***}	2.66 ^{***}	2.38 ^{***}	0.93	1.0	
1925–1934	0.64 [*]	2.82 ^{**}	2.42 ^{**}	2.69 ^{***}	1.30	1.0	
1935–1944	1.0	1.38	1.73	1.38	1.20	1.0	
1945–1954	1.56 [*]		1.04	0.97	0.75	1.0	
1955–1964	2.16 ^{**}			1.01	0.58	1.0	
1965–1974	3.00 ^{**}					1.0	
1975–1981	3.75 ^{**}					1.0	
Pseudo R2	0.29						

Truncated cohorts and age groups below age 18 were controlled for in the model

^a The latest survey wave is the reference category (OR 1.0), thereby showing ORs for earlier waves in each cohort. Omitted OR indicates lack of data regarding the cohort for that particular wave. These interaction terms between cohort and time period were introduced in the model because the average period change over all cohorts provided a poor description (evident by the cohorts' different (OR) period changes between 1968 and 2002)

^b This linear estimate shows the relative odds for an increase of ten years in age

^c The quadratic term was included to model age for a better fit. It suggests that the increase of odds with increasing age is better described as curvilinear, suggesting an increase of odds that becomes larger in older age. Notice, the addition of the quadratic term makes the straight linear estimate non-significant, i.e., in a model without the quadratic term the linear estimate is significant

^d The 1935–1944 cohort (OR 1.0) is the reference category. Since the model includes the interaction terms between cohort and time period (i.e., survey wave) the cohorts' OR are only for the latest wave, i.e., for 2000/2002 (with the exception of the 1892–1894 cohort for which it is 1968, and the 1895–1904 cohort for which it is 1992)

* $P < 0.05$, ** $P < 0.01$ *** $P < 0.001$

Table 2 shows the corresponding model for edentulousness. The model shows that age is not significant when adjusted for period and cohort differences. Similarly, period differences adjusted for age and cohort differences are not significant either. In short, the model indicates that only the cohort effects were significant.

Discussion

This study compared cross-sectional and longitudinal trends in prevalence rates of walking limitations and edentulousness. In general, cross-sectional and longitudinal plots of age differences showed a large correspondence for walking limitations. Rates of limitations increased with increasing age. For edentulousness, cross-sectional plots indicated strong age relatedness, whereas longitudinal plots indicated no age changes. Conversely, cross-sectional and time-lag plots of the period differences showed a large correspon-

dence for edentulousness, but not for mobility limitations. Rates of edentulousness were successively lower in later-born cohorts, but the large cohort differences had remained unchanged over time.

The observed patterns suggest that age effects dominated walking limitations, whereas cohort effects dominated dental status. The cohort effects in dental health status shows up as “false” age differences in cross-sectional data.

Our results also indicate that the cohort effects in dental status obscure any regular analyses of the trends over time, i.e., the period effects. In the dental health area many interventions have been made and the changes over time in connection with these interventions have been of great interest. For example, at the end of the 1960s large socioeconomic differences in dental health were found. This provoked a national debate that resulted in the initiation of a general insurance scheme in 1974, something quite unique even among the Nordic welfare states. With this scheme, the government aimed to create greater social class equity in

Table 2 Logistic regression modeling relative odds to be edentulous in the adult Swedish population between 1968 and 2002, for age, time period (survey wave), and cohort (birth year)

	OR
Age ^a	1.487
Time period ^b	
1968	2.00
1974	2.22
1981	1.80
1991/1992	1.10
1992 ^c	1.05
2000/2002	1.0
2002 ^d	1.03
Cohort ^e	1.864*
Pseudo R2	0.59

Age groups 15–18 are controlled for in the model

^a The increase of odds for an increase of 10 years in age

^b The 2000/2002 wave is the reference category (OR 1.0)

^c The 1992 survey concerned age 77+, whereas earlier waves concerned age 15–76

^d The 2002 survey also concerned age 77+

^e The relative increase of odds for a decrease of 10 years in birth year

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

dental health; it also had the goal of generally promoting better dental health in the Swedish population. The scheme was successively abandoned during the 1980s and 1990s.

The cohort effect is likely to reflect successive changes in dentistry taking place several decades ago. Extraction was a widely used dental cure earlier in the twentieth century. A gradual change of treatments, allowing more people to keep their teeth during the decades preceding this study's baseline, would have created the gradual decrease in edentulousness observed for later cohorts.

In another study we have discussed more elaborately the changes in edentulousness as well as changes in dental care services (Ahacic and Thorslund 2006). This study suggested that cohort effects dominate not only dental status but also dental care.

The improvement in dental status often seen in traditional trend analyses is the result of cohort replacement (older cohorts with high rates of edentulousness pass away), and the edentulousness rates for specific cohorts have been stable over time. Therefore, conclusions based on repeated cross-sectional studies, i.e., time-lag analysis, may have been erroneous.

Inconveniently, age, period, and cohort cannot be disentangled by empirical analysis alone (Donaldson and Horn 1992; Glenn 1977). For example, the complete lack of intra-cohort decline may be interpreted as to suggest an absence of age effects in edentulousness. On the other hand,

successful period interventions, preventing age-related decay may give a false impression. If this is the case, all three kinds of effects were in fact present but the magnitude of the age and period effects unknown. However, we would be able to infer that the age and period effects were of equal magnitude but of an opposite character, neutralizing each other. This represents the so-called identification problem, common to all approaches that try to identify effects. The important message here is that it is not possible to know by empirical evidence alone whether to ascribe the change to cohort effects, i.e., effects of events before baseline, or to period effects, i.e., events between baseline and follow-up (1968–2002). This is highly relevant in view of the interventions in dental health care policy.

A local Norwegian study of oral health found evidence for the presence of all three effects (Holst and Schuller 2000). These findings imply that there really are age effects, in which case these were perhaps successfully countered by interventions throughout the period in Sweden. Increasing knowledge of conditions and effects across countries is needed to better evaluate changes.

Our results suggest that disability is strongly characterized by age effects, indicating that it may be intrinsic to the biological aging process. The period effects in mobility might be explained by increases in the white-collar sector and women's entrance into the labor market (Ahacic et al. 2003). While increased physical activity contributed to period improvement, improvement was also counteracted by continued smoking habits.

The composition of the population being studied is always changing in ways that may not be well understood. For example, immigration or changes in the class structure may increase or decrease the population's risk for certain diseases. Mortality steadily changes the risk composition of the population, because those who die (and are thus removed from consideration) may have been at greater or lower risk of the diseases of interest than the surviving population. Different cohorts not only have different life histories and exposures to risk factors, prevention programs, and treatment methods, but even those interventions which they share with other cohorts may have been initiated at different ages in the different cohorts.

The present study minimizes some of the above concerns by being done in Sweden, where the population pyramid has been more stable than in many countries, and both immigration and emigration have been relatively modest and stable.

There are other possible sources of bias, e.g., measurement problems, non-response, and representativity. However, in light of the opposite patterns of mobility and dental health it seems likely that our findings are robust.

Our results suggest that disability is strongly characterized by age effects. Edentulousness, on the other hand, is

largely characterized by cohort effects that must be considered in analyses of trends over time.

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