Low vision and active life expectancy in Japanese Older Adults

Aaron Hagedorn and Yasuhiko Saito

Abstract

OBJECTIVE: To investigate how the onset of vision impairment affects disability and active life expectancy in a nationally representative cohort of older adults in Japan over a 13 year time period.

METHODS: The Nihon University Longitudinal Study of Aging is a population based survey with 5 waves of data collected between 1999 and 2009. Vision is classified as poor when respondents said they see “not very well” and treated as a time varying covariate across all 5 waves of the NUJLSOA. Disability was measured as having difficulty with any of the 7 Activities of Daily Living or 7 Instrumental Activities of Daily Living. In order to use vision as a time varying covariate in IMaCh 0.98Q revision 1.133, the data were pooled so consecutive observation s could have a different covariate value for vision. The resulting pooled data set had 13,846 time interval observations among 6,201 respondents ages 65 and older across the 5 waves of study.

RESULTS: The results indicate that among those who experienced poor vision over the survey period, total life expectancy at age 65 was nearly 5 years less than for those who reported normal vision. The largest differences were seen in disabled years, with approximately 7.3 years expected in disability for women age 65 with poor vision, compared to 6.3 years for women with good vision. By age 85, those with vision loss can expect to live most of their life with disability, while those without vision loss have more than half of their expected years without disability. The transition rates to disability are clearly higher for females with poor vision, and recovery rates are substantially lower for those with poor vision. Mortality it highest for males with poor vision, and lowest for females with good vision. Experiencing poor vision has an impact on both active life expectancy and mortality risk. This analysis suggests that poor vision may play a role in causing higher disability rates among older people in Japan.

INTRODUCTION:

Independence at older ages is a function of physical, cognitive and sensory capacities. Each of these capacities can affected by aging and interact with health and lifestyle factors which can cumulatively add up to a life at older age divided with some time functionally capable and some time with less capacity and a reliance on others for support. Vision is a critical sensory capacity which declines naturally with presbyopia, and could decline further with cataracts and many other common age-associated conditions. Some vision loss can be recovered, such as cataracts, through procedures that are relatively inexpensive; especially in Japan. Given the ubiquity of lifestyle factors that depend on vision, and an established literature that has shown those with low vision have more disability (Crews & Campbell, 2004; Furner, Rudberg, & Cassel, 1995; Lee, Spritzer, & Hays, 1997) and shorter lives (Karpa et al., 2009). This paper aims to examine how the dynamics of vision loss and disability change over time using a nationally representative data from Japan.

The gradual loss of the sensory systems including vision and hearing are evident with increasing age. In Japan, 1.3% of the population is affected by vision impairment caused by glaucoma, diabetic retinopathy, degenerative myopia, age-related macular degeneration and cataract (Yamada et al., 2010), and myopia, a significant independent risk factor for visual impairment, has been escalating in Japan and may greatly impact the lives of those affected (Saw et al., 1996).

Vision impairment related to aging can have detrimental effects on the individual's ability to live independently and to perform their normal daily routines. For example, visual impairment has been linked to unstable gait patterns, as well as the increased risk for falls, decreased postural stability and decreased balance (Helbostad et al., 2009; Ray, et al., 2008). In addition, visual impairment in older Japanese females has been linked to other disorders such as depression and poorer self-rated health (Harada et al., 2008). While there are obvious links to disability, there is relatively little looking at how the onset of vision loss affects length of time lives with disability.

With the advent of longitudinal data and multistate models, a range of new summary measures of health have been developed which offer a unique view at the dynamics of disability onset and recovery. Using multistate models to estimate transition probabilities.

METHOD

The data were collected from 1999 to 2009 waves of the Nihon University Longitudinal Study of Aging (NUJLSOA). The sample is composed of people ages 65-104. Vision is classified as poor when respondents (reported they see "not very well" and treated as a time varying covariate across all 5 waves of the NUJLSOA. Disability was measured as having difficulty with any of the Activities of Daily Living or Instrumental activities of daily living. In order to use vision as a time varying covariate in IMaCh 0.98Q revision 1.133, the data were pooled so consecutive observation s could have a different covariate value for vision, with concurrent observations on disability status. The resulting pooled data set had 15,911 time interval observations among 6,201 respondents ages 65 and older across the 5 waves of study. The interval between observations varies slightly across waves, generally 2 years apart, though occasionally respondents missed a survey. The data were collected in 1999, 2001, 2003, 2007, 2009. The variables used in the analysis include vision as a dichotomous variable (those who report seeing well-enough-excellent vs. those who cannot see well or blind in both eye), gender, a sample weight, date of birth, date of each interview, and health status at each interview.

Analysis of the NUJLSOA data was based on a multi-state life table that was calculated through the IMaCH (Version 0.98Q) algorithm designed by Brouard and Lievre (2001). The program calculates weighted estimates of life expectancy and implied disability prevalence based on the recent rates of onset and recovery from disability and age-specific rates of death by disability state (Lievre et al., 2003). One advantage of this program is that variable interval lengths within individuals can be used. This will adjust for the differences in interval length between the two surveys and allow cases with some missing data to contribute to the results. Other methods, such as the hazard equation approach, exclude any interval with missing data, and assume only one transition between points of observation.

Laditka and Wolf (1998) described how the parameters of an embedded Markov Chain could be used to model disability change over time in longitudinal data with a maximum likelihood estimation technique. The advantage of this Markov Chain approach is that it can capture change that occurs between survey interviews. Markov Chains have been used in similar studies before modeling disease onset and progression (Jackson & Sharples, 2002).

The IMaCh method has been used in a variety of health transition studies using longitudinal data to examine health expectancy in relationship to gender (Minicuci et al., 2005; Kaneda, Zimmer, & Tang, 2005; Jagger, Goyder, Clarke, Brouard, & Arthur, 2003), education (Minicuci et al., 2005; Kaneda, Zimmer, & Tang, 2005), and diabetes (Jagger et al., 2003). The IMaCh approach allows the computation of age-specific transition schedules for the onset of disability, recovery from disability, mortality among the disabled, and mortality among the non-disabled. The calculations are done through an estimation of a Markov Chain, a statistical technique that allows controllable levels of random variation over time to simulate health changes in observed data (Laditka & Wolf, 1998). The random nature of the Markov model is used to estimate variation in disability status over time, including between survey intervals.

The Markov chain in the IMaCh program uses conditional probabilities to estimate the likelihood for being in a specific state at a given time. In mathematical notation the probabilities could be described as hP_{ijx} where the initial state is represented by i, age is x, j is the final state, and h is the time period between observations to which the probability refers. This notation indicates that the result is conditional to the observed state *i* at age *x* for a given period of allowed transitions, '*h*'. This transition is modeled in the following multinomial logistic equation:

Ln [(p)/(1-p)] = Bx (Age) + Cx (Covariate1) + Dx (Covariate2) + Error

This equation is solved using a maximum likelihood estimation and the multiplication of a series of matrices. The *hPx* matrix (where h is the set time period and P is an estimated probability), is the product of the *nh*stepm* matrices, where n is the number of matrices. The contribution of each individual to the likelihood of a transition is denoted as hP_{ijx}.

The three states are able (coded 1), disabled (coded 2), or dead (coded 3). The transition probabilities were estimated based on a series of 3 x 3 matrices:

$$
{}_h\mathrm{P}_x = ({}_h p_x^{ij}) = \begin{pmatrix} {}_h p_x^{11} & {}_h p_x^{12} & {}_h p_x^{13} \\ {}_h p_x^{21} & {}_h p_x^{22} & {}_h p_x^{23} \\ 0 & 0 & 1 \end{pmatrix}
$$

The transition probabilities are then used as the inputs to a multi-state life table using the maximum likelihood approach. The multiple states are illustrated in Figure 3.1. The model can have two or more states of health, and an absorbing state (in the case of this study, death).

The multi-state method calculates active life expectancy from a set of transitions between active and inactive states of life and to death. Since this method is based on incidence rates from longitudinal data, results represent only the most recent occurrences in the population. The method provides standard errors for the model parameters which are then used to derive standard errors for the life expectancies derived from the transition probabilities (Liévre et al., 2003).

The calculation of active life expectancy used in this dissertation relied on having at least two data points, showing a transition between health states, and thus the imputation scheme described earlier was important in order to accurately reflect the life expectancy of the actual population. Individuals who did not report any transitions (e.g., those lost to follow-up) would not be included in the analysis. This would bias the results, if those individuals were not included in some way. The imputations were made only if an individual had a disability status at the baseline interview, and was known to be alive (but not interviewed) at the time of a subsequent wave.

The multi-state calculation of active life expectancy is an estimate of the average length of active life expected in a 'synthetic cohort.' A synthetic cohort is a hypothetical group of people who experience the morbidity and mortality rates described in the life table at all ages (Crimmins, Saito, & Hayward, 1993). The results of multi-state life tables demonstrate the effect that current disability and mortality rates would have if applied to the life cycle of the current cohort. The results of the calculation are estimates of total active and disabled life expectancy.

RESULTS

Data description

The data for this study come from the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA). The baseline survey took place in 1999 with follow-up surveys every 2-3 years of a nationally representative sample of community-dwelling older adults. In order to ensure a sufficient number of respondents aged 75 and older, a multistage stratified probability sampling method drew from an initial pool of 6,700 older adults and oversamples those 75 and older. Weights are applied to represent the national population. The sample used in the present analyses consists of 6,201 people ages 65-104, who participated in any of the surveys conducted between 1999-2009. The baseline sample consisted of 4,997 which was refreshed in 2001 and 2003 to retain individuals in the youngest age group (ages 65-66). The analysis is based on a pooled sample that counted each observation of two interviews as an observation, and the pooled sample consisted of 15,911 observations.

Table 2 shows the total number of transitions between consecutive surveys. These transitions are used in the Markov Model to calculate life expectancy. The 4,942 people with functional health data in waves 1 and 2 experienced 9,886 transitions, of which 3,945 were known health states, while 675 were either not found at wave 2 or did not answer the functional ability questions, and 324 were reported deceased. Table 3 shows similar patterns occurred in subsequent waves. The IMaCh algorithm needs a closed interval in order to calculate a transition probability, and thus in order to maximize the number of closed time intervals, we created a pooled data set that created closed intervals using the next wave with known data. Table 3 shows what the data structure becomes when the data are pooled with consecutive known observations matched across individuals. This process creates a new line of data for each observed group of time intervals for an individual, and allows us to use vision as a time varying covariate.

Active Life Expectancy

Table 4 shows selected results of Total, Active and Inactive life expectancy by level of visual acuity. The results show that low vision appears to reduce total life expectancy at age 65 by about 4 years (4.1 for men, and 4.6 for women at age 65), a difference of 3 years at age 75 (3.2 for men, 3.8 years for women), and 2 years at age 85 (1.9 for men, 2.5 for women). Furthermore, most of those years of lost life are years lived active (see Table 4). For example, the difference in expected active years between those with poor vision versus those with good vision is about 5 fewer years (4.8 for men, 5.6 for women) at age 65, while at age 75 it is about 4 years (3.7 for men, 4.2 for women), and about 2 years at age 85 (1.9 for men, 2.0 for women) (see Table 4). The net effect of these results show men at age 65 with good vision can expect to life 82.5% of their life active, while a lower-vision counterpart might expect only 72.6% of their life active. The effects of poor vision are especially pronounced at older ages. At age 85 a man with good vision can expect 51% of his remaining years to be active, whereas an 85 year old with low vision can expect only 29.9% of his remaining years active. Among women at age 85, those with good vision can expect a smaller proportion of active life than their male counterparts, at just 38.2% of remaining life active (compared to 51% for men), however having low vision has an even stronger effect, leaving just 20.7% of remaining years expected active.

Conclusion

This study investigated the effect of vision loss on the disability and mortality transitions in a cohort of older adults. We estimated total, active and inactive life expectancy to understand how vision loss can impact quality and quantity of life. While vision loss is associated with reduced ability for self-care (Rudberg, Furner, Dunn & Cassel, 1993), it is also associated with poor health as a result of conditions such as Diabetes. Of course vision loss is is closely tied to aging as well, with visual impairment rising from affecting about 7% of the population at age 65 up to nearly 30% at age 85 (Rudberg, Furner, Dunn & Cassel, 1993). While some of the age-related causes of lost visual acuity may be reversible (e.g., cataracts), or managed to some degree (e.g., glaucoma), many age-related retinal or optic nerve diseases lead to permanent loses that greatly impair functional capacity. Strokes are especially common in Japan, and can sometimes lead to serious vision loss or blindness as well.

Many basic daily tasks require visual acuity in order to complete alone, though many older people can adapt to limitations with their visual acuity. It should be noted that a number of respondents who reported low vision did not report any difficulty with any of the 10 activities of daily living or instrumental activities of daily living. Expectations for what counts as difficulty with an activity of daily living may change as we get older, thus affecting our perception of ourselves as disabled or not.

To conclude, a major strength of this study is that it is based on nationally representative longitudinal data over an extended period of time. The questions used in this survey did not change over time and each wave has more than an 80% response rate. There are very few questions with issues of non-response. The life expectancy estimates are within half a year of national estimates, and may be slightly higher because the initial sample was composed of only community dwelling Japanese and excluded those initially institutionalized. Later surveys followed-up with the institutionalized. We are limited in our ability to adjust for the clustering of repeated observations for the same respondent with IMaCh, though adjustments in previous studies have found the difference in the estimates are not large. In addition, the algorithm is capable of looking at varying levels of disability, and thus the pooled data may be large enough to allow us to investigate the difference between mild and more severe forms of disability.

Table 1. Descriptive Statistics

Age	65-104 mean 75.4 (6.49 SD)
Male	43.3%
Low Vision	Overall 7.8%: T1=7.1%, T2=7.5%. T3=7.7%, T4=7.7%, T5=8.8%
ADL/IADL prevalence	Overall 23.1%: T1=22.3%, T2=21.7%, T3=21.6, T4=25.1%, T5=25.4%
Death	Total N=1,495 T2 N=327, T3 N=381, T4 N=476, T5 N=311
N	4997 baseline, 6,201 unique individuals, 15,911 pooled interval observations

Table 2: Unpooled Transition across surveys

	Female	Male	Combined	
W1 alive	2845	2097	4942	
W1-W2	2258	1687	3945	Respondent in time 2
	427	248	675	transition to missing
	162	162	324	transition to dead
w2 alive	**2619**	**1997**	4616	
W2-W3	2101	1617	3718	Respondent in time 3
	328	236	564	transition to missing
	196	185	381	transition to dead
w3 alive	**2527**	**1958**	4485	
W3-W4	1835	1455	3290	Respondent in time 4
	488	298	786	transition to missing
	240	236	476	transition to dead
w4 alive	**1892**	**1500**	3392	
W4-W5	1421	966	2387	Respondent in time 5
	332	187	519	transition to missing
	142	169	311	transition to dead
w5 alive	1422	1145	2567	

Table 3: Pooled data observed transitions between surveys

W1 alive	14099	
W1-W2	13136	Respondent in time 2
	963	transition to missing
	307	transition to dead
	15083	Among those in W1 and W2, total observations
W2 alive	13345	Respondent in time 3
W2-W3	1017	transition to missing
	643	transition to dead
	14530	Among those in W2 and W3, total observations
W3 alive	11736	Respondent in time 4
W3-W4	1562	transition to missing
	1234	transition to dead
	11751	Among those in W3 and W4, total observations
W4 alive	8875	Respondent in time 5
W4-W5	1758	transition to missing
	1127	transition to dead
	8882	Among those in W4 and W5, total observations

Table 4: Total, Active, and Inactive Life Expectancies and Proportion of Active Life Expectancy by vision

	Selected age	TLE	95% CI	ALE	95% CI	IALE	95% CI	ALE/TLE%
Men								
Poor vision	65	15.6	14.2-17.1	11.4	10.1-12.6	4.3	3.5-5.0	72.6
	75	8.7	7.8-9.6	4.8	4.0-5.6	3.9	3.3-4.5	55.1
	85	4.4	3.9-4.9	1.3	0.9-1.7	3.1	2.6-3.6	29.9
Good vision	65	19.7	19.1-20.3	16.2	15.7-16.7	3.4	3.1-3.8	82.5
	75	11.9	11.4-12.4	8.5	8.1-8.9	3.4	3.0-3.7	71.6
	85	6.3	5.9-6.8	3.2	2.9-3.6	3.1	2.7-3.5	51.0
Women								
Poor vision	65	19.0	17.6-20.4	11.7	10.4-12.9	7.3	6.3-8.4	61.3
	75	11.3	10.3-12.3	4.8	3.9-5.6	6.5	5.7-7.3	42.2
	85	6.1	5.4-6.8	1.3	0.9-1.6	4.8	4.2-5.5	20.7
Good vision								
	65	23.6	22.9-24.3	17.3	16.8-17.8	6.3	5.8-6.9	73.1
	75	15.1	14.5-15.8	9.0	8.6-9.5	6.1	5.6-6.6	59.6
	85	8.6	7.9-9.2	3.3	2.9-3.6	5.3	4.8-5.8	38.2

Figure 1: Life expectancy at age 65 for females in Japan divided into years expected active and disabled.

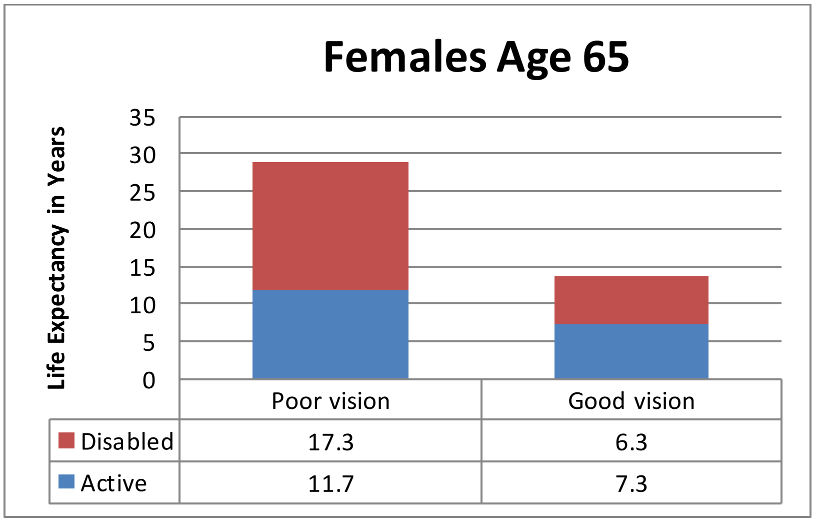


Figure 2: Life expectancy at age 65 for males in Japan divided into years expected active and disabled.

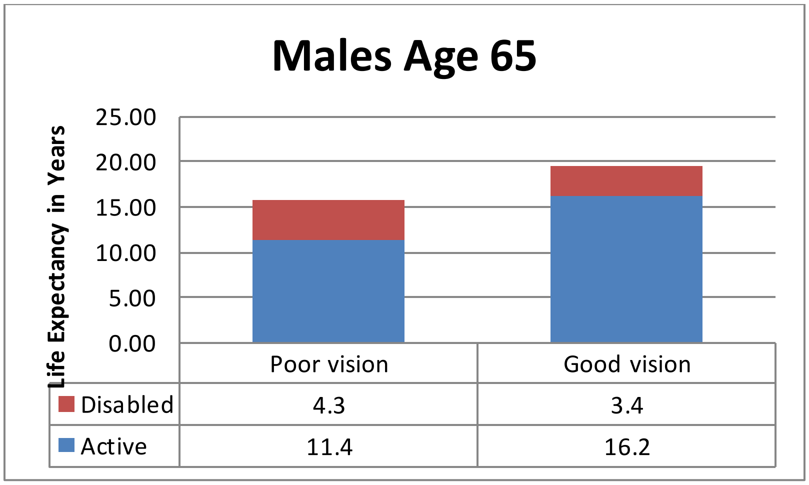


Figure 3: Life expectancy at age 85 for females in Japan divided into years expected active and disabled.

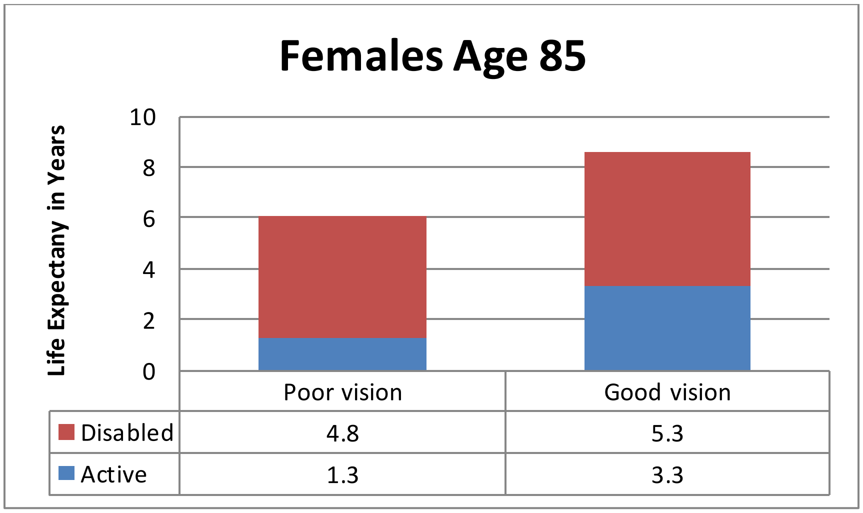


Figure 4: Life expectancy at age 85 for males in Japan divided into years expected active and disabled.

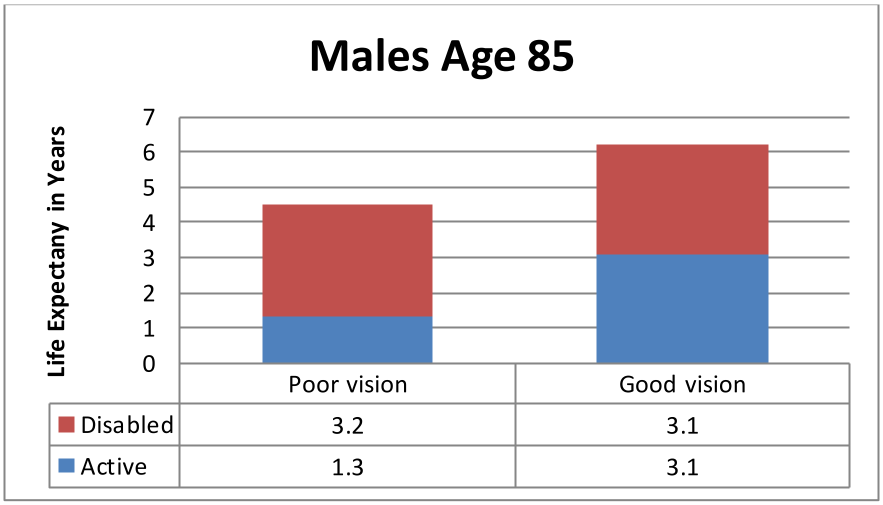


Figure 5: Transition rates for disability onset by gender and vision ability

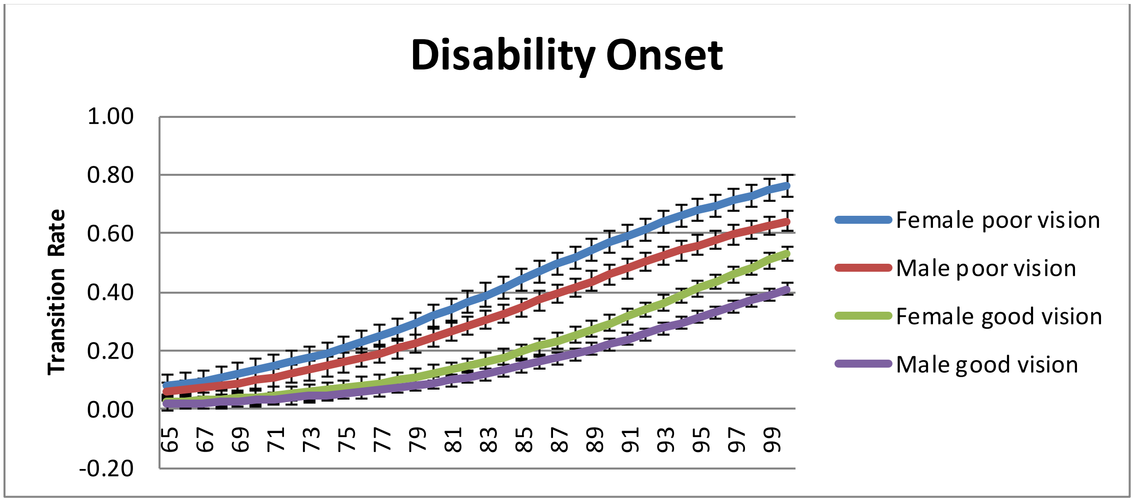


Figure 6: Transition rates for disability recovery by gender and vision ability

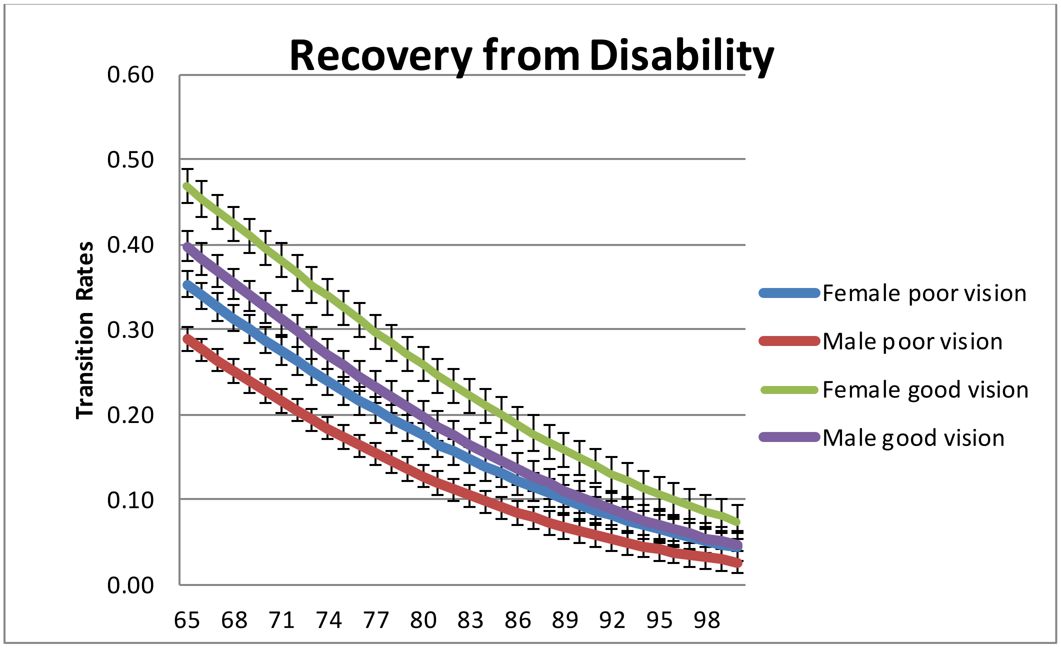
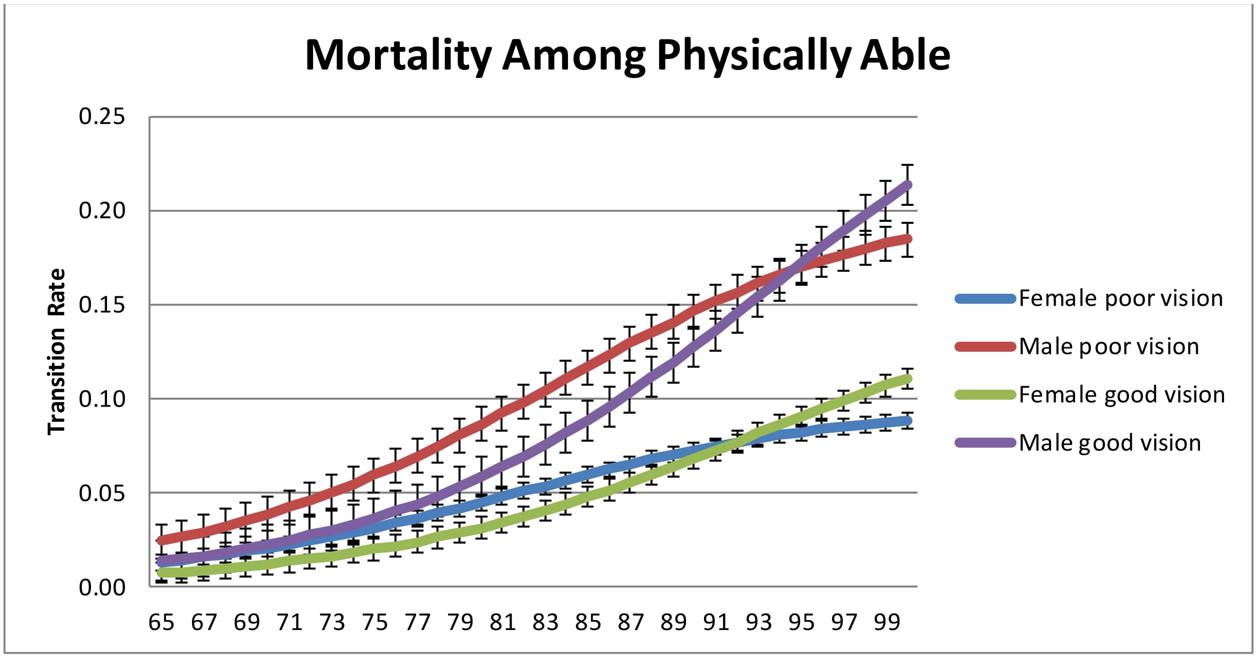
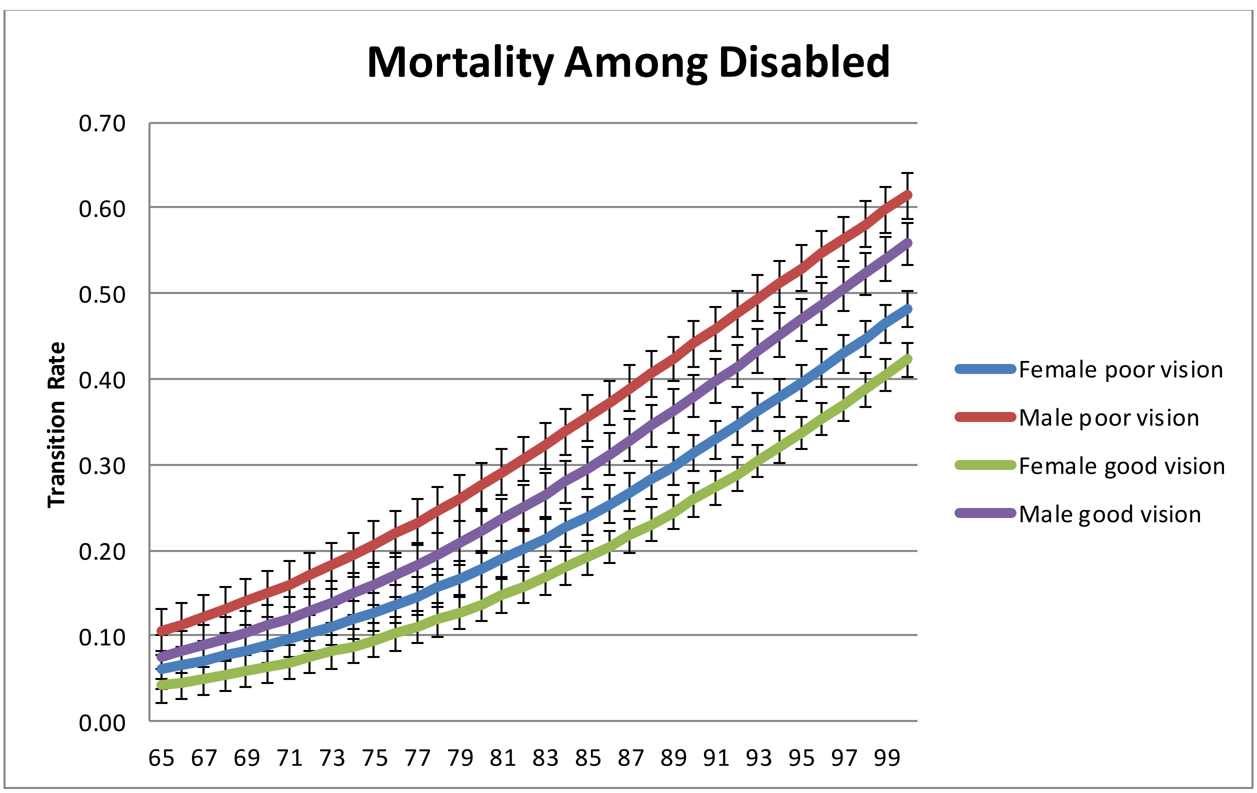


Figure 7: Transition rates for mortality by gender, vision ability, and disability





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