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## Childhood Sensorineural Hearing Loss and Divorce in a Large Norwegian Cohort: Results from the HUNT Study

Mariann Idstad <sup>a</sup>, Kamilla Rognmo <sup>b</sup>, and Bo Lars Engdahl

<sup>a</sup>Department of Chronic Diseases and Ageing, Division for Mental and Physical Health, Norwegian Institute of Public Health, Oslo, Norway; <sup>b</sup>Department of Psychology, UIT The Arctic University of Norway, Tromsø, Norway

### ABSTRACT

The aim of this study is to investigate the association between childhood sensorineural hearing loss (CSNHL) and divorce in a large, Norwegian cohort. Data from the School Hearing Investigation in Nord-Trøndelag (SHINT), Norway, are combined with registry data on marital status from Statistics Norway and matched controls from the Nord-Trøndelag Health Study (HUNT). The sample includes a total of 50,022 individuals, of which 756 persons were classified with CSNHL (216 with moderate-severe, 294 with mild, and 246 with slight CSNHL). The results from the cox regression analyses showed that people in the group with any CSNHL as well as people with moderate-severe CSNHL had a significantly higher risk of getting divorced compared to the reference group (HR = 1.21,  $p = .024$ , 95% CI = 1.03–1.42; HR = 1.33,  $p = .052$ , 95% CI = 1.00–1.76, respectively) after controlling for age at first marriage, sex and education. This suggests that CSNHL in one or both partners in a couple could be a potential threat to the marriage.

### KEYWORDS

Sensorineural hearing loss; divorce; cohort; HUNT

## Introduction

Studies on divorce among people with hearing loss are almost non-existing. This is somewhat surprising given that hearing loss, like divorce, is a major public health issue that receives considerable attention (Goman et al., 2017; Stevens et al., 2013). Hearing loss affects cognitive, emotional, and social development and represents a barrier to communication, which in turn may hinder the forming and maintaining of social relationships (Fellinger et al., 2012; Govender et al., 2014). Furthermore, once in a relationship, communication difficulties may occur because of the hearing loss (Piercy & Piercy, 2002). Each partner in a couple in which one person has a hearing loss may make negative attributions about the other's behavior, resulting in impatience and resignation in both spouses. The partner with hearing loss may be reluctant to go to restaurants, parties, or even to participate in conversations

**CONTACT** Mariann Idstad  [mariannidstad@hotmail.com](mailto:mariannidstad@hotmail.com)  Department of Chronic Diseases and Ageing, Norwegian Institute of Public Health, PO Box 222 Skøyen, 0213 Oslo, Norway.

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with friends. Hence, the hearing spouse is left with the pleasure of, but also the responsibility for, the couple's social life (Piercy & Piercy, 2002).

Marriage tends to yield health benefits (Robles & Kiecolt-Glaser, 2003), whereas divorce may have detrimental effects on people's mental and physical health (Amato, 2000, 2014) and increase the risk of early mortality (Sbarra & Nietert, 2009). There are many reasons why people in general get divorced (Amato & Previti, 2003; Hawkins et al., 2012), but there are few studies on relationship problems among people with hearing loss. Two relevant issues have been studied: partner violence and hearing compatibility. One study based on data from 339 deaf Americans found a higher prevalence of obesity, suicide, and partner violence in this group compared to hearing individuals from the local general population (Barnett et al., 2011). Another study investigating partner violence among 97 female deaf undergraduate students found evidence for a higher rate of negotiation within couples that were compatible in terms of hearing (deaf/deaf or hard of hearing/hard of hearing) compared to incompatible couples (deaf/hard of hearing, deaf/hearing, or hard of hearing/hearing) (Anderson & Kobek Pezzarossi, 2014). Language preference compatibility yielded a similar result, with higher rates of negotiation in couples where both partners were bilingual or preferred American Sign Language or English, respectively. This suggests that hearing compatibility and a shared language preference both aid communication. Contrary to the study's hypothesis that the prevalence of partner violence would be higher in deaf/hearing relationships than deaf/deaf relationships, no difference was found with respect to physical assault, psychological aggression, or injury. In fact, sexual coercion was lower in relationships with a hearing partner. However, when analyzed in more detail, the researchers found that minor sexual coercion was more common among couples compatible in hearing (deaf/deaf and hard of hearing/hard of hearing) whereas severe sexual coercion was more common among couples with a hearing partner. The authors argue that this may reflect a power imbalance in hearing/deaf relationships in which the hearing partner abuses the advantage of hearing.

The abovementioned studies indicate that people with hearing loss are at an increased risk of experiencing communication problems and partner violence in their relationships, hence one might expect divorce rates to be higher among people with hearing loss than among people with normal hearing. However, this is a complex matter. A study investigating marital status and birth rate of deaf people in the two Swedish counties Närke and Värmland reported mixed results (Carlsson et al., 2004). In this study, deaf individuals aged 25–95 were identified through the records of the centers for deaf interpreters in each county. The profound hearing impairment usually occurred at a prelingual stage, and these participants used sign as their first language. Both counties had a total adult population of close to 200,000. The former had a strong deaf community, with many schools for deaf children and 518 deaf

inhabitants, whereas Värmland had a weak deaf community, with 82 deaf inhabitants and only one pre-school for deaf children. Interestingly, 99% of the deaf married sample in Närke had deaf spouses compared to only 10% in the married sample in Värmland. The divorce rate among the deaf in Närke (11.9%) did not differ from the reference population (12.7%), whereas the divorce rate among the deaf in Värmland (4.9%) was significantly lower compared to the reference population (12.3%). The authors concluded that this suggests that deaf people in Närke may feel confident that they will find a new deaf partner, whereas deaf people in Värmland might be more hesitant going through with a divorce due to the social isolation that could follow in a weak deaf community (Carlsson et al., 2004).

In conclusion, it is unclear whether hearing loss is a risk factor for divorce. The aim of the present study is to help fill the current knowledge gap by investigating divorce rates among people with childhood sensorineural hearing loss in a large Norwegian cohort. Hearing loss is a global public health problem (Stevens et al., 2013) representing a hinder to communication and thus a potential threat to the marriage irrespective of culture and nationality. The results from this study may therefore be of interest to any individuals and practitioners involved with issues related to hearing loss and relationships.

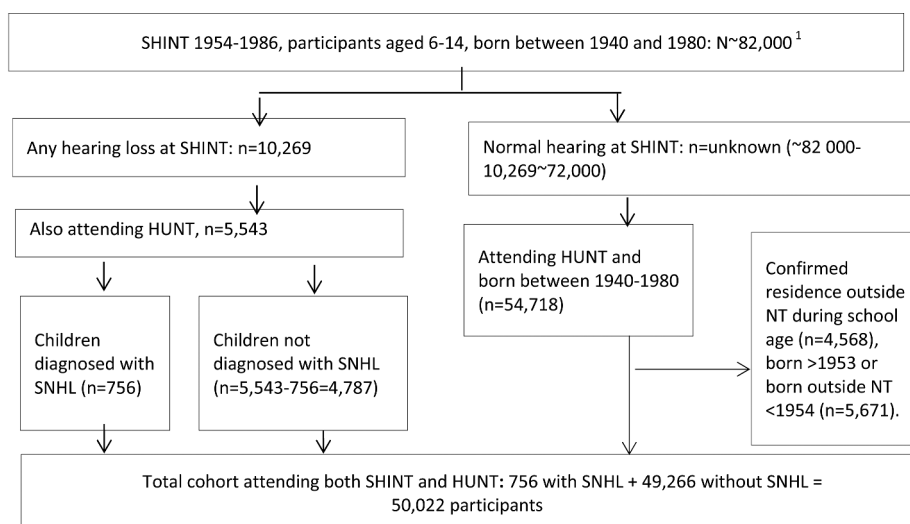
## Materials and methods

### Sample

The present study is based on data from the School Hearing Investigation in Nord-Trøndelag (SHINT), Norway, and registry data on marital status from Statistics Norway and has been approved by the Regional Committee for Medical and Health Research Ethics (REK 2011/2466). The sample includes 50,022 individuals and is restricted to subjects with given consent from one of the three waves of the Norwegian Health Study (HUNT, i.e., HUNT 1, 2, or 3). The SHINT and the HUNT studies were carried out in Nord-Trøndelag County. See [Figure 1](#) for an overview of the participant flow.

### The SHINT study

The SHINT lasted from 1954 to 1986, led by the late otolaryngologist Hans Fabritius. In this period, as good as every pupil in the first, fourth, and/or seventh grade in regular primary school in Nord-Trøndelag County participated in an audiometric screening. This initial screening took place in a quiet location at the school premises and was performed by a health nurse or a trained hearing assistant. Air-conduction thresholds were obtained by means of pure tone audiometry at 0.25, 0.5, 1, 2, 4, and 8 kHz using Amplivox audiometers following the international standard at all times. Pupils were registered with hearing loss if they had thresholds of 20 dB or



**Figure 1.** Flow chart of participants from the baseline childhood study (the school hearing investigation in Nord-Trøndelag; SHINT) and the matched control group study (the Norwegian health study; HUNT). <sup>1</sup> Children born in Nord Trøndelag between 1940 and 1980 = 81,920.

greater at three or more frequencies in the same ear and/or a threshold of 30 dB or more at one or more frequencies. No records were made for pupils without hearing loss, which is unfortunate because this means that the exact number of participants is unknown. We do know, however, that the children who participated in the SHINT were born between 1940 and 1980, and we know that a total of 81,920 children were born in Nord-Trøndelag in this period. It is likely that most of these children participated in the screening at some point, either at one, two or all three time points. A total of 10,269 children tested positive for hearing loss at the screening and were invited to have their hearing further tested with a full examination by an ENT specialist at one of the 14 out-patient clinics in Nord-Trøndelag. Questionnaire data regarding the children's ear problems were also collected from the parents. The visit at the ENT specialist's office included a new pure tone audiometry with both air- and bone-conduction thresholds as well as a complete medical examination including family and medical history. The ENT specialist recorded findings and hearing disorder diagnoses (for example, sensorineural hearing loss, otitis media, etc.), and we base our sample on these diagnoses. To ensure correct classification, the children underwent at least one ENT examination and sometimes more, depending on the diagnosis. Sensorineural hearing loss was defined by Dr Fabritius as a hearing loss in which the air-conduction thresholds followed those of the bone-conduction. He did, however, not include a maximum accepted air-bone gap in his definition. Dr Fabritius and his team were renowned for their diligent work, so there is

reason to believe that the high attendance rate of 97% between 1954 and 1962 persisted (Fabritius, 1968).

### *The HUNT studies*

The HUNT studies are large general health surveys comprising the entire adult population in Nord-Trøndelag County. HUNT 1 was carried out in 1984–86 (about 75,000 participants, response rate about 90%), HUNT 2 in 1995–97 (70,000, 70%), and HUNT 3 in 2006–08 (60,000, 56%). In the present study, we link data from the SHINT with the HUNT studies in order to obtain a matched control group. Out of the 10,269 children that tested positive for hearing loss at the screening in the SHINT, 5,543 also participated in HUNT 1, 2 or 3. As mentioned above, the exact number of participants in the SHINT is unknown. We may, however, make the following assumption: Since it is likely that many of the 81,920 children who were born in Nord-Trøndelag between 1940 and 1980 participated in the SHINT, and we know that 10,269 of these children tested positive for hearing loss at the screening, about 72,000 children (82,000–10,269) most likely had no hearing loss. Many of the children who did *not* test positive for hearing loss in the SHINT probably *also* participated in the HUNT. Therefore, we use those HUNT participants who did *not* screen positive for hearing loss in the SHINT and who were born in the same period as the SHINT participants as our control group ( $n = 54,718$ ). For subjects born 1954 and later we have information of residence during primary school age, and for subjects born before 1954 we have information of residence at birth. We excluded those born 1954 and later with confirmed residence outside Nord-Trøndelag during primary school age ( $n = 5,671$ ) and those born before 1953 with confirmed residence outside Nord-Trøndelag at birth (4,568), resulting in 44,479 (negative-screening) controls.

### *The final sample*

A total of 5,543 children out of the examined children from the SHINT also participated in HUNT 1, 2 or 3 with given consent. For the purpose of the present study, only children diagnosed with sensorineural hearing loss in the SHINT were selected for participation. Altogether, 216 persons were classified with moderate-severe sensorineural hearing loss, 294 with mild sensorineural hearing loss, and 246 with slight sensorineural hearing loss (see further details under “measures”). The final sample thus comprises 756 people with any degree of sensorineural hearing loss and 49,266 controls (of which 44,479 screened negative for hearing loss in the SHINT, and 4,787 screened positive in the SHINT but were not diagnosed with sensorineural hearing loss), in total 50,022 people.

## **Measures**

### ***Childhood hearing loss (predictor)***

Hearing was measured in the SHINT by pure-tone audiometry at 0.25, 0.5, 1, 2, 4, and 8 kHz. The range for registered hearing levels (HL) was 20 dB – 100 dB. Hearing levels below 20 dB were not registered, and hearing levels of 100 dB or more were registered as “100 dB HL.” In the present study, we used the last audiogram from the ENT examination to estimate the average hearing threshold of 0.5, 1, 2, and 4 kHz in both ears. We defined moderate-severe hearing loss as 41–100 dB HL, mild hearing loss as 26–40 dB HL and slight hearing loss as 16–25 dB HL. According to the World Health Organization, a hearing loss is considered disabling at 40 dB or greater in the better hearing ear for adults, and 30 dB or greater for children (WHO, 2020). This means that people with a moderate-severe hearing loss will have difficulty hearing conversational speech and people with mild hearing loss will struggle to understand soft speech. Although slight hearing loss may not be disabling, people may still perceive spoken words as somewhat unclear and as a consequence struggle to follow the conversation.

### ***Divorce (outcome)***

Data on marital status including divorces were available from Statistics Norway yearly from 1975 up until year 2015.

### ***Control variables***

We controlled for possible confounding by age at first marriage, and sex and subsequently also for highest obtained education as a possible confounder and/or mediator. Data on these variables were provided by Statistics Norway.

### ***Mortality***

Information on death and time of death was obtained from the National Cause of Death Registry. The data on death are considered to be complete.

### ***Treatment of missing values***

Since records for children with normal hearing in the SHINT were not registered, values below 20 dB were missing for many frequencies. Hence, we replaced the missing value for each frequency with the frequency specific mean values of the scores below 20 dB in the original sample (N = 10,269).

Data on the outcome variable of divorce from Statistics Norway is regarded as complete. Subjects with missing data on education (0,2%) were deleted listwise.

## Design and statistical analyses

This study applies a longitudinal design, investigating the association between childhood sensorineural hearing loss at baseline starting in 1954–1986 and divorce in adulthood registered yearly from 1975 as late as 2015.

First, we explore divorce rates among married descriptively. Only people who were married sometime in the period from 1975 to 2015 were included in the analyses because the initial number of divorces depends on the rate of marriage which in turn may differ between the groups.

Second, we test the relation between sensorineural hearing loss and divorce by means of cox proportional hazards regression models estimating hazard ratios (HRs) and 95% confidence intervals (95% CIs). We used STATA version 15.0. All statistical tests are two-tailed and calculated at a 95% confidence interval ( $p < .05$ ) All married subjects are followed from the first year registered as married until the year of divorce, the year of death, or the end of follow-up (2015), whichever comes first. The first model tests the relation between sensorineural hearing loss and divorce, whereas the second and third model tests the same relation adjusted for control variables.

Before running the analyses, we tested our data for the assumption of proportional hazards, and we also checked for multicollinearity. Testing the assumption of proportional hazards was performed by the `stptest` in Stata. This assumption was met by the exposure variable, childhood hearing loss. Analyses were stratified on covariates for which the effect did not meet the proportional hazards assumption using the `strata` option in Stata. This is equivalent to fitting separate Cox proportional hazards models under the constraint that the coefficients are equal, but the baseline hazard functions are not. Test of variance inflation factors for the independent variables (VIF) indicated that multicollinearity was not a problem in any of the models.

## Results

Descriptive statistics of number of divorces are presented in [Table 1](#). In general, divorce rates are higher among people with hearing loss than among people without hearing loss. For example, out of the total of 49,266

**Table 1.** Childhood sensorineural hearing loss (CSNHL), marriage, and divorces in the period 1975–2015.

CSNHL	N	Married	Divorced
No hearing loss	49,266	38,152(77.4)	9,143(24.0)
Any hearing loss	756	513(67.9)	147(28.7)
Slight hearing loss	246	179(72.8)	51(28.5)
Mild hearing loss	294	184(62.6)	48(26.1)
Moderate-severe hearing loss	216	150(69.4)	48(32.0)
Total	50,022	38,665(77.3)	9,290(24.0)



people with no hearing loss, 38,152 people got married, and 24.0% of these people got divorced. In comparison, out of the 216 people with moderate-severe hearing loss, 150 people got married, and 32.0% of these people got divorced.

The results from the cox regression analyses are presented in Table 2. A total of 2572 persons died in this period and were censored out. In the first model, there was a significantly higher risk of divorce for people with any hearing loss, slight hearing loss, and moderate-severe hearing loss than for people with no hearing loss. This effect remained significant for people with any hearing loss and for moderate-severe hearing loss after adjusting for age at first marriage and sex. Controlling for education did not substantially reduce the estimates.

**Table 2.** Cox regression with childhood sensorineural hearing loss (CSNHL) as predictor of divorce. Total sample included all married in the period 1975–2015, N = 38,665.

CSNHL	Crude		Model 1			Model 2			
	HR	p	CI (95%)	HR	p	CI (95%)	HR	p	CI (95%)
Any hearing loss	1.30	0.002	1.10–1.53	1.23	0.013	1.05–1.45	1.21	0.024	1.03–1.42
Slight hearing loss	1.35	0.032	1.03–1.78	1.31	0.055	0.99–1.73	1.29	0.073	0.98–1.70
Mild hearing loss	1.16	0.304	0.87–1.54	1.08	0.613	0.81–1.43	1.05	0.762	0.79–1.39
Moderate-severe hearing loss	1.41	0.017	1.07–1.88	1.34	0.046	1.00–1.77	1.33	0.052	1.00–1.76

Model 1 – adjusted for age at first marriage and sex

Model 2 – adjusted for age at first marriage, sex and education

## Discussion

The present study provides evidence for a higher risk of divorce among people with hearing loss compared to people without hearing loss. It is not a straightforward matter to compare our results with those from the Swedish study (Carlsson et al., 2004) because the county of Nord-Trøndelag, in which our study was conducted, does not have a clear profile in terms of having a weak or strong deaf community. Nord-Trøndelag does have one school for deaf children, but we do not suspect that the number of deaf inhabitants is particularly high in this county. In general, Norway does not have any counties with strong deaf communities; thus, we assume that our sample most resembles the sample from the Swedish county with a weak deaf community. If we are correct in this assumption, our results do not support those from the Swedish study, since the divorce rate among deaf people in that study was significantly lower than the divorce rate in the reference population, whereas in our study, divorce rates were significantly higher among people with any hearing loss compared to people with normal hearing. This is surprising because Sweden and Norway are comparable societies in terms of culture and welfare. Carlsson et al. (2004) argued that one reason why fewer people

got divorced in the weak deaf community might be fear of subsequent potential social isolation, which is a plausible explanation. It is difficult to explain why the divorce rate in our study showed the opposite tendency, because it does not seem likely that Norwegian people with hearing loss should be less fearful of social isolation than their Swedish counterparts. Our data are however somewhat more recent than the Swedish ones, and it might be that people in general are less hesitant when it comes to divorce than before.

We do not know which partner took the initiative to get divorced in our study. If people with hearing loss have a higher threshold for leaving the marriage due to a perceived higher difficulty of finding a new partner, they might be less expected to take the initiative to get divorced. If this is the case, then there might be a selection effect present in which people with hearing loss are being selected out of marriage. There may, however, be several other reasons for the high divorce rate among people with hearing loss. As mentioned above, hearing loss has been found to be associated with communication problems (Fellinger et al., 2012; Govender et al., 2014; Piercy & Piercy, 2002) and partner violence (Anderson & Kobek Pezzarossi, 2014; Barnett et al., 2011), and these are factors that are likely to be associated with divorce. Unfortunately, we do not have data on reason for divorce.

Although we do not know how many of the couples in our study that are compatible in terms of hearing, it is likely that the majority of the couples in our study are incompatible since they live in a county that could be regarded as having a weak deaf community. Anderson and Kobek Pezzarossi (2014) found a higher rate of negotiation in couples where both partners were hard of hearing or deaf, respectively, compared to couples who were incompatible. The authors argue that this suggests a higher quality of communication in these couples. Following our assumption that there is an overweight of incompatible couples in our study, the high divorce rate among people with hearing loss in our study might be interpreted as supportive of Anderson and Kobek Pezzarossi (2014) results. It is likely that communication is easier for couples who are compatible in terms of hearing. It should be mentioned, however, that hearing incompatibility may not necessarily be a big problem if the two partners in a couple share a preferred language, since this yields a higher rate of negotiation just like hearing compatibility (Anderson & Kobek Pezzarossi, 2014).

### ***Strengths and limitations***

The present study has several strengths. It is based on a large cohort followed for several decades, and hearing is measured by pure-tone audiometry. This is a rather unique data material and our results make an important contribution to the largely understudied field of divorce among people with hearing loss. Since hearing loss in general is a potential hinder for communication to all

people with impaired hearing, and communication problems is a known risk factor for divorce, it is possible that our results are generalizable to other populations with hearing loss despite cultural differences.

The present study has some limitations. There are many possible reasons for why people get divorced, such as marital satisfaction, violence, drug abuse, negative life events, communication problems, and language incompatibility, and unfortunately, we do not have data on any of these.

Future studies should aim at including as many explanatory factors as possible in order to better understand the relation between hearing loss and divorce, and both qualitative and quantitative studies are needed in order to shed light on the specific challenges for couples in which one or both partners have a hearing loss. Health professionals working with couples and families should keep in mind that hearing loss may be a potential threat to the marriage.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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## ORCID

Mariann Idstad  <http://orcid.org/0000-0001-8423-3554>

Kamilla Rognmo  <http://orcid.org/0000-0002-6746-6548>

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