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ORIGINAL ARTICLE

Decomposing socioeconomic inequalities in the use of preventive eye screening services among individuals with diabetes in Korea

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Abstract
Objectives The aim of this study was to assess the socioeconomic inequalities in the use of preventive eye screening services among individuals with diabetes in Korea.
Methods Using nationally representative survey data, the concentration index (CI) and decomposition of the CI were used to capture and quantify income-related inequalities.
Results The results show income-related inequality in the use of eye screening services among individuals with diabetes, suggesting that services were concentrated among individuals with higher incomes. After adjusting for need factors, such as sex, age and self-rated health, the inequality still persisted as observed horizontal inequity in the services, indicating that unequal care was provided for equal need. The decomposition approach revealed that the largest contributions to the observed inequality were higher education and higher income levels. Having private insurance and residing in non-Seoul metro areas also contributed to the observed pro-rich inequality.
Conclusions These findings suggest that income- and education-related barriers to the use of preventive eye screening services for individuals with diabetes should be targeted for removal at the national level to achieve the goal of equal care for equal need in diabetes management.

Keywords Concentration index · Decomposition · Diabetes · Preventive eye care services · Inequality · Socioeconomic status

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Introduction

The increasing prevalence of diabetes is a major public health issue (Hwang and Shon 2014). The recent estimated prevalence of type 2 diabetes among Korean adults (aged 20–79) is approximately 7.7 %, which is higher than the average prevalence of diabetes among Organisation for Economic Co-operation and Development (OECD) countries (6.9 %) (OECD 2013). Diabetic retinopathy (DR) is a major cause of visual impairment and blindness (Hooper et al. 2012). DR-related visual impairment and blindness ultimately impedes daily activities and decreases quality of life in people with diabetes (Buhrmann et al. 2007; Perruccio et al. 2010). The development of DR is closely associated with the duration of diabetes; as the diabetic condition develops, the risk of visual impairment increases (Hooper et al. 2012). Approximately, 78 % of individuals with a 15-year duration of diabetes have DR, a higher prevalence of DR compared with individuals with a 5-year duration (Klein et al. 1984). However, visual impairment is clinically manageable if diagnosed early (Boyd et al. 2013; Hooper et al. 2012). For early detection and timely treatment, it is recommended that all individuals diagnosed with diabetes receive an annual eye screening by an eye health professional (KAMS 2014).

Despite the recognised importance of eye screening services for individuals with diabetes, inequalities in the use of these services have been found (Moss et al. 1995; Saadine et al. 2008). In particular, lower socioeconomic status (SES) is consistently associated with the underutilisation of diabetic eye screening services, a pattern that has been observed internationally regardless of the type of health-care system (Fraser and Edwards 2010; Kliner et al. 2012; McCarty et al. 1998; Millett and Dodhia 2006; Scanlon et al. 2008). As there is a strong association

between higher prevalence of diabetic eye complications and lower SES (Chaturvedi et al. 1996), the underutilisation of annual eye screening services could increase the risk of diabetic eye complications, especially among lower SES groups. In Korea, a recent national survey estimated that only 39 % of individuals with diabetes had received the recommended annual eye examination (Byun et al. 2013). Ophthalmic care services, including preventive eye care services, are covered by Korea's National Health Insurance, which aims to cover health-care services with out-of-pocket (OOP) payments made at the time of service (Kwon 2009). Individuals who use health-care services are required to pay a portion of the total care cost, called a co-payment. Because of the National Health Insurance co-payment scheme, economic barriers to health care have not been completely eliminated, and socioeconomic inequalities in health care remain major challenges in Korea (Lu et al. 2007). For example, individuals of lower SES are more likely to experience unmet health-care needs (Heo et al. 2012). Considering the growing interest in health-care inequalities in Korea (Cho 2013), it is crucial to examine whether all individuals with diabetes receive the recommended annual eye screening as part of their diabetes management, regardless of SES. The objectives of this study were to measure the socioeconomic inequalities in diabetic eye screening services, identify the contribution of each determinant to the observed inequalities and determine whether the observed inequality is a matter of inequity.

Methods

Data and participants

Data from the Korea National Health and Nutrition Examination Survey (KNHANES) 2005 (Cycle 3) and 2007–2009 (Cycle 4) were used. The KNHANES is a national survey for assessing the health and nutritional status of Koreans, monitoring risk factors for disease, and describing the burden of chronic diseases (Kweon et al. 2014). The KNHANES collects data from non-institutionalised Koreans residing in Korea, including detailed information on SES, health behaviours, quality of life, health-care utilisation, and various health examination results (Kweon et al. 2014). The KNHANES sampling strategy follows a multi-stage clustered probability design. The KNHANES is designed for a pooled sample approach by combining different survey waves using survey weights (Kweon et al. 2014). More details on the KNHANES can be found at http://knhanes.cdc.go.kr/knhanes/eng.

The KNHANES classifies diabetic conditions using three different measures. First, participants were asked whether they had a diabetic condition and whether they had ever been diagnosed with diabetes by a physician. Second, fasting glucose levels were collected as part of the health examination, and participants were asked about their current treatment for diabetes to classify diabetic conditions in the survey (Hwang and Shon 2014). Based on these measures, this study included 2214 individuals over 20 years old who were classified as having diabetes out of a total of 59,016 survey respondents.

Variables

Our outcome variable of interest in the health survey was the use of eye screening services, which was measured as an individual's self-reported experience of diabetic eye screening services within the past year. Self-reported annual household income was used to measure income.

Statistical analyses

Concentration index (CI)

To examine inequality in the use of eye screening services, the concentration index (CI), a standard tool to measure income-related inequality in health policy and economics research, was used (O'Donnell et al. 2008). The CI is derived from a concentration curve in which the individuals are ranked by income, and the cumulative rankings of each individual are plotted against the cumulative share of the use of health-care services. In general, the CI ranges from -1 to $+1$, and if there is no inequality, the index has a value of zero. A positive CI value indicates that higher income groups use more health-care services, whereas a negative value indicates more use of services by lower-income groups. When the main outcome is a binary indicator, the CI does not range from -1 to $+1$, but changes based on the mean of the outcome variable (O'Donnell et al. 2008). For a binary outcome, the lower and upper bounds are $\mu - 1$ and $1 - \mu$, respectively.

Decomposition of the CI

After the CI was calculated, a decomposition method was applied to assess the major contributors of socio-demographic factors to the observed inequality. The decomposition approach enables us to quantify the contribution of each factor to income-related inequality in the use of diabetic eye screening services. To apply the decomposition, age, sex, duration of diabetes, self-rated health and diabetes-related comorbidities (i.e. hypertension, hyperlipidaemia, angina pectoris, myocardial infarction, stroke, chronic renal disease, glaucoma, and cataract) were included as "need" factors (i.e. risk or use

would be expected to increase with need factors), whereas educational attainment, occupation, health insurance, education experience in diabetes management, and region were included as "non-need" factors in the analytic model. The non-need factors included in the analytic models are well-documented determinants of health care in the literature (Brown et al. 2004; Vandenheede et al. 2015). The decomposition was conducted using the following steps: (1) the outcome variable (i.e. eye screening services) was regressed against the need and non-need factor variables using a probit model. Through this step, the partial effects ($\beta\frac{\rho}{k}$) of the need and non-need factor variables were estimated. (2) The means of the outcome variable and each of the need and non-need factor variables (i.e. x_k) were calculated. (3) The CI for the outcome variable and the need and non-need factor variables (i.e. C and C_k) were calculated, as was the residual term (i.e. GC). The following steps were used to quantify the contribution of each determinant to the CI: (1) the absolute contribution of each determinant was calculated by multiplying its outcome elasticity ($\beta\frac{\rho}{k}x_k/\mu$) with respect to each determinant and the CI of each determinant. (2) The percentage contribution of each determinant was calculated by dividing its absolute contribution by the CI of the outcome variable (O'Donnell et al. 2008). A positive or negative contribution of a determinant indicates that the determinant is associated with both income and eye screening services use. In other words, a positive contribution of the determinant indicates that the observed inequalities can be reduced by x % if the determinant is distributed equally across income groups.

Horizontal inequity index (HI)

In addition to the decomposition of the CI, the horizontal inequity index (HI) was obtained to determine whether the observed inequality is a matter of inequity. The HI was computed as the CI minus the sum of the absolute contributions of all need factor variables, which predict healthcare utilisation (O'Donnell et al. 2008). A positive (negative) HI value indicates horizontal inequity favouring better-off (worse-off) individuals. A zero HI value indicates horizontal equity.

All analyses were conducted using STATA v.12 (StataCorp, College Station, TX), and the survey weights provided by KNHANES were applied to all analyses.

Results

Table 1 presents the general characteristics of the respondents. Among the 2214 respondents with diabetes, 906 (40.9 %) indicated that they had received dilated eye

Table 1 General characteristics of the survey respondents from the Korea National Health and Nutrition Examination Survey (KNHANES) Cycle 3 (2005) and Cycle 4 (2007–2009) ($n = 2124$)

Variable	Eye screening-yes		Eye screening-no	
	N/mean	%/SD	*N*/mean	%/SD
Gender				
Female	496	40.4	671	59.6
Male	410	35.1	637	64.9
Age				
20–44	72	32.3	112	67.7
45–64	414	36.6	624	63.4
65 or over	420	40.7	572	59.3
Self-rated health				
Very good/good	116	31	232	69
Fair	235	33.8	380	66.2
Very bad/bad	555	41.9	696	58.2
Comorbidity				
Number of comorbidities	1.08	±0.97	0.80	±0.83
Marital status				
Single	235	37	361	63
Married/partnered	671	38.2	947	61.9
Education				
Elementary school	435	34.8	731	65.2
Middle school	148	40.2	196	59.9
High school	209	39.8	259	60.2
Post-secondary school	114	45	122	55
Region				
Seoul metro area	435	45.7	443	54.3
Non-Seoul metro areas	471	32.5	865	67.5
Duration of DM				
0–6 years	400	29.7	824	70.3
7 years or over	506	51.5	484	48.5
Income				
Quintile 1 (lowest)	196	36.3	300	63.7
Quintile 2	211	37.4	323	62.6
Quintile 3	111	34	189	66
Quintile 4	225	38.8	302	61.2
Quintile 5 (highest)	163	42.7	194	57.3
Occupation				
White collar	78	42.7	87	52.7
Service and sales	64	36.6	111	63.4
Farming and fishing	65	29.6	155	70.5
Blue collar	124	36.5	216	63.5
Out of labour market	575	43.8	739	56.2
Health insurance				
National Health Insurance	820	37.6	1183	62.4
Medicare or no	86	39.6	125	60.4
Private insurance				
Yes	413	38	595	62
No or do not know	493	37.7	713	62.3

Table 1 continued

Variable	Eye screening-yes		Eye screening-no	
	N/mean	%/SD	*N*/mean	%/SD
DM Education				
Yes	322	58.9	212	41.1
No	584	31.7	1096	68.3
Total	906	37.8	1308	62.2

screening services from a health professional. The use of eye screening services was slightly higher in women than in men (40.4 vs. 35.1 %). The use of eye screening was more prevalent in the respondents with the highest incomes compared to those with the lowest incomes (38.8 vs. 36.3 %). Approximately, 45 % of individuals who received eye screening services within the past year resided in the Seoul metro area. In addition, 51.5 % of individuals with longer durations of diabetes (7 years or over) reported screening service use.

The results of the income-related CI are presented in Table 2. The income-related CI for eye screening services had a positive value (0.027), suggesting that the recommended eye screening services were more concentrated among individuals with higher incomes. The HI, which captures the idea of equal care for equal need, also favoured the rich (0.080). This result suggests that diabetic eye screening services were concentrated among individuals with higher incomes and that the observed inequality in the use of eye screening services is a matter of inequity.

Table 3 shows the contributions of each determinant to the observed pro-rich inequality (i.e. positive CI). A positive elasticity indicates that an increase in an explanatory variable increases the probability of seeking recommended eye care services. The positive contribution of a particular factor shows that the socioeconomic distribution of the factors and the association of the relevant factor and eye screening services lead to an increase in the probability of receiving eye screening services. The largest contribution to the CI for eye screening services comes from education, particularly the higher educational attainment groups. Income was the second-largest contributor.

Having private insurance contributed approximately 37 % to the observed CI for the use of eye screening services. In addition, living in non-Seoul metro areas, and occupation and experience in diabetes management education positively contributed to the observed pro-rich CI for recommended eye screening services use among individuals with diabetes.

Discussion

Although Korea's universal health insurance covers diabetic eye screening examinations, the concentration index (CI) indicates pro-rich inequality, suggesting that the use of recommended diabetic eye screening services is concentrated among individuals with higher incomes. This finding is consistent with previously reported findings in various countries. For instance, in Canada and the UK, where publicly funded health-care systems exist and promote the expectation that there should be no financial barriers to accessing physician services, individuals with lower incomes were less likely to seek regular diabetic eye screenings (Hwang et al. 2015; Kliner et al. 2012). Additionally, a lower proportion of lower income individuals with diabetes sought eye screening services in the USA (Frohlich et al. 2006). This consistent finding across various countries may help conclude that the observed lower rate of diabetic eye screening is common regardless of the type of health-care system.

Adjusting for need factors to calculate the HI reveals a pro-rich direction of an increased magnitude compared with the observed CI. As the HI indicates, there is violation of the equal care for the equal need principle (O'Donnell et al. 2008); this finding indicates that avoidable inequality in the use of recommended eye screening services among individuals with diabetes persists after adjusting for need factors of health-care utilisation.

Although inequality and inequity are often used interchangeably throughout the existing literature, a distinction between these terms should be made (Asada 2005). Inequality in health care implies that there are unavoidable differences in access or utilisation, whereas inequity indicates avoidable variation, injustice or social concern that arises from inequalities within and between groups (WHO 2008).

The decomposition of the CI revealed that the distinction between inequality and inequity can be judged based on the estimated contributions of need and non-need factors (O'Donnell et al. 2008). In general, inequities in health

Table 2 Concentration index (CI) and horizontal inequity index (HI) for eye screening examinations from the Korea National Health and Nutrition Examination Survey (KNHANES) Cycle 3 (2005) and Cycle 4 (2007–2009) ($n = 2124$)

Outcome variable	Mean	Concentration index (95 % confidence interval)	CI range (min, max)	Horizontal inequity index (HI)
Eye screening examinations	0.409	0.027 (0.00–0.06)	−0.591, 0.591	0.080

Table 3 Decomposition of income inequality in eye screening services in individuals with diabetes from the Korea National Health and Nutrition Examination Survey (KNHANES) Cycle 3 (2005) and Cycle 4 (2007–2009) ($n = 2124$)

Variable	Partial effect	Elasticity	CI_k	Absolute contribution	Sum	Contribution (%)
Gender						
Male	0.064*	0.231	−0.031	−0.007		−25.9
Age						
45–64	0.012	0.015	0.105	0.002	−0.013	−48.1
65 or over	0.067	0.061	−0.245	−0.015		
Self-rated health						
Fair	0.060	0.046	0.127	0.006	−0.008	−29.6
Very bad/bad	0.101*	0.130	−0.106	−0.014		
Comorbidity						
Number of comorbidities	0.074*	0.155	−0.095	−0.015		−55.6
Duration of DM						
7 years or over	0.163*	0.169	−0.058	−0.010		−37.0
Need factors total				−0.053		
Region						
Non-Seoul metro areas	0.116*	0.128	0.091	0.012		44.4
Marital status						
Married	0.033	0.060	0.086	0.005		18.5
Education						
Middle school	0.088*	0.035	0.028	0.001	0.027	100.0
High school	0.094*	0.055	0.205	0.011		
Post-secondary	0.118*	0.037	0.398	0.015		
Income						
Quintile 2 (low)	0.002	0.004	−0.391	−0.001	0.021	77.8
Quintile 3	−0.013	−0.004	−0.017	0.000		
Quintile 4	0.015	0.009	0.372	0.003		
Quintile 5 (high)	0.050	0.023	0.812	0.019		
Occupation						
Services and sales	−0.079	−0.017	0.250	−0.004	0.005	18.5
Farming/fishing	−0.095	−0.017	−0.114	0.002		
Blue collar	−0.043	−0.019	0.089	−0.002		
Out of labour market	−0.043	−0.059	−0.146	0.009		
Health insurance						
Medicare/no	0.022	0.005	−0.564	−0.003		−11.1
Private insurance						
Yes	0.034	0.041	0.256	0.010		37.0
DM education						
Yes	0.208*	0.120	0.065	0.008		29.6
Non-need factors total				0.085		
Residual				−0.005		−18.5

* $p < 0.05$

care are caused by contributions from non-need factors, after controlling for all need factors for health-care utilisation. In this study, the observed pro-rich HI can be considered an avoidable variation in the use of eye screening services, which should be modified because it violates the equal care for equal need principle at which Korea's National Health Insurance should aim (Kwon 2009). This finding suggests that equity in preventive eye care services among individuals with diabetes cannot be simply achieved by maintaining the current universal health-care system and that additional policy interventions (e.g. targeted chronic disease management programmes for

lower SES individuals) should be considered to provide necessary preventive eye screening services for lower SES individuals with diabetes.

The identification of contributors to the pro-rich CI value for DR screening among individuals with diabetes is a critical step in planning population-based policy interventions to diminish the existing inequalities. The decomposition results reveal that higher income and education levels are major contributors to the observed inequalities. These results are consistent with existing studies, suggesting that higher income and higher education levels increase the probability of using preventive care services, including a dilated eye screening service (Dunlop et al. 2000; Jotkowitz et al. 2006; Morris et al. 2005). Several studies have revealed inequalities in specialist care, suggesting that higher incomes lead to inequalities in specialist services, even under publicly funded health-care systems (Allin 2008; Asada 2005; Asada and Kephart 2007; Veugelers and Yip 2003). In Korea, lower income and lower educational attainment levels have often been suggested as the main factors associated with lower use of preventive services across all age groups (Cho 2013). The role of SES in the lower use of preventive health-care services has been elucidated in previous studies (Asada and Kephart 2007; Carrieri and Wuebker 2013; Hwang et al. 2015). For instance, individuals with higher SES are more likely to have better knowledge of essential care and higher levels of health literacy, which are closely associated with the use of recommended care services in diabetes management, because a better understanding of necessary care is associated with higher rates of initial appointments for specialist care (Brown et al. 2004; Hwang et al. 2015; Lorant et al. 2002; McGrail 2008). Accordingly, higher income and education levels are predictors for preventive eye screening services among individuals with diabetes; thus, to ameliorate the observed inequality, individuals with lower income and lower education levels should be considered primary targets for diabetes management.

Additionally, more attention should be devoted to supplementary health insurance and diabetes education, which also contributed to the observed pro-rich inequalities. Despite Korea's universal health-care system, private health insurance still plays a pivotal role in the use of essential eye screening services in diabetes management. This result may occur because individuals with higher incomes have a stronger tendency to purchase private health insurance, as the concentration index (C_k) for private insurance shows a pro-rich pattern (Table 3). It is not uncommon for individuals with higher incomes to purchase voluntary insurance, which may increase the use of preventive services, even under a universal health system (Borrell et al. 2001). Furthermore, the contribution of diabetes education implies that individuals with lower incomes may have limited knowledge of proper diabetes management, as attending diabetes education sessions was more likely among individuals with higher incomes (see the CI for diabetes education, Table 3). Income has previously been reported as a predictor of diabetes education in Korea, and greater attention was suggested to mitigate income-related barriers to educational opportunities for diabetes management (Hwang and Johnson 2015).

Additionally, the contribution of the place of residence (non-Seoul metro areas) to the existing inequalities cannot be overlooked. Regional variations in health care are not new in Korea, but this finding emphasises the need for policy action to reduce geographical inequalities in health care. The observed contribution of region might be stimulated by an uneven distribution of health-care resources between the Seoul metro area and the areas outside of Seoul metro. Approximately, 50 % of health-care resources are concentrated in the Seoul metro area (HIRA 2015), and this skewed distribution of health-care facilities may hinder the access of non-Seoul metro dwellers with lower incomes to the recommended eye screening services. Additionally, limited access to the recommended eye screening services in non-Seoul metro areas may worsen diabetic eye health outcomes, as individuals dwelling in these areas do not receive regular screenings that allow for the early detection and timely treatment of DR. Further investigations should be considered to better understand geographical differences in the use of eye screening services and diabetic eye health outcomes.

Limitations

Although the decomposition of the CI allows one to identify the factors contributing to observed inequalities, it should be noted that the decomposition analysis does not provide causal pathways between socio-demographic determinants and eye screening services. The contribution of a determinant to the observed inequality usually depends on the products of its estimated elasticity with the health-care outcomes at the sample means and on the CI of the factor itself; so, this analysis fails to identify causal pathways. Additionally, the decomposition method is a deterministic approach, and there may be other factors, such as clinical determinants, that are not included in the analytical model and may have contributed to inequalities in eye screening services. For instance, although several factors associated with diabetic eye complications, such as age, sex, and duration of diabetes, were included need factors for eye screening services, there are several other important clinical indicators, such as glycaemic control and blood pressure. In relation to the non-need factors, other health system characteristics, such as availability and accessibility of services (e.g. locations and hours of

ophthalmic services), should be considered for inclusion in future studies when data become available (Hwang et al. 2015). Additionally, information on the current prevalence of diagnosed diabetes eye complications was not included. The KNHANES provides self-reported data, and recall bias may have impacted our results: previous studies suggest that lower SES individuals sometimes have difficulty accurately reporting their socio-demographic and health information (Gallo and Matthews 2003; Matthews and Gallo 2011).

Conclusion

Despite clear guidelines intended to provide early detection and timely treatment of DR for all individuals with diabetes, the findings of this study suggest that individuals living with diabetes in Korea experience income-related inequities in the use of eye screening services. Particularly, higher income and higher educational attainment appear to be the main contributors to the existing inequalities that favour the rich, in addition to residing in non- Seoul metro areas and having private health insurance. To achieve equal care for equal need in diabetes management, removing the barriers identified in this study should be considered potential policy targets at the national level.

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