Int J Public Health (2017) 62:989–996
DOI 10.1007/s00038-017-0966-5

ORIGINAL ARTICLE

Disparities in mortality by disability: an 11-year follow-up study of 1 million individuals

Jung Min Park[1] · Ukchan Oh[2] · Beop-Rae Roh[1] · Yeongmin Moon[1]

Received: 6 October 2016 / Revised: 23 February 2017 / Accepted: 27 February 2017 / Published online: 18 March 2017
© Swiss School of Public Health (SSPH+) 2017

Abstract
Objectives This longitudinal study examines to what extent the risk of mortality—all-cause, natural death, suicide, and unintentional injury mortality—differs by types and severity of disabilities as well as disability status.
Methods Data were the National Sample Cohort of 1,025,340 individuals in South Korea followed from 2002 to 2013. Cox regression with time-variant variables was used to estimate the hazard ratio of mortality by disability.
Results Individuals with disabilities had a higher risk of mortality compared to those without (HR 1.84, 95% CI 1.80–1.88 for natural death; HR 1.83, 95% CI 1.64–2.03 for suicide; HR 1.54, 95% CI 1.38–1.71 for unintentional injury). All types of disability were associated with an increased risk of natural death. Individuals with mental disability were the highest risk group for suicide (HR 7.14, 95% CI 5.31–9.60). People defined as having severe disability had an elevated risk for all categories of mortality.
Conclusions Disabilities are important markers of high risk of mortality. Findings call for actions to reduce mortality risk of people with disabilities, including preventing suicidal behaviors of those with mental disability.

Keywords Mortality · Disability · Health inequalities · Natural death · Suicide · Unintentional injury · Korea

✉ Jung Min Park
parkjm@snu.ac.kr

Ukchan Oh
ukchanoh@daum.net

Beop-Rae Roh
rohbr2@gmail.com

Yeongmin Moon
saojung1@snu.ac.kr

1 Department of Social Welfare, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea

2 National Pension Research Institute, Jeonju, Republic of Korea

Introduction

Research has shown a close link between having disabilities and health, economic, and psychosocial disadvantages (WHO 2011; OECD 2010). Mortality is another area in which disparities exist between individuals with and without disabilities. Studies have found a higher mortality risk associated with having disabilities. Nordic studies reported that the relative risk of mortality was in the range of 1.7–2.9 for men and women on disability pension, when compared with those not on disability pension (Karlsson et al. 2007; Gjesdal et al. 2008; Björkenstam et al. 2014). A Dutch study showed that the adjusted hazard ratio of mortality was 1.6–1.9 times higher for people with disability in terms of activities of daily living (Majer et al. 2011). A US study found that the mortality risk for adults with any disability was 1.5 times higher than that for adults without disability (Forman-Hoffman et al. 2015).

This study builds on the 'biopsychosocial' view of disability proposed by the International Classification of Functioning, Disability, and Health. A person's disability is conceived as an interaction between health conditions (diseases, disorders, injuries, etc.) and contextual factors—both environmental and personal (WHO 2011). High mortality rates of people with disabilities can be attributed to social barriers such as limited access to health care, inadequate sanitation and nutrition, and poverty. High risk of deaths of people with disabilities can be also associated with

the impairment causing a disability or a problem directly caused by disease or other health conditions.

There are several explanations about the relationship between disability and mortality risk. An explanation is that having disabilities is a stressor that increases the likelihood of being exposed to health-damaging environment (e.g., occupational stressors, economic strain, disadvantaged neighborhood, discriminatory experiences, etc.). Physical disability, for instance, is considered a source of chronic stress that involves difficulties in daily activities, thwarted belongingness, and perceived burdensomeness (Turner and Noh 1988; Van Orden et al. 2010), and it increases psychiatric comorbidity and suicide risk (Giannini et al. 2010). Repeated stressors have a cumulative, adverse effect on health and contribute to the elevated rates of morbidity and mortality (Pearlin et al. 2005).

Another explanation focuses on the association of disability with health-related behaviors. Health-related behaviors are important protective and risk factors for morbidity and mortality, as shown in a report that tobacco smoking, alcohol drinking, dietary risk factors and physical inactivity were responsible for approximately 21% of the disease burden estimated by disability-adjusted life years (Lim et al. 2013). People with disabilities are more likely than those without disabilities to report health-impairing behaviors, such as smoking, drinking, obesity, physical inactivity, and limited health promoting activities (Australian Institute of Health and Welfare 2010; Husemoen et al. 2004; Amosun et al. 2005), which can heighten mortality risk.

Another explanation emphasizes the link between disability and having secondary health conditions. A risk of secondary health conditions is related to complications and injuries occurring after the onset of the primary disability condition and it is also associated with behavioral, environmental disadvantages, such as substance abuse, obesity, and hypertension (Rimmer 1999). People with disabilities are susceptible to secondary health conditions, including osteoporosis, weight problems, decreased balance and strength, depression, heart disease, high blood pressure, respiratory disease, and diabetes (Rimmer 1999; WHO 2011). Secondary conditions can lead to premature death in addition to lowering the quality of life.

Although studies have examined the link between disability and mortality, there is a paucity of research on the impact of specific disability conditions (e.g., types and severity) on mortality. Additionally, most studies focused on individuals of working age, old age, or those granted disability benefits (Wallman et al. 2006; Karlsson et al. 2007; Gjesdal et al. 2008; Feng et al. 2010; Landi et al. 2010; Majer et al. 2011; Dale et al. 2012; Gustafson et al. 2012; Björkenstam et al. 2014; Gómez-Olivé et al. 2014; Forman-Hoffman et al. 2015; Polvinen et al. 2015). Building on prior research, this study includes individuals of all ages and examines the role of types and severity of disability on mortality. This study is also unique in that disability conditions are based on the government-administered indicators rather than respondents' self-reports or the receipt of disability benefits.

This cohort study examines (1) rates of overall and cause-specific (e.g., natural death, suicide, and unintentional injury) mortality by disability conditions, (2) mortality risk by disability, after controlling for other covariates, and (3) the extent to which the risk of mortality is associated with types and severity of disabilities by sex and age.

Methods

Data and sample

Data for this study were South Korea's National Sample Cohort (NSC) 2002–2013, provided by the National Health Insurance Service (NHIS). The NSC is comprised of 1,025,340 individuals (2.2% of the total eligible population in 2002) and it was followed until 2013 unless participants' eligibility was disqualified due to death or emigration (Lee et al. 2016). The attrition rate of the original cohort was 1.1% on average annually and the cumulative rate of attrition was 10.8%. The NHIS compared the sample with the population in terms of average annual medical expenses, residence distribution, and insurance premiums, and the difference was negligible or changed slightly during the follow-up years 2003–2013 by 0–0.3% (Lee et al. 2016). All information in the NSC was extracted from administrative databases. This study was approved by the Institutional Review Board of Seoul National University.

Measures

Outcome: mortality

Outcome measures were overall and cause-specific mortality based on the cause of death records. Cause of death records in the data were classified following the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). The cause of death records provided by Statistics Korea were linked to the NSC by the NHIS, and it is an integral part of the data.

The NASH categories of death—natural, accidental, suicidal, and homocidal—have been commonly used for the certification relating to death (Shneidman 1981; Leenaars et al. 1998). Although it contains limited information on specific modes of death, the classfication is a simple way of describing the circumstances resulting in the death. Additionally, deaths due to suicide or accidents are often considered indicators of avoidable, preventable mortaliy

(Westerling et al. 1996). Thus, this study followed the NASH classification, but it excluded homicide because its proportion was extremely low.

Cause of death codes were classified for analyses into three groups of cause-specific mortality: (1) suicide (X60–X84), (2) unintentional injury (V01–V99: transport accident, W00–W19: falls, W25–W29:cut or pierce, W24, W30–W31: machinery, W65–W74: drowning, X00–X19: fire/hot object or substance, X40–X49: accidental poisoning by and exposure to noxious substances, W42, W43, W53–W64: natural or environment), (3) natural death (all others excluding aforementioned codes).

Exposure: disability

Measures of disability included the severity and types of disability. In South Korea, people can apply for registration of their disability conditions to local governments, who provide a certificate of disability based on medical records. Certificate of disability is required to be eligible for such government supports as disability benefits, employment support, and transportation assistance. Approximately, 2.5 million people (4.8% of the total population) were enrolled in the National Disability Registry in 2015 (MOHW 2015).

The method of assessing disability is provided in detail by the Act on Welfare of Persons with Disabilities (AWPD). The assessment is based on the impairment table or baremas (tables showing a certain percentage of disability corresponding to specified impairments). The method evaluates the status and degree of disability focusing on individual's impairment, e.g. degree of loss of sight or hearing (Mabbett 2003). The impairment table of the AWPD classifies impairments into 15 types and 6 levels, and the types and levels of impairment are determined by medical diagnoses and assessment scores. When individuals have more than one type of impairment, their multiple impairments are listed with a primary condition designated. Primary conditions are used for classifying types of impairment.

The severity of disability is categorized as 1–6 levels on administrative registration, with a lower number indicating a more severe condition. Levels 1–2 are often considered a proxy of severe disability conditions, and benefits such as disability pension mainly target individuals in those levels. The criteria for the six levels are also described in the AWPD for each type of impairment. This study classified people with disability into severe disability (levels 1–2) and mild disability (levels 3–6) groups to explore whether the two groups are different in mortality risk.

Types of disability in the data were classified into: (1) physical, (2) brain lesion, (3) visual, (4) hearing, (5) kidney dysfunction, (6) intellectual, (7) mental, and (8) others.

Covariates

Age in the baseline year was categorized as 17 groups with 5-year interval (i.e., 0–4, 5–9…, 80+). Area of residence was categorized as metropolis, small-medium cities, and rural areas. Household income was divided into 11 quantiles (0–10) with a lower number indicating lower income. All medical aid beneficiaries were coded as 0. For analyses, individuals were divided into low income (0–3), middle income (4–7), and high income (8–10) groups. Type of health care coverage was classified as the National Health Insurance and Medical Aid. The National Health Insurance is a universal health care program, covering over 96% of the entire population. Medical Aid is a public assistance program for the poor, covering nearly 4% of the population.

Statistical analysis

Descriptive analyses were conducted to examine characteristics of the study sample and to compare frequency distributions and mean by disability status. Cox model with time-variant variables was used to estimate the hazard ratio of mortality by disability. All covariates except sex and the age group were time-variant. Time-variant variables may change at different rates for different individuals across time, so do their hazard ratios. Cox model with time-variant variables allows for nonproportional hazards.

Cox regression models estimated the association of disability with mortality with and without adjustment of covariates. The unadjusted results were compared to the adjusted results to assess the effect of other covariates on mortality. Covariates included in the analysis were age, sex, area of residence, household income, and type of health care coverage. A test of the proportional hazard assumption for the time-constant covariates showed a violation of the assumption, which indicates that there is an interaction between the covariates and time. To incorporate the interaction, we analyzed separate models for men and women and for different age groups. The origin time for estimating mortality was January 1st, 2003 and the observation termination time was December 31st, 2013. All persons still alive at the end of the study period were censored.

Results

Table 1 describes characteristics of the study sample at baseline by disability status. The disability group compared to the non-disability group was older, more male, had lower income, and was more likely to be covered by Medical Aid and to live in rural area. The mean age was 49.7 in the disability group and 34.2 in the non-disability group. The proportion of male was 67.1% in the disability group and

Table 1 Characteristics of the sample, the National Sample Cohort of South Korea, 2002–2013 ($N = 1{,}025{,}340$)

	All	Non-disability group	Disability group
Age (%)			
Mean, years (SD)	34.6 (19.9)	34.2 (19.8)	49.7 (17.0)
Under 60 years	92.2	92.5	81.4
60 years or older	7.8	7.5	18.6
Sex (%)			
Male	50.1	49.6	67.1
Female	49.6	50.4	32.9
Income (%)			
Low	22.2	21.6	44.0
Middle	39.1	39.3	31.4
High	38.6	39.0	24.6
Health care (%)			
National health insurance	97.0	97.5	80.6
Medical aid	3.0	2.6	19.4
Region (%)			
Metropolis	47.7	47.9	41.3
Small-medium city	14.0	14.1	11.8
Rural area	38.3	38.0	47.0
Disability status (%)			
Yes	2.6	0.0	100.0
No	97.4	100.0	0.0
Mortality rate (age-adjusted, per 100,000)	319.1	327.9	913.9

49.6% in the non-disability group. The low-income group accounted for 44.0% of the disability group, while it did 21.6% of the non-disability group. The proportion of individuals covered by Medical Aid was 19.4% in the disability group and 2.6% in the non-disability group. People with disabilities were 2.6% of the study sample. In the disability group, physical disability accounted for 58.5%, and 34.6% were in categories of 1 and 2. The age-adjusted all-cause mortality rate was 2.8 times higher for individuals with disabilities compared to those without (913.9 vs. 327.9).

Risk of mortality by disability

Table 2 shows that an adjusted hazard ratio (HR) of all-cause mortality of individuals with disabilities was higher than that of those without disabilities (HR = 1.83). The mortality risk was also higher for natural death (HR = 1.84), suicide (HR = 1.83), and death due to unintentional injury (HR = 1.54).

The HRs for disability conditions were substantially lowered in the adjusted results, indicating that other covariates (e.g., income, age, sex) played a significant role in terms of mortality.

The table also reports that all types of disability were associated with an increased mortality risk. The HR of all-cause mortality was over three times higher for individuals with kidney, brain lesion, intellectual, and other disabilities compared to those without disabilities. For natural deaths, all types of disability were associated with an increased mortality risk. For suicide, individuals with mental disability were the highest risk group (HR = 7.14). The physical, brain legion, hearing, kidney, and others groups also showed a higher risk of suicide compared to the non-disability group. For unintentional injury mortality, those with physical, brain legion, intellectual, and kidney disabilities had an increased risk of such deaths.

Having severe disability conditions was associated with a significantly increased risk for all measures of mortality.

Association of mortality risk with types and severity of disabilities by sex and age

The mortality risk associated with disability was greater for men (Table 3). For men, the HR of all-cause mortality was 69% higher for individuals with disabilities compared to those without. For women, it was 39%. The association of having a disability with the risk of suicide and unintentional injury deaths was statistically significant only for men.

The impact of disability on mortality risk is greater for younger groups and it attenuates as people age. Of people under the age of 30 years, individuals with disabilities

Table 2 Unadjusted and adjusted hazard ratios of mortality by disability (The National Sample Cohort of South Korea, 2002–2013)

	Unadjusted analysis				Adjusted analysis			
	All-cause	Natural death	Suicide	Unintentional injury	All-cause	Natural death	Suicide	Unintentional injury
Disability								
Yes (vs. no)	5.01*** (4.91, 5.11)	5.27*** (5.16, 5.38)	3.04*** (2.74, 3.38)	2.93*** (2.64, 3.26)	1.83*** (1.79, 1.87)	1.84*** (1.80, 1.88)	1.83*** (1.64, 2.03)	1.54*** (1.38, 1.71)
Type (vs. no)								
Physical	3.49*** (3.39, 3.60)	3.56*** (3.44, 3.67)	2.86*** (2.48, 3.29)	3.09*** (2.70, 3.53)	1.30*** (1.26, 1.34)	1.27*** (1.23, 1.31)	1.70*** (1.47, 1.96)	1.63*** (1.42, 1.87)
Brain legion	13.05*** (12.6, 13.5)	14.22*** (13.7, 14.8)	3.61*** (2.73, 4.78)	3.97*** (3.05, 5.18)	3.51*** (3.39, 3.64)	3.64*** (3.51, 3.78)	1.85*** (1.40, 2.46)	1.7*** (1.30, 2.22)
Visual	3.97*** (3.72, 4.23)	4.18*** (3.91, 4.47)	2.13*** (1.48, 3.08)	2.38*** (1.69, 3.36)	1.35*** (1.27, 1.44)	1.36*** (1.27, 1.45)	1.22 (0.84, 1.76)	1.19 (0.84, 1.68)
Hearing	5.00*** (4.72, 5.30)	5.23*** (4.93, 5.55)	3.19*** (2.36, 4.31)	3.22*** (2.39, 4.33)	1.24*** (1.17, 1.32)	1.23*** (1.16, 1.31)	1.57** (1.16, 2.13)	1.31 (0.97, 1.77)
Intellectual	1.72*** (1.53, 1.93)	1.74*** (1.54, 1.98)	1.12 (0.60, 2.09)	1.87* (1.16, 3.01)	3.07*** (2.73, 3.46)	3.34*** (2.94, 3.78)	1.28 (0.69, 2.39)	2.24*** (1.39, 3.60)
Mental	2.62*** (2.31, 2.97)	2.30*** (2, 20.65)	8.56*** (6.37, 11.5)	1.71 (0.89, 3.29)	2.46*** (2.17, 2.79)	2.19*** (1.90, 2.52)	7.14*** (5.31, 9.60)	1.45 (0.75, 2.79)
Kidney	12.40*** (11.6, 13.3)	13.50*** (12.6, 14.5)	3.99*** (2.36, 6.75)	3.38*** (1.92, 5.97)	5.14*** (4.79, 5.52)	5.41*** (5.03, 5.82)	2.47*** (1.46, 4.18)	1.86* (1.06, 3.29)
Others	10.44*** (9.8, 11.1)	11.46*** (10.8, 12.2)	3.22*** (2.02, 5.11)	1.58 (0.82, 3.05)	3.89*** (3.66, 4.14)	4.13*** (3.88, 4.40)	1.89** (1.18, 3.00)	0.78 (0.41, 1.51)
Severity								
Mild (vs. no)	3.59*** (3.50, 3.68)	3.68*** (3.58, 3.78)	2.84*** (2.51, 3.20)	2.87*** (2.55, 3.24)	1.24*** (1.21, 1.28)	1.22*** (1.19, 1.25)	1.64*** (1.45, 1.86)	1.45*** (1.28, 1.64)
Severe (vs. no)	9.12*** (8.87, 9.37)	9.85*** (9.57, 10.4)	3.65*** (3.06, 4.36)	3.10*** (2.57, 3.75)	3.94*** (3.83, 4.05)	4.10*** (3.99, 4.22)	2.43*** (2.03, 2.90)	1.82*** (1.51, 2.21)

*$p<.05$; **$p<.01$; ***$p<.001$

95% confidence intervals in parenthesis

had an all-cause mortality risk 4.4 times higher than those without disabilities. In the 30–59 years group, those with disabilities had an all-cause mortality risk 2.6 times higher than those without disabilities. Of people over the age of 60 years, the disability group's all-cause mortality risk was just 1.1 times that of the non-disability group.

Discussion

Principal findings

This study confirmed the close link between disability and mortality risk. Individuals with disabilities had an age-adjusted mortality rate nearly three times higher and an adjusted hazard ratio 57% higher compared to those without disabilities. The findings are in line with prior research, although the magnitude of the difference varies by definitions of disability, age range of the sample, and observation period.

Socioeconomic disparities experienced by people with disabilities can explain some extent of their high risk of mortality. People with disabilities are known to be disadvantaged in terms of education, income, employment, and housing vulnerability, and they are also more likely to report adverse health behaviors (AIHW 2010; Kavanagh et al. 2015). While this study provides limited information on the manner in which disability increases mortality risk, the difference in unadjusted and adjusted estimates of mortality for disability reiterates the significant role of contextual factors on high mortality risk.

The prevalence of people with disabilities in this study, 2.7%, seems a conservative assessment. Estimated prevalence of disability differs by the purpose of data collection and methods of assessment. When the assessment of disability is for evaluating an eligibility for government support, it is likely to underestimate the prevalence than a self-reported questionnaire based on functional limitations. There are several methods of assessing disability: the barema method, care needs assessment, the measurement of functional capacity, and the calculation of economic loss (Mabbett 2003; Wright and De Boer 2002). The method being used in Korea is close to the barema method, which is more likely than others to focus on severe conditions of disabilities. Using a frequently used self-reported measure of disability, activities of daily living, the Korean Labor and Income Panel Study shows the prevalence of disability about two times higher than that of this study.

The purpose and method of assessing disability in Korea can partly explain a high mortality risk of the study sample. The threshold for disability in Korea is quite stringent especially compared to countries who shifted from heavy reliance on medical information to more focus on work

Table 3 Adjusted hazard ratios of mortality by disability status by sex and age groups (The National Sample Cohort of South Korea, 2002–2013)

Disability, Yes (Ref. No.)	All-cause	Natural death	Suicide	Unintentional injury
Sex				
Men	1.69*** (1.65, 1.74)	1.72*** (1.67, 1.77)	1.60*** (1.41, 1.81)	1.47*** (1.29, 1.67)
Women	1.39*** (1.35, 1.44)	1.42*** (1.37, 1.47)	1.26 (1.00, 1.58)	0.96 (0.76, 1.21)
Age group (years)				
0–29	4.41*** (4.03, 4.83)	6.13*** (5.50, 6.84)	2.47*** (1.95, 3.13)	1.92*** (1.44, 2.55)
30–59	2.56*** (2.47, 2.65)	2.56*** (2.47, 2.65)	1.58*** (1.35, 1.85)	1.45*** (1.24, 1.69)
60	1.14*** (1.10, 1.17)	1.14*** (1.11, 1.17)	1.12 (0.91, 1.37)	0.99 (0.82, 1.20)

***$p < .001$

95% confidence intervals in parenthesis

capacity, prospect or process of return-to-work, and social environment. Thus, people counted as having a disability in this study might have more severe health conditions, which contributes to a higher mortality risk.

The results also point to a greater impact of disabilities for males on natural death mortality and its statistically significant role on suicide and unintentional injury mortality. The result can be partly accounted for by the fact that females have a longer life expectancy and are more likely to develop aging-related disabilities, such as musculoskeletal diseases, which have a lower likelihood of leading to death. Additionally, males report an earlier onset of disability conditions (Kim et al. 2014). Longer duration of having a disability increases the chance of developing secondary health problems and experiencing frustration and social exclusion, which in turn increases the risk of mortality.

The impact of disability on mortality risk varies across age groups, with its role greater among the younger ones. Medical conditions may play a more important role as people age. A greater impact of disability on mortality risk among young people indicates that being born with impairment or developing disability conditions at an earlier age is an important indicator for premature death.

Mortality risk varies by types of disability. All-cause mortality risk is particularly higher for individuals with kidney, brain lesion, and intellectual disabilities. Kidney dysfunction and brain legion are impairments directly linked to mortality risk. Another explanation is that individuals with kidney and brain lesion disabilities are more likely to have chronic illnesses. Disabilities accompanying progressive diseases or chronic illnesses, such as respiratory, endocrine and neurological disorders, are known to have a higher mortality risk (Gjesdal et al. 2008; Björkenstam et al. 2014). A national survey in Korea that the percentage of having chronic illnesses was 12–20% higher for these groups compared with the average of the disability group (Kim et al. 2014) provides additional support for the explanation.

While research has reported that people with intellectual disabilities have a higher mortality risk than the general population (Dieckmann et al. 2015; Florio and Trollor 2015; Heslop and Glover 2015; Lauer and McCallion 2015; McCarron et al. 2015; Ouellette-Kuntz et al. 2015), little is known about their relative risk compared with those with other types of disability. This study has shed the light on the higher mortality risk among individuals with intellectual disabilities.

The risk of suicide is a 7.1 fold higher for those with mental disability compared to the general population and that the risk was higher for females. Of mental disorders, depression is considered the most powerful predictor of suicide, and females report a higher incidence of depressive disorders (Kahng 2010; Kim et al. 2014). The association of suicide with mental disability has been well documented (Björkenstam et al. 2014; Leinonen et al. 2014; Forman-Hoffman et al. 2015). The current finding consistent with previous studies once again points out the importance of reducing and preventing suicide among people with mental disability.

Having severe disability conditions is associated with a higher risk of all-cause and cause-specific mortality. With some exceptions (Wallman et al. 2006), few studies have looked at the relations between the severity of disability and mortality. While the measurement of assessing the severity of disability can be an issue, this study adds to the literature empirical evidence that severe disability conditions as well as having a disability itself significantly increases the risk of natural death, suicide, and unintentional injury-mortality.

Strengths and limitations

A major strength of this study is that it was based on a large randomly selected cohort of all ages and it compared individuals registered as having a disability and those without. This study has another strength of looking

at the variations in mortality risk by different types of disabilities and the degree of impairment.

This study has several limitations to note. First, while controlling for several socio-economic-demographic characteristics, the analyses did not adjust for morbidity. The association between disability conditions and mortality risk may reflect confounding of morbidity. In addition, health behaviors that may contribute to health conditions and the risk of premature death were not included. Thus, this study is limited in understanding why disability increases the mortality risk. Second, this study identified disability conditions by administrative registration. This can be regarded as a strength and a limitation; Relying on objective criteria is a strength and possible underreporting of disability is a limitation. Third, a couple of issues need to be considered in terms of generalizability of the study findings. The definition and assessment method of disability used in this study is constrained by administrative decision-making, characterized reliance on medical evidence and low degree of discretion of assessors. Nordic studies (Karlsson et al. 2007; Gjesdal et al. 2008; Björkenstam et al. 2014) also used administrative criteria for disability pension, but their disability assessment is less dependent on medical evidence and allows more discretion of assessors. The sample of this study encompassed all ages, while prior research often focused on adults in working age or disability pension-eligible individuals.

Conclusions

This study clearly shows that disability conditions are important markers of high risk of mortality. The risk of mortality was disproportionately distributed across types and severity of disability, suggesting that strategies to reduce mortality risk of individuals with disabilities need to be tailored to disability conditions (e.g., actions to prevent suicidal behaviors of people with mental disability and to reduce death due to unintentional injuries for people with intellectual disability). Further research is essential to enhance our understanding of the determinants of mortality risk for various disability conditions, which could inform how to reduce the disparity in mortality between people with and without disabilities.

Acknowledgements This study was supported by a research Grant of Seoul National University (No. 200-20160025). The authors would like to thank the anonymous reviewers for their helpful comments that greatly contributed to enhancing the quality of this manuscript.

Compliance with ethical standards

Conflict of interest None.

Institutional approval This study was approved by the Institutional Review Board of Seoul National University (IRB No. E1604/001-007).

References

Amosun SL, Mutimura E, Frantz JM (2005) Health promotion needs of physically disabled individuals with lower limb amputation in Rwanda. Disabil Rehabil 27:837–847

Australian Institute of Health and Welfare (2010) Health of Australians with disability: health status and risk factors. Australian Government, Canberra

Björkenstam C, Alexanderson K, Björkenstam E, Lindholm C, Mittendorfer-Rutz E (2014) Diagnosis-specific disability pension and risk of all-cause and cause-specific mortality: a cohort study of 4.9 million inhabitants in Sweden. BMC Public Health 14:1–11

Dale C, Prieto-Merino D, Kuper H, Adamson J, Bowling A, Ebrahim S, Casas JP (2012) Modelling the association of disability according to the WHO International Classification of Functioning, Disability and Health (ICF) with mortality in the British Women's Heart and Health Study. J Epidemiol Community Health 66:170–175

Dieckmann F, Giovis C, Offergeld J (2015) The life expectancy of people with intellectual disabilities in Germany. J Appl Res Intellect Disabil 28:373–382

Feng Q, Hoenig H-M, Gu D, Yi Z, Purser J-L (2010) Effect of new disability subtype on 3-year mortality in Chinese older adults. J Am Geriatr Soc 58:1952–1958

Florio T, Trollor J (2015) Mortality among a cohort of persons with an intellectual disability in New South Wales, Australia. J Appl Res Intellect Disabil 28:383–393

Forman-Hoffman VL, Ault KL, Anderson WL, Weiner JM, Stevens A, Campbell VA, Armour BS (2015) Disability status, mortality, and leading causes of death in the US community population. Med Care 53:346–354

Giannini MJ, Bergmark B, Kreshover S, Elias E, Plummer C, O'Keefe E (2010) Understanding suicide and disability through three major disabling conditions: intellectual disability, spinal cord injury, and multiple sclerosis. Disabil Health J 3:74–78

Gjesdal S, Mæland JG, Svedberg P, Hagberg J, Alexanderson K (2008) Role of diagnoses and socioeconomic status in mortality among disability pensioners in Norway: a population-based cohort study. Scand J Work Environ Health 34:479–482

Gómez-Olivé FX, Thorogood M, Bocquier P, Mee P, Kahn K, Berkman L, Tollman S (2014) Social conditions and disability related to the mortality of older people in rural South Africa. Int J Epidemiol 43:1531–1541

Gustafson DR, Mazzuco S, Ongaro F, Antuono P, Forloni G, Albani D, Gajo GB, Durante E, Caberlotto L, Zanardo A, Siculi M, Gallucci M (2012) Body mass index, cognition, disability, APOE genotype, and mortality: the "Treviso Longeva" study. Am J Geriatr Psychiatry 20:594–602

Heslop P, Glover G (2015) Mortality of people with intellectual disabilities in England: a comparison of data from existing sources. J Appl Res Intellect Disabil 28:414–422

Husemoen LLN, Osler M, Godtfredsen NS, Prescott E (2004) Smoking and subsequent risk of early retirement due to permanent disability. Eur J Public Health 14:86–92

Kahng S-K (2010) Does depression predict suicide?: gender and age difference in the relationship between depression and suicidal attitudes. Korean J Soc Welf Stud 41:67–99

Karlsson NE, Carstensen JM, Gjesdal S, Alexanderson KAE (2007) Mortality in relation to disability pension: findings from a

12-year prospective population-based cohort study in Sweden. Scand J Public Health 35:341–347

Kavanagh AM, Krnjacki L, Aitken Z, LaMontagne AD, Beer A, Baker E, Bentley R (2015) Intersections between disability, type of impairment, gender and socio-economic disadvantage in a nationally representative sample of 33,101 working-aged Australians. Disabil Health J 8:191–199

Kim S-H, Lee Y-H, Hwang J-H, Oh M-A, Lee M-K, Lee N-H, Kang D-U, Kwon S-J, Oh H-K, Yoon S-Y, Lee S-W (2014) 2014 Survey on persons with disabilities. Korea Institute for Health and Social Affairs, Seoul

Landi F, Liperoti R, Russo A, Capoluongo E, Barillaro C, Pahor M, Bernabei R, Onder G (2010) Disability, more than multimorbidity, was predictive of mortality among older persons aged 80 years and older. J Clin Epidemiol 63:752–759

Lauer E, McCallion P (2015) Mortality of people with intellectual and developmental disabilities from select US state disability service systems and medical claims data. J Appl Res Intellect Disabil 28:394–405

Lee J, Lee J-S, Park S-H, Shin S-A, Kim K-W (2016) Cohort Profile: the National Health Insurance Service–National Sample Cohort (NHIS-NSC), South Korea. Int J Epidemiol. doi:10.1093/ije/dyv319

Leenaars AA, Lester D (1998) Social factors and mortality from NASH in Canada. Crisis 19:73–77.

Leinonen T, Martikainen P, Laaksonen M, Lahelma E (2014) Excess mortality after disability retirement due to mental disorders: variations by socio-demographic factors and causes of death. Soc Psychiatry Psychiatr Epidemiol 49:639–649

Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, Aryee M (2013) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 380(9859):2224–2260

Mabbett D (2003) Definitions of disability in Europe: a comparative analysis. European Commission, Brussels

Majer IM, Nusselder WJ, Mackenbach JP, Klijs B, van Baal PHM (2011) Mortality risk associated with disability: a population-based record linkage study. Am J Public Health 101:e9–e15

McCarron M, Carroll R, Kelly C, McCallion P (2015) Mortality rates in the general Irish population compared to those with an intellectual disability from 2003 to 2012. J Appl Res Intellect Disabil 28:406–413

OECD (2010) Sickness, disability and work: breaking the barriers: a synthesis of findings across OECD countries. OECD Publishing, Paris

Ouellette-Kuntz H, Shooshtari S, Balogh R, Martens P (2015) Understanding information about mortality among people with intellectual and developmental disabilities in Canada. J Appl Res Intellect Disabil 28:423–435

Pearlin LI, Schieman S, Fazio EM, Meersman SC (2005) Stress, health, and the life course: some conceptual perspectives. J Health Soc Behav 46:205–219

Polvinen A, Laaksonen M, Gould R, Lahelma E, Leinonen T, Martikainen P (2015) Socioeconomic inequalities in cause-specific mortality after disability retirement due to different diseases. Scand J Public Health 43:159–168.

Republic of Korea Ministry of Health and Welfare (2015) Current status of individuals on the National Disability Registry. http://www.mohw.go.kr/front_new/jb/sjb030301ls.jsp?PAR_MENU_ID=03&MENU_ID=0321#. Accessed 5 Oct 2016

Rimmer JH (1999) Health promotion for people with disabilities: the emerging paradigm shift from disability prevention to prevention of secondary conditions. Phys Ther 79:495–502

Shneidman ES (1981) The psychological autopsy. Suicide Life Threat Behav 11(4), 325–340.

Turner RJ, Noh S (1988) Physical disability and depression: a longitudinal analysis. J Health Soc Behav 29:23–37

Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite SR, Selby EA, Joiner TE (2010) The interpersonal theory of suicide. Psychol Rev 117:575–600

Wallman T, Wedel H, Johansson S, Rosengren A, Eriksson H, Welin L, Svärdsudd K (2006) The prognosis for individuals on disability retirement: an 18-year mortality follow-up study of 6887 men and women sampled from the general population. BMC Public Health 6:1–9

Westerling R, Gullberg A, Rosen M (1996) Socioeconomic differences in 'avoidable' mortality in Sweden 1986–1990. Int J Epidemiol 25:560–567

WHO (2011) World report on disability. World Health Organization, Geneva

Wright P, De Boer W (2002) Introduction. In: Assessing disability in Europe: similarities and differences. Council of Europe Publishing, Strasbourg, pp 7-23.