Development and Validation of a Risk Assessment Nomogram for Hearing Loss Among Community-Dwelling Older Adults in China

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March 2025

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1. Background

Rapid Aging in China: The Need to Address Hearing Health

- **Global Trend:** WHO estimates that by 2050, 16% of the global population will be aged 65 or older
- **China's Situation:** Rapid population aging will continue over the next 30 years
- **Burden of Hearing Loss in Older Adults:** High prevalence leads to impaired communication, increased psychological risks, cognitive decline, and significant economic costs

1. Background

Enhancing Hearing Loss Prediction in Older Adults Through Primary Healthcare Centers

- **Hearing is one of the six domains of intrinsic capacity in older adults, as defined by WHO**
- **Utilizing primary healthcare centers for hearing loss management in older adults is a cost–effective approach**
- **Developing a risk prediction method in these centers can enhance early identification, facilitate referrals, enable audiometric screening, and optimize resource allocation**

1. Background

A Hearing Loss Prediction Nomogram Model Urgently Needs to Be Developed

- However，no predictive model has been developed for hearing loss in older adults
- A nomogram integrates multiple factors to calculate individual risk scores and has shown excellent predictive accuracy and clinical utility across various fields

2. Objectives

This study aims to develop and validate a nomogram–based prediction model for hearing loss among community–dwelling older adults in China

3. Methods

3.1 Participants

- Data come from electronic medical record (EMR) from older adults who participated in the annual physical examination between March 01, 2022 and March 01, 2023 at Community Primary Healthcare Centers (CPHCs) in Dongcheng District, Beijing

- Participants aged ⩾65 years with complete hearing assessments and relevant factors data. Those with cognitive impairment, neurological disorders, congenital conditions, or severe ear diseases were excluded.

3. Methods

3.2 Model Development

① A total of 23 variables were initially included

② Univariate analysis identified those significantly associated with hearing loss

③ Forward stepwise regression determined the final predictors

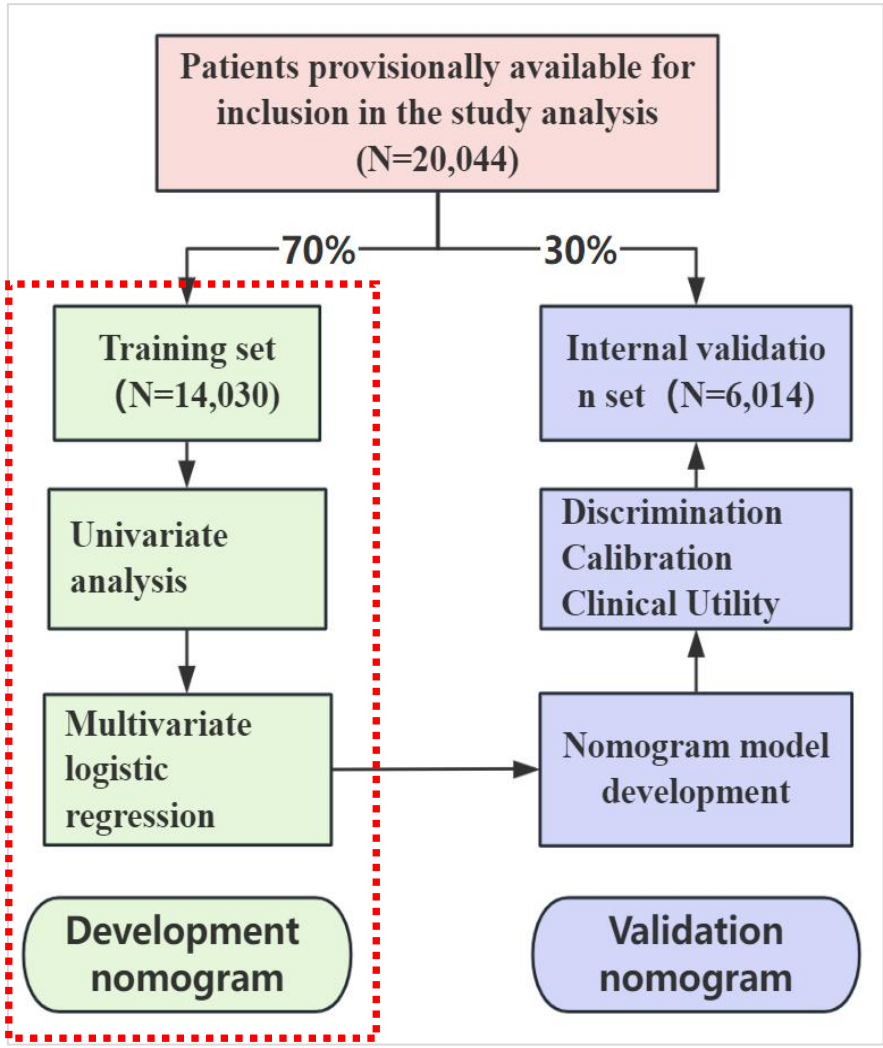

Fig.1 Flowchart of Model Development and Validation

3. Methods

3.3 Model Validation

- **Discrimination**
  - **Area under the receiver operating characteristic curve (AUC)**
- **Calibration**
  - **Calibration curve**
- **Clinical Utility**
  - **Decision curve analysis (DCA)**

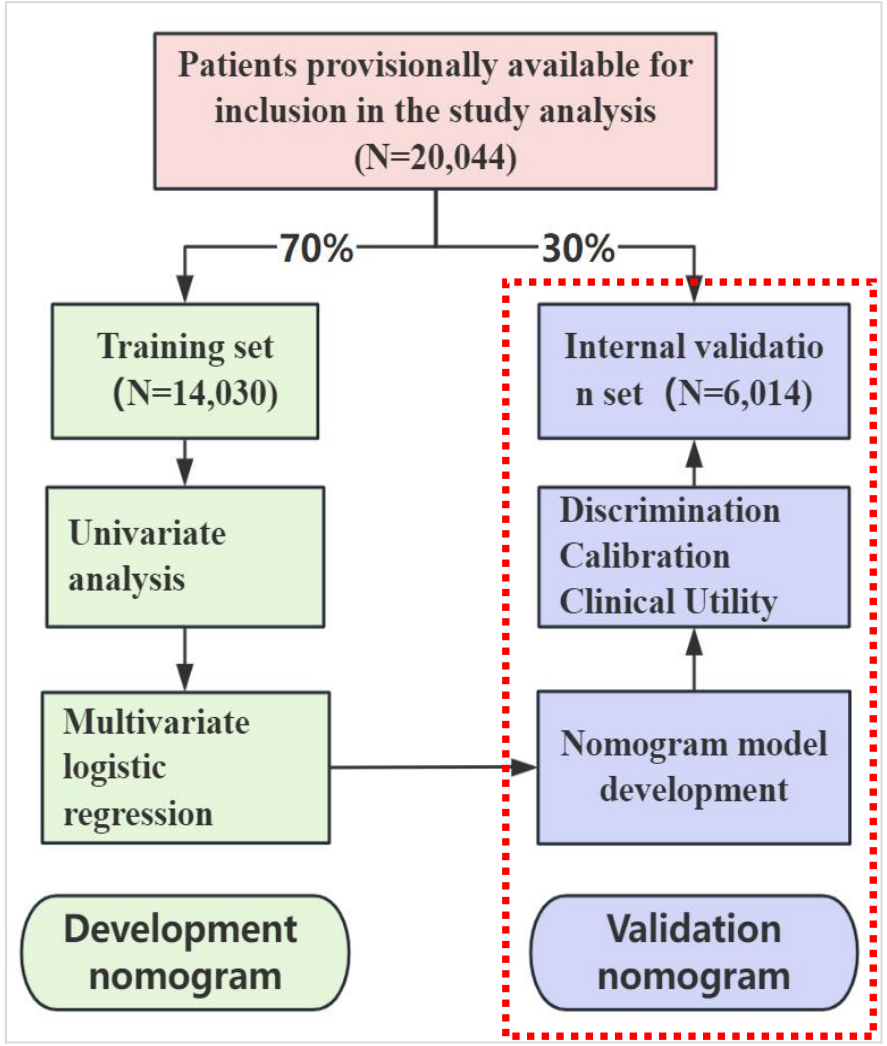

Fig.1 Flowchart of Model Development and Validation

4. Results

4.1 Univariate analysis

- A total of 1,236 (6.2%) patients developed hearing loss
- 15 variables with statistically significant differences

Table 1 Univariate analysis

Variables	M ± SD / n (%)	No hearing loss n (%)	Hearing loss n (%)	Z/χ^2	*P*
性别				0.001	0.9792
男	8821 (44.01)	10530	693		
女	11223 (55.99)	8278	543		
年龄				**1260.1**	**< 2.2e-16**
61~70	10646 (53.11)	10430	216		
71~80	5810 (28.99)	5439	371		
81~90	3235 (16.14)	2684	551		
＞91	353 (1.76)	255	98		
健康状态自评				**210.25**	**< 2.2e-16**
满意	19306 (96.32)	18209	1097		
不满意	738 (3.68)	599	139		
生活自理能力				**652.21**	**< 2.2e-16**
可自理	19233 (95.95)	18216	1017		
轻度依赖	457 (2.28)	348	109		
中重度依赖	354 (1.77)	244	110		
锻炼频率				**1288**	**< 2.2e-16**
每天	11153 (55.64)	10858	295		
每周一次以上	2512 (12.53)	2399	113		
偶尔	1403 (7.00)	1315	88		
不锻炼	3363 (16.78)	2707	656		
未记录	1613 (8.05)	1529	84		
饮食习惯				**27.69**	**1.441e-05**
荤素搭配	17043 (85.03)	16035	1008		
素食为主	817 (4.08)	737	80		
荤食为主	215 (1.07)	737	80		
嗜糖/嗜盐/嗜油	191 (0.95)	171	20		
未记录	1778 (8.87)	1667	111		
吸烟				**27.176**	**1.256e-06**
从不吸烟	18134 (90.47)	16978	1156		
已戒烟	1343 (6.70)	1304	39		
吸烟	567 (2.83)	526	41		

4. Results

Variables	M ± SD / n (%)	No hearing loss n (%)	Hearing loss n (%)	Z/χ^2	*P*
饮酒频率				**19.544**	**5.702e-05**
从不	18208 (90.84)				
偶尔	1043 (5.20)	1001	42		
经常或每天	793 (3.96)	765	28		
运动功能				**963.73**	**< 2.2e-16**
可顺利完后	19788 (98.72)	18687	1101		
无法独立完成其中任何一个动作	256 (1.28)	121	135		
高血压				**25.659**	**4.074e-07**
否	7627 (38.05)	7241	386		
是	12418 (61.95)	11568	850		
冠心病				**26.246**	**3.006e-07**
否	13713 (68.41)	12949	764		
是	6331 (31.59)	5859	472		
心率				0.94028	0.3322
60~100	19285 (96.21)	18089	1196		
＜60 or ＞100	759 (3.79)	719	40		
脑卒中				**9.46**	**0.0021**
否	16952 (84.57)	15945	1007		
是	3092 (15.43)	2863	229		
糖尿病				0.30676	0.5797
否	13901 (69.35)	13053	848		
是	6143 (30.65)	5755	388		
COPD				0.0071753	0.9325
否	19771 (98.64)	18551	1220		
是	273 (1.36)	257	16		
血糖				0.20632	0.6023
4.4~7.0	18020 (37.01)	16896	1124		
＜4.4 or ＞7.0	2024 (62.99)	1912	112		
腰围				0.24111	0.6234
正常	7418 (37.01)	6952	466		
异常	12626 (62.99)	11856	770		
BMI				**22.319**	**1.424e-05**
＜18.5	306 (1.53)	281	25		
18.5~29.9	19112 (95.35)	17966	1146		
＞30.0	626 (3.12)	561	65		
认知功能障碍				**391.03**	**< 2.2e-16**
否	19951 (99.54)	18767	1184		
是	93 (0.46)	41	52		
left_DBP				**4.6542**	**0.03098**
60~90	17717 (88.39)	1183			
＜60 or ＞90	1091 (5.44)	53			
left_SBP				**6.0356**	**0.01402**
90~140	17369 (86.65)	16269	1100		
＜90 or ＞140	2675 (13.35)	2539	136		
right_DBP				0.0055779	0.9405
60~90		17821	1170		
＜60 or ＞90		987	66		
right_SBP				3.4872	0.06184
90~140	17366 (86.64)	16273	1093		
＜90 or ＞140	2635 (13.15)	16273	1093		

4. Results

4.2 Multivariate analysis

- **The final logistic regression model consisted of nine factors: age, exercise frequency, physical function, Ability of Daily Living, dietary habits, smoking, hypertension, cognitive function, and body mass index**

4. Results

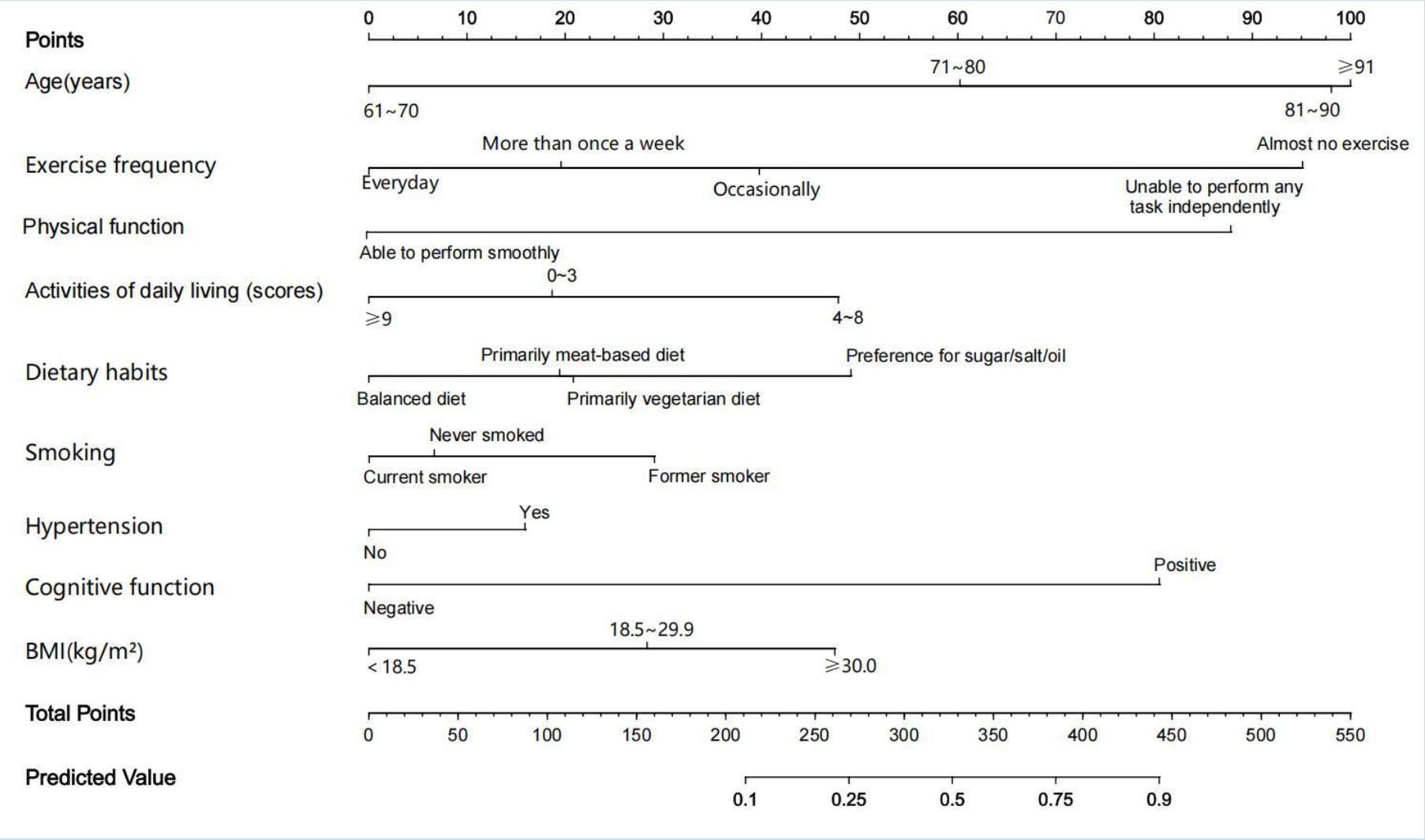

Fig 2. Nomogram to predict the probability of hearing loss with community older adults

4. Results

4.3 Internal Validation

- **AUC in training set:**

  0.828, 95%CI : 0.812~840

- **AUC in validation set:**

  0.803, 95% CI:0.788~0.834

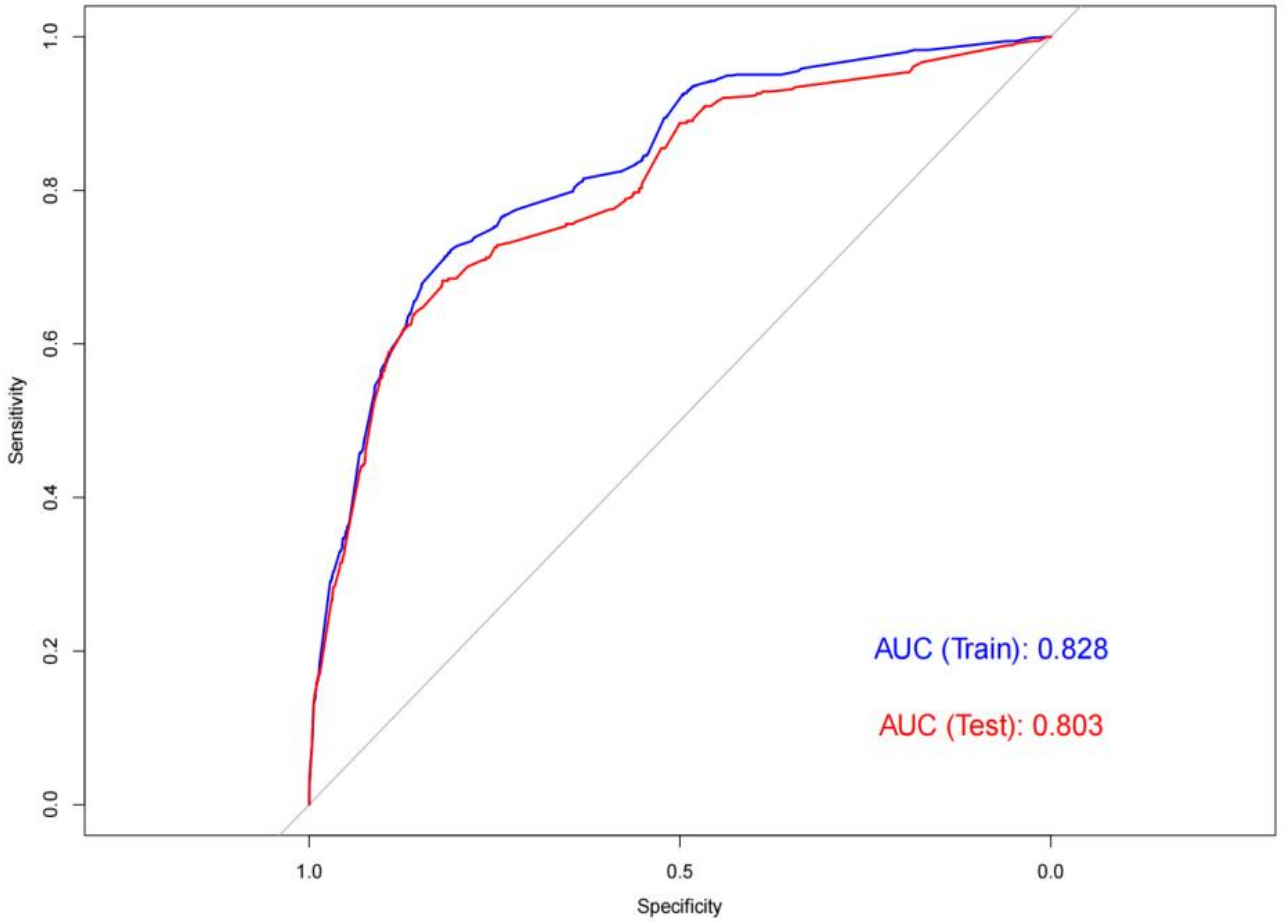

Fig.3 ROC curves of the nomogram in the training and test sets.

4. Results

4.3 Internal Validation

- The calibration curves, which compared the predicted hearing loss probability and observed event rate, revealed the accurate performance of the nomogram model.
- Brier score: 0.195

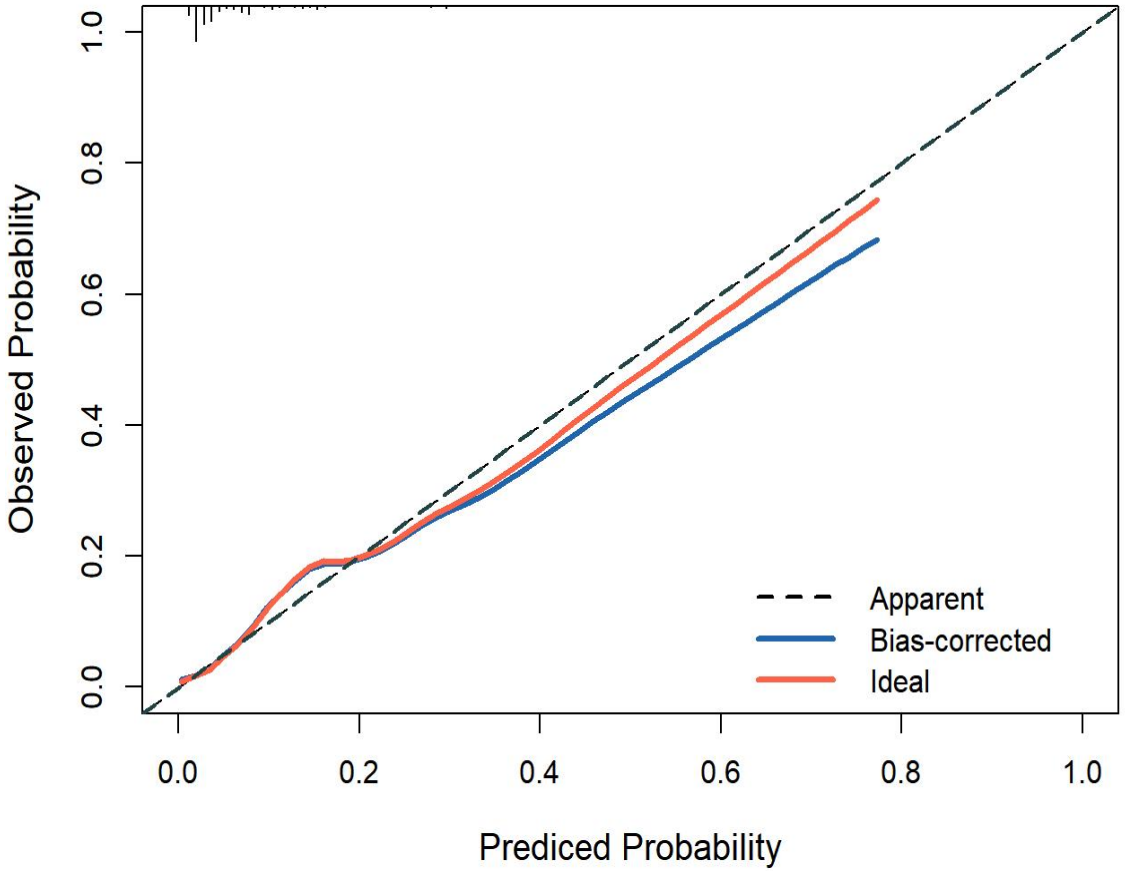

Fig.4 Calibration plot

4. Results

4.3 Internal Validation

- DCA demonstrated that the nomogram was clinically beneficial
- Net benefit was observed within a risk threshold range of 5% to 60%

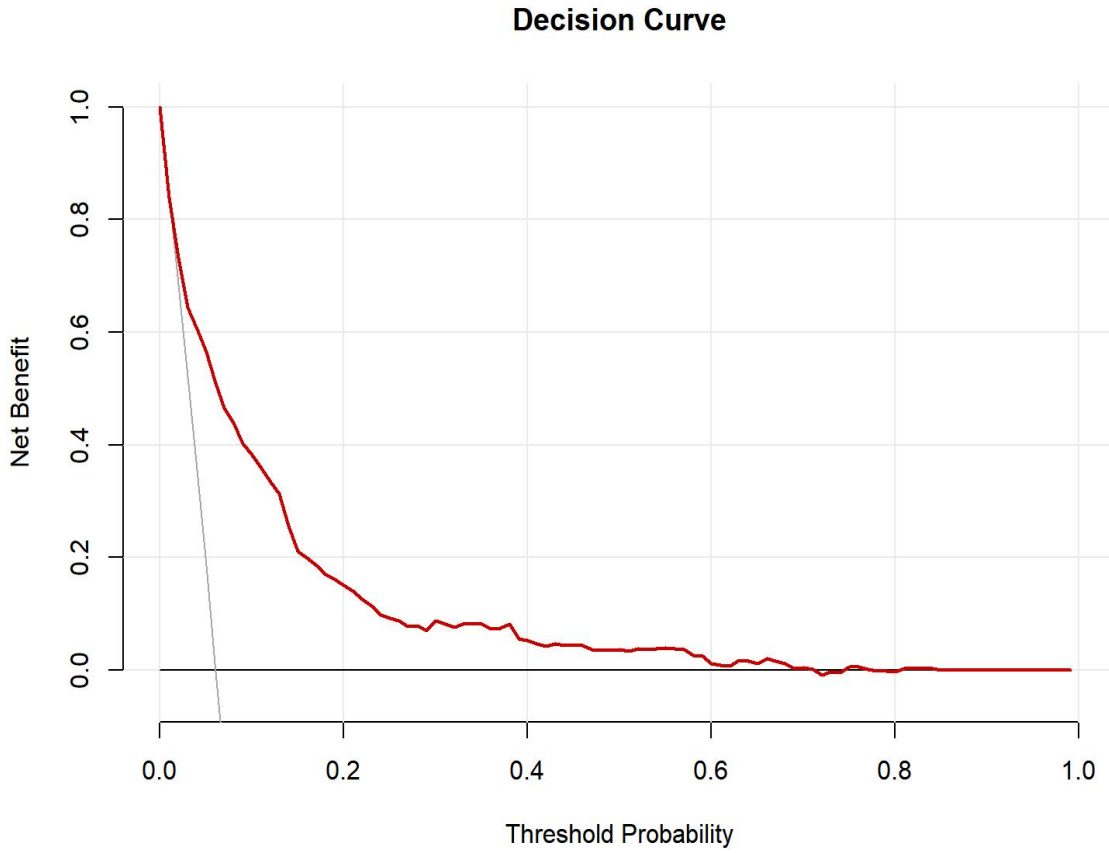

Fig.5 Decision curve analysis

5. Discussion

- **This study is the first to develop a risk prediction model for hearing loss in community-dwelling older adults in China, providing a reference for precise screening and early intervention**

- **The nomogram model incorporates demographic, lifestyle, and chronic disease factors, aligning broadly with previous studies**

- **The model is simple and easy to use, with easily accessible predictors and high performance**

5. Discussion

- **Limitations**
  - **Lack of external validation**
  - **Cross–sectional study cannot establish causality**
  - **Hearing loss assessment via whisper test may lead to measurement bias.**

6. Conclusions

The most important risk factors for hearing loss in elderly were age, and exercise frequency. The nomogram developed in this study could be a promising and convenient tool to predict hearing loss risk, but further external validation is needed.

Thank you for your attention

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March 2025