The association between lifetime cigarette smoking and dysphonia in the Korean general population: findings from a national survey

Haewon Byeon

This study aims to investigate the relationship between current smoking and lifetime amount smoked and the incidence of dysphonia using data from a national cross-sectional survey that represents the Korean population. Subjects were 3,600 non-institutionalised civilian adults over the age of 19 (1,501 males and 2,099 females) who completed the laryngeal examination of the 2008 Korea National Health and Nutrition Examination Survey (KNHANES). For lifetime amount smoked, subjects were classified as light smokers (≤26.7 pack years), medium smokers (26.7-40.5 pack years), heavy smokers (40.5-55.5 pack years), and very heavy smokers (55.5-156 pack years) based on pack years (packs smoked per day × years as a smoker). The odds ratio (OR) for the statistical test was presented using hierarchical logistic regression. When adjusted for covariates (age, gender, level of education, income, occupation, alcohol consumption and pain/discomfort during the last two weeks), current smokers had a 1.8 times (OR=1.77, 95% CI: 1.17-2.68) higher risk for self-reported voice problems than non-smokers. Moreover, current smokers had a 1.6 times (OR=1.56, 95% CI: 1.02-2.38) higher risk of laryngeal disorder (p<0.05). In terms of pack years, very heavy smokers were significantly more likely to have laryngeal disorder, while self-reported voice problems were significantly more likely for heavy smokers but not very heavy smokers. The results of this study imply that chronic smoking has a significant relationship with dysphonia. Longitudinal studies are required in future work to verify the causality between lifetime smoking amount and dysphonia.

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26

Introduction

28   Although the smoking rate of adults in Korea has been steadily decreasing for the last decade,

29   the smoking rate of adult males in Korea as of 2008 is 46.1%, which is the highest among OECD

30   countries (Ministry of Health and Welfare, 2010). Smoking is a major risk factor that exerts a

31   detrimental effect on vocal health. Repeated smoking can lead to the inability to move the vocal cords

32   completely during vocalisation through its harmful impact on the mucosal membrane of the oral cavity,

33   resulting in a deterioration of vocal quality and pitch (Menvielle et al., 2004). An acoustic analysis of

34   the voices of smokers revealed that smokers have a lower fundamental frequency than non-smokers

35   (Awan, 2011; Wiskirska-Woźnica et al., 2004) and their vocal quality is unstable (Vincent & Gilbert,

36   2012). Moreover, it has been shown that it takes smokers less time before the onset of vocal fatigue

37   than non-smokers and smokers experience more severe vocal fatigue (Park, 2003). In addition,

38   smoking is known as a risk factor for laryngeal disorders. Chronic smoking is a major cause of

39   laryngeal and oral cancer, and it is a risk factor for laryngeal keratosis, Reinke's edema and laryngeal

40   leukoplakia (Feierabend & Shahram, 2009; Gnjatic, Stankovic, & Djukić, 2009; Schultz, 2011).

41   Without the elimination of chronic stimulants such as tobacco, permanent recovery from dysphonia is

42   difficult to attain through surgical operations alone (Boone, 2013; Cohen, 2010). Therefore, for the

43   prevention of dysphonia, risk factors must be identified and systematically managed.

44   Meanwhile, self-reported voice problems have been identified as a significant risk indicator for

45   the progression of dysphonia (Byeon, 2011; Miller & Verdolini, 1995). Together with the laryngeal

46   endoscopy test and acoustic phonetic test, the self-reported status of a vocal problem is a standard in

47   the diagnosis of dysphonia in clinical practice (Lehto et al., 2006; Verdolini & Ramig, 2001). Although

48   it has a tendency to be perceived as a more severe problem than it actually is, the subjective recognition

49   of health problems has long been used as an indicator to represent the health status of interviewees,

50 because it is easy to measure and useful for predicting the risk of disease (Idler & Kasl, 1991; Ware,

51 1986).

52   Even though several studies (Feierabend & Shahram, 2009; Marcotullio, Magliulo, & Pezone,

53 2002; Zvrko, Gledović, & Ljaljević, 2008) have reported that smoking has an adverse effect on the

54 larynx, two studies on community populations did not find any significant association between

55 smoking and dysphonia (Byeon, 2014; Roy, 2005). One of the studies (Byeon, 2014) diagnosed

56 laryngeal disorders with only the diagnostic results of a laryngeal endoscopy; thus, it cannot be

57 concluded that smoking does not have anything to do with voice problems simply because it was

58 confirmed that smoking has no association with laryngeal disorders. As it currently stands, there have

59 been few, if any, studies on the relationship between the amount people have smoked over their

60 lifetime and voice problems in the community population.

61   This study aims to investigate the relationship between current smoking and lifetime amount

62 smoked and the prevalence of dysphonia using data from a national cross-sectional survey that

63 represents the Korean population.

64

65

66   **Methods**

67

68 **Subjects**

69   The data resource of this study was part of raw data of The Korea National Health and

70 Nutrition Examination Survey (KNHANES) conducted by Korea Centers for Disease Control and

71 Prevention in 2008. The KNHANES is a national cross-sectional survey for the non-institutionalized

72 civilian population of South Korea. A complex, stratified, multistage probability sampling design based

73 on age, sex, and region was used in this survey to represent the Korean population (Ministry of Health

74 and Welfare, 2010). The survey was approved by the Institutional Review Board of the Korean Center

75 for Disease Control and Prevention (2011-02CON-06). In brief, The KNHANES consists of health

76 questionnaire survey, examination survey and nutrition survey. Health questionnaire survey included

77 health behaviors such as smoking and drinking and for Examination Survey, otolaryngological

78 examinations were conducted by otolaryngologists. Survey on level of education and economic

79 activities were conducted with individual interviews, while health behaviors like smoking and self-

80 reported voice problems were surveyed by self-administered reporting method. The target population

81 of KNHANES comprises non-institutionalized Korean citizens residing in Korea. The sampling plan

82 follows a multi-stage clustered probability design based on the National Census Data. For example, in

83 the 2008 survey, 100 primary sampling units were drawn from approximately 200,000 geographically

84 defined primary sampling units for the whole country. The 2008 KNHANES response rate was 74.3%

85 for the health interview and examination survey.

86   The subjects of this study were 3,623 adults over the full age of 19 who completed both Health

87 Questionnaire Survey and otolaryngological examination of KNHANES performed in 2008. Among

88 them, finally a total 3,600 adults (1,501 males and 2,099 females) were analyzed with the exclusion of

89 32 non-respondents to otolaryngologic interviews (Figure. 1).

90

91 **Measurement**

92   **Smoking.** Smokers were classified into current smokers, past smokers and non-smokers. According

93 to the definition of WHO, a current smoker was defined as someone who has smoked more than 100

94 cigarettes over their life and either sometimes smokes, or smokes every day. A past smoker is defined

95 as someone who has smoked more than 100 cigarettes during their life and does not currently smoke.

96 Pack years (Total smoked over a lifetime) was calculated as packs of cigarettes smoked per day

97 multiplied by the years spent as a smoker (Sabia et al., 2008). Smokers were grouped based on their

98   calculated pack years, into light smoking (≤26.7 pack years), medium smoking (26.7–40.5 pack years),

99   heavy smoking (40.5–55.5 pack years), and very heavy smoking (55.5–156 pack years) with reference

100   to preceding studies (Juan et al., 2004; Tyas et al., 2003).

101

102   **Self-reported voice problems.** Self-reported voice problems were classified into 'yes' and 'no' in

103   response to the question 'Do you think that you currently have pain and discomfort in your own voice?'

104   in the otolaryngologic interviews.

105

106   **Laryngeal disease**. A total of 45 otolaryngologists from 43 general hospitals conducted endoscopic

107   laryngeal examinations for laryngeal lesions using a 70˚endoscope that was attached to a charge-

108   coupled device camera on male and female adults aged 19 and over [13].

109   The laryngeal examinations were collaborating with Korean Society of Otorhinolaryngology-Head

110   and Neck Surgery providing technical advice and highly trained otolaryngologists. Prior to the research,

111   otolaryngologists were trained three times, and common criterion errors were examined through theory

112   education, pre-training, and mock surveys. The index of coincidence was evaluated twice, and the

113   quality improvement committee re-evaluated the examined pictures and videos (640×480-sized audio

114   video interleave files which were compressed by DivX 4.12 codec using a compression rate of 6

115   Mb/sec) by otolaryngologists and computed results. The laryngoscope examination index of

116   coincidence was 75%.

117   Based on data from laryngoscopic examination, the definition of laryngeal disease included vocal

118   nodules, vocal polyp, intracordal cyst, Reinke edema, laryngeal granuloma, sulcus vocalis, laryngeal

119   keratosis, laryngitis, laryngeal papilloma, vocal cord paralysis, and suspected malignant neoplasm of

120   the larynx.

121

122   **Confounding variables.** Confounding variables included age, gender, level of education, income,

123   occupation, alcohol drinking, pain & discomfort from disease for the recent 2 weeks. Level of

124   education was classified into primary, middle and high school graduates and university graduates and

125   over. Income was classified into 4 quartiles. Occupation was surveyed based on the 6th revised version

126   of the Korean Standard for Classification of Occupations (KSCO-6; Korea national statistical office,

127   2007) and was reclassified into economically inactive (unemployed persons, housewives and students),

128   non-manual (managers & professionals, clerical support workers and service & sales workers) and

129   manual (skilled agricultural &forestry & fishery workers, craft & related trades workers and

130   elementary occupations). Alcohol drinking was classified into 'less than once a month' and 'once or

131   more' a month based on the drinking behavior for recent one year. Pain and discomfort from disease for

132   the recent 2 weeks was classified into ' yes' and 'no.'

133

134   **Statistical analysis**

135   The weighted values of The KNHANES were calculated so that the subjects of the survey

136   could represent the overall Korean population. Detailed explanations of how the weighted values were

137   derived are shown in Ministry of Health and Welfare (2010). For the characteristics of subjects based

138   on whether or not they smoked and the total amount smoked over their lifetime, the weighted mean,

139   standard variance and weighted percentage were presented using descriptive analysis while, for the

140   difference between groups, a continuous variable was analyzed with a weighted one-way ANOVA and

141   the nominal variable was analyzed with a Rao-Scott chi-square test. For the association between pack

142   years and dysphonia, the odds ratio and 95% confidence interval were presented using hierarchical

143   logistic regression. For confounding variables, only socio-demographic variables were adjusted for

144   Model 1; both socio-demographic variables and health-risk behavior variables were adjusted for Model

145   2; and all confounding variables including level of health were adjusted Model 3. IBM SPSS version

146   21.0 (IBM Inc., Chicago, Illinois, USA) was used for all analyses and significance level was 0.05 in

147   two-sided test.

148

149   **Results**

150

151   **Characteristics of subjects based on level of pack years**

152   The characteristics of subjects based on the level of pack years are demonstrated in Table 1.

153   The average age was the lowest for light smokers and highest for very heavy smokers ($p<0.001$). Males

154   had the highest percentage of heavy smokers and the lowest percentage of non-smokers whereas

155   females had the highest percentage of non-smokers and the lowest percentage of heavy smokers

156   ($p<0.001$). As for level of education, a high percentage of heavy smokers and very heavy smokers were

157   elementary school graduates, while a high percentage of light smokers were high school and university

158   graduates ($p<0.001$). As for occupation, non-smokers included the highest percentage of economically

159   inactive individuals, while medium and heavy smokers included the highest percentage of manual

160   laborers ($p<0.001$). Concerning drinking, non-smokers included the highest percentage of those who

161   drank less than once a month, whereas light, medium, and heavy smokers included a higher percentage

162   of those who drank once or more a month ($p<0.001$). Regarding level of health, very heavy smokers

163   had the highest level of recognition of pain and discomfort from disease over the last two weeks, self-

164   reported voice problems and laryngeal disease ($p<0.05$).

165

166   **Association between current smoking and dysphonia**

167   The association between current smoking habits and dysphonia is presented in Table 2. The

168   results of the hierarchical logistic regression, where socio-demographic variables (age, gender, level of

169   education and occupation) were adjusted in Model 1, indicated that current smokers had a 102%

170   (OR=1.02, 95% CI: 1.01–1.03) higher risk of developing voice problems than non-smokers. Moreover,

171   current smokers had a 1.5 times (OR=1.53, 95% CI: 1.01–2.33) higher risk of laryngeal disorder

172   (p<0.05).

173   When drinking was additionally adjusted in Model 2, current smokers had a 1.8 times

174   (OR=1.81, 95% CI: 1.19–2.73) higher risk of developing self-reported voice problems than non-

175   smokers, and current smokers had a 1.6 times (OR=1.56, 95% CI: 1.02–2.38) higher risk of laryngeal

176   disorder (p<0.05).

177   In Model 3, when all confounding variables were adjusted, current smokers had a 1.8 times

178   (OR=1.77, 95% CI: 1.17–2.68) higher risk of self-reported voice problems than non-smokers, and

179   current smokers had a 1.6 times (OR=1.56, 95% CI: 1.02–2.38) higher risk of laryngeal disorder

180   (p<0.05).

181

182   **Association between pack years and dysphonia**

183   The association between pack years and dysphonia for smokers is provided in Table 3. As a

184   result of the hierarchical logistic regression, heavy smoking (40.5–55.5 pack years) was found to have

185   a significant relationship with self-reported voice problems, and very heavy smoking (>55.5–156) was

186   found to have a significant relationship with laryngeal disorder.

187   When all confounding variables were adjusted (Model 3), heavy smokers had a 3.9 times

188   (OR=3.86, 95% CI: 1.69–8.79) higher risk of self-reported voice problems than non-smokers, and very

189   heavy smokers had a 4 times (OR=3.98, 95% CI: 1.22–13.00) higher risk of laryngeal disorder

190   (p<0.05).

191

192   **Discussion**

193

194   This national cross-sectional study analyzed the relationship between current smoking and

195 pack years and dysphonia for adults in local communities. The study demonstrated that current

196 smokers had a 1.8 times (OR=1.77, 95% CI: 1.17–2.68) higher risk of self-reported voice problems

197 than non-smokers, and current smokers had a 1.6 times (OR=1.56, 95% CI: 1.02–2.38) higher risk of

198 laryngeal disorder. This result was incongruous with that of Glas et al. (2008) who concluded that

199 smoking did not have a significant effect on self-reported voice problems. This difference may be due

200 to the fact that the study of Glas et al. (2008) had as its subjects only patients with vocal disorders who

201 visited medical institutions. Naturally, no significant relationship between self-reported voice problems

202 and smoking was shown, since most patients already had voice problems when they visited medical

203 institutions whether they smoked or not.

204   The causal relationship between smoking and vocal disorders has been corroborated in diverse

205 studies. Numerous epidemiological studies have reported that smoking is a major cause of Reinke's

206 edema (Marcotullio, Magliulo, & Pezone, 2002; Zvrko, Gledović, & Ljaljević, 2008) and is closely

207 linked with chronic laryngitis, laryngeal keratosis and laryngeal leukoplakia (Feierabend & Shahram,

208 2009). Smoking has been proven to be the direct cause of deformation in the mucosa of vocal cords in

209 animal experimental research studies as well (Duarte et al., 2006; Işik et al., 2004). Chronic smoking

210 causes anatomical changes in the larynx, worsening pain and voice problems (Park, 2003).

211 Furthermore, since smoking causes vocal fatigue in the short term by stimulating the mucosal

212 membrane of the vocal cords, it is speculated that current smokers are more likely to perceive their

213 own voice problems than non-smokers. Since few studies have analysed the relationship between

214 smoking and self-reported voice problems in local community populations, cohort studies on various

215 races should be conducted in the future.

216   Another finding of this study is that in terms of pack years, very heavy smokers were

217 significantly more likely to suffer from laryngeal disorder, while self-reported voice problems were

218 significantly more likely in heavy smokers but not very heavy smokers. Preceding studies (Lubin et al.,

219 2007, 2008) have reported that an increase in pack years subsequently increases the risk of laryngeal

220 pathologies, such as larynx cancer. However, even those classed as very heavy smokers in terms of

221 pack years in this study were not significantly more likely to suffer from self-reported voice problems.

222 This can be explained by two factors: First, it is possible that smokers' subjective recognition of voice

223 problems did not reflect their actual level of health. Even though subjective recognition of voice

224 problems is a useful index that represents a subject's overall health status, subjects tend to over- or

225 under-estimate the actual status of their health (Idler & Kasl, 1991). Thus, it is possible that no

226 significant relationship was found between very heavy smoking and self-reported voice problems since

227 very heavy smokers with excessive pack years perceived their vocal health as better than it actually

228 was. Second, the result may have been due to the survival effect of very heavy smokers. The average

229 age of very heavy smokers was over 60, which was the highest of all groups. The subjects of this study

230 were from the general population of local communities, and thus, those with poor health from heavy

231 smoking might have been hospitalized or already deceased.

232   The limitations of this study are as follows: First, as this study investigated only the subjective

233 recognition of voice problems, it is not possible to interpret the severity and type of voice problems.

234 Thus, future studies that use standardized subjective vocal evaluation methods are required. Second,

235 since smoking is a negative health behavior, survey responses might have been underestimates. Third,

236 since this is a cross-sectional study, the results cannot be interpreted as indicating a causal relationship.

237

238 **Conclusion**

239 Excessive cigarette smoking had an independent relationship with dysphonia. Further longitudinal

240 studies are required to investigate the causality between smoking and voice problems.

241

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245

Author Contributions

247

Byeon H. designed the research and wrote the paper.

249

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Table 1. Characteristics of subjects based on level of packyears , weighted %

Table 1. Characteristics of subjects based on level of pack years, weighted %

Characteristics	Non smoke (n=2,114)	Light (n=1,372)	Medium (n=142)	Heavy (n=41)	Very heavy (n=17)	p^*
Age(mean±s.d)	49.1±16.6	47.3±16.6	54.4±13.6	56.9±12.3	63.6±12.2	<0.001
Sex						<0.001
Male	13.8	82.2	89.4	90.2	76.5	
Female	86.2	17.8	10.6	9.8	23.5	
Education level						<0.001
Elementary school	34.1	21.3	33.8	46.3	52.9	
Middle school	10.3	11.6	16.9	19.5	17.6	
High school	32.9	38.2	31.7	22.0	11.8	
≥ College	22.6	28.9	17.6	12.2	17.6	
Income						0.744
1st quartile	21.8	18.5	19.3	22.5	31.2	
2nd quartile	26.5	27.2	27.9	25.0	25.0	
3rd quartile	27.0	28.8	28.6	22.5	31.2	
4th quartile	24.6	25.5	24.3	30.0	12.5	
Occupation						<0.001
Economically inactive	48.0	28.6	27.5	27.5	52.9	
Non-manual	26.0	36.3	26.1	20.0	17.6	
Manual	26.0	35.1	46.5	52.5	29.4	
Alcohol drinking						<0.001
< 1 time per month	60.7	24.8	27.5	26.8	52.9	
≥1 time per month	39.3	75.2	72.5	73.2	47.1	

Pain and discomfort during the last 2 weeks						<0.001
Yes	31.7	21.6	20.4	34.1	58.8	
Laryngeal disease						<0.001
Yes	5.3	7.5	9.2	9.8	23.5	
Self-reported voice problems						0.010
Yes	6.8	6.2	3.5	17.1	17.6	

* Rao-Scott chi-square test for categorical variables; weighted ANOVA test for continuous variables.

The light smoking defined ≤26.7 pack years; medium smoking defined >26.7～40.5 pack years;

heavy smoking defined >40.5～55.5 pack years; very heavy smoking defined >55.5～156 pack years.

Table 2. Hierarchical logistic regression analyses of the association between smoking and dysphonia : odds ratio (OR) and confidence interval (CI)

Table 2. Hierarchical logistic regression analyses of the association between smoking and dysphonia : odds ratio (OR) and confidence interval (CI)

Smoking	Model 1		Model 2		Model 3	
	SVP	LD	SVP	LD	SVP	LD
Non smoker	1	1	1	1	1	1
Past smoker	1.37	1.05	1.42	1.06	1.38	1.06
	(0.89,	(0.66,	(0.92,	(0.69,	(0.90,	(0.67,
	2.12)	1.65)	2.19)	1.67)	2.14)	1.68)
Current smoker	1.02	1.53	1.81	1.56	1.77	1.56
	(1.01,	(1.01,	(1.19,	(1.02,	(1.17,	(1.02,
	1.03) *	2.33) *	2.73) *	2.38) *	2.68) *	2.38) *

* $p < 0.05$

SVP: self-reported voice problem; LD: laryngeal disease

Model 1: adjusted for age, sex, education, quartiles of income, and occupation.

Model 2: additionally adjusted for alcohol drinking

Model 3: additionally adjusted for pain and discomfort during the last 2 weeks.

Figure 1 . The flow chart of study
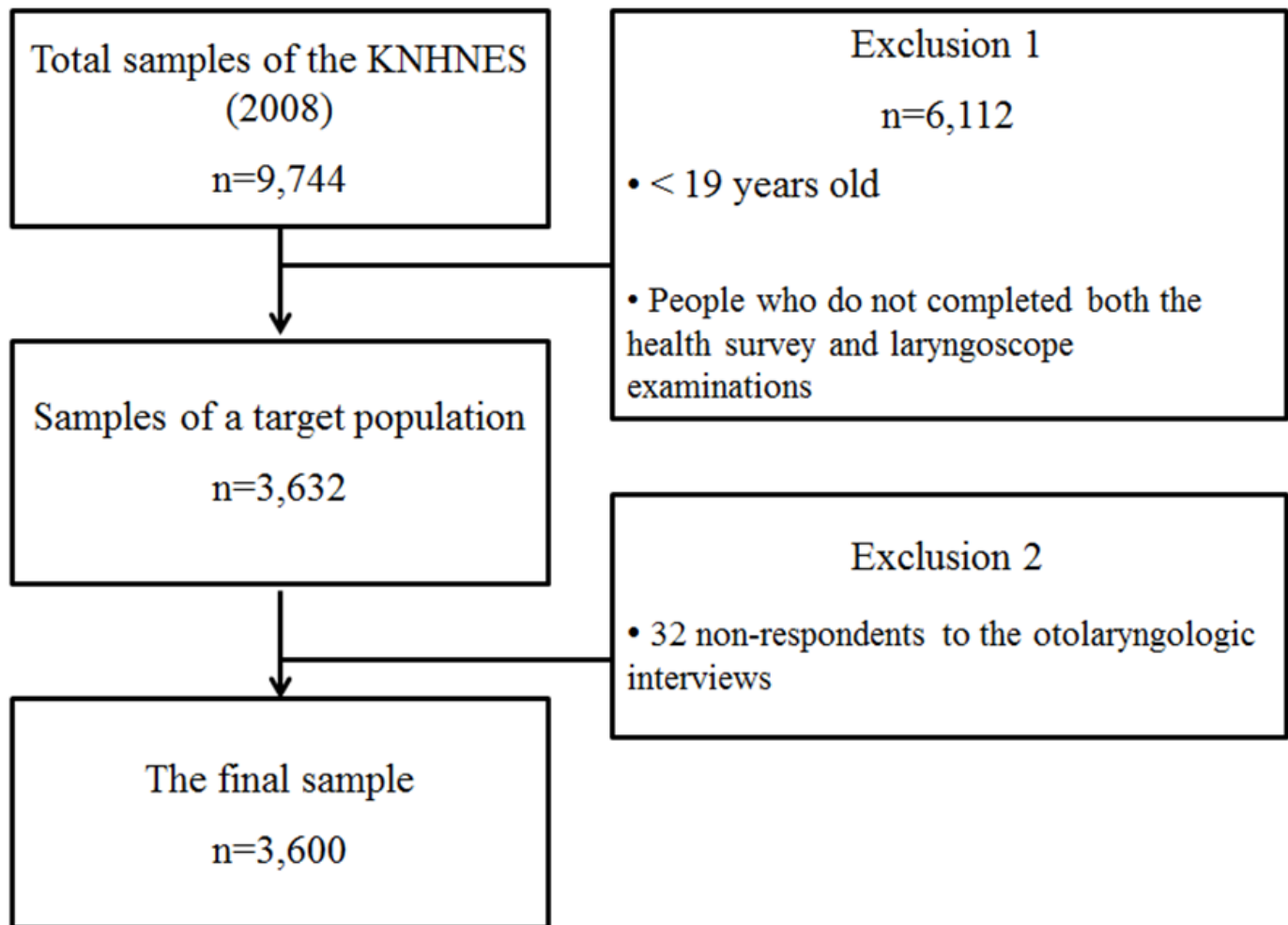
Table 3. Hierarchical logistic regression analyses of the association between the Level of smoking and dysphonia: odds ratio (OR) and confidence interval (CI)

Table 3. Hierarchical logistic regression analyses of the association between the Level of smoking and dysphonia: odds ratio (OR) and confidence interval (CI)

Level of smoking (pack years)	Model 1		Model 2		Model 3	
	SVP	LD	SVP	LD	SVP	LD
Light (≤26.7)	1.38 (0.95, 2.01)	1.18 (0.81, 1.71)	1.47 (1.00, 2.14)	1.20 (0.82, 1.76)	1.44 (0.98, 2.10)	1.20 (0.82, 1.76)
Medium (>26.7-40.5)	0.77 (0.30, 1.95)	1.34 (0.70, 2.55)	0.82 (0.32, 2.09)	1.37 (0.71, 2.62)	0.84 (0.33, 2.15)	1.36 (0.71, 2.61)
Heavy (>40.5-55.5)	3.69 * (1.64, 8.31)	2.13 (0.83, 5.44)	3.96 * (1.75, 8.95)	2.18 (0.85, 5.58)	3.86 * (1.69, 8.79)	2.17 (0.85, 5.57)
Very heavy (>55.5-156)	3.05 (0.95, 9.83)	3.98 * (1.22, 12.95)	3.19 (0.99, 10.28)	4.01 * (1.23, 13.05)	2.70 (0.84, 8.73)	3.98 * (1.22, 13.00)

Reference group is non smoker.

SVP: self-reported voice problem; LD: laryngeal disease

* p<0.05

* pack years = (packs smoked per day) $\times$ (years as a smoker)

Model 1: adjusted for age, sex, education, quartiles of income, and occupation.

Model 2: additionally adjusted for alcohol drinking

Model 3: additionally adjusted for pain and discomfort during the last 2 weeks.