Study setting and design

A retrospective cohort study design was utilized based on data from the Medicare Current Beneficiary Survey (MCBS) between 1999 and 2006. The MCBS is a continuous survey of a nationally representative sample of Medicare beneficiaries conducted by the Centers for Medicare & Medicaid Services (CMS). Each sampled beneficiary is interviewed up to three times per year for up to four consecutive years with participants entering and leaving the survey annually. The MCBS is linked to the CMS enrollment file and further connected to Medicare claims files that provide detailed information on healthcare utilization and costs. We defined periods of two-year units between the index years of 1999 to 2006 where each subject was included only once in the analysis. The first year of the two-year study units allowed us to ascertain data on certain predictors such as emergency department visits and hospital admissions. Data on the primary outcome, whether the participant had a hospital admission, was obtained from the second year of the two-year study units. We defined our study period as between 1999 to 2006 because we only had access to the MCBS files for these years.

Inclusion criteria

Participants included in this study were community-dwelling, aged 65 years and older, and had self-reported hearing and/or vision impairment at the start of the study period. This represents 15,999 participants out of a total cohort of 24,009 participants interviewed between 1999 and 2006. Hearing impairment was defined based on two self-reported questions: 1) Which statement best describes your hearing (with a hearing aid, if you use one)? (no trouble, a little trouble, or a lot of trouble) and 2) Do you use a hearing aid (yes, no, or deaf)? If participants reported "a little trouble" or "a lot of trouble" or if they used hearing aids or indicated deafness,

then the participants were classified as hearing impaired. Vision impairment was defined based on one self-reported question: "How much trouble do you have with your vision?" (no trouble, little trouble, or a lot of trouble). Subjects who reported "little trouble" or "a lot of trouble" were classified as visually impaired. We did not define vision impairment based on reported use of glasses or contacts because 83% of subjects reported using glasses suggesting poor measure sensitivity.

Exclusion criteria

We excluded survey participants who were residing in a long-term care facility at the start of the study period. The reason for this exclusion is that the ultimate focus of this study was to identify high-risk individuals specifically living in the community who may not have ready access to supportive care and health resources.

Candidate predictors

Candidate predictors were chosen based on prior research suggesting an association between sensory impairments and hospital admissions. Predictors were grouped into the following categories: socio-demographic factors, health care use, comorbidities, functional impairment, and patient level factors.

Socio-demographic factors

These included age (modeled as a continuous variable), gender (male, female), race (non-Hispanic white, non-Hispanic black, Hispanic, or other), education (graduation from high school or greater vs. never graduated from high school), living arrangement (lives with spouse, lives with others, or lives alone), income (less than $10,000 per year vs. greater than $10,000 per year) and insurance coverage (Medicare and Medicaid vs. Medicare alone).

Health care use

Measures of health care use were obtained from the first year of the two-year study period, as previously described. These included number of hospital admissions in the one-year period and number of emergency department visits that did not result in a hospital admission in the one-year period.

Comorbidities

Regarding medical comorbidities, the MCBS asks about medical conditions in the following manner: "Next I'm going to read a list of medical conditions…Please tell me if a doctor ever told you that you had any of these conditions." Medical conditions that were assessed in the model included self-reported emphysema/asthma/chronic obstructive pulmonary disease, hypertension, myocardial infarction, dementia, Parkinson's disease, stroke/brain hemorrhage, diabetes, cancer (other than skin cancer), rheumatoid arthritis, osteoarthritis, and osteoporosis.

Functional impairment

Functional impairment was assessed based on questions that addressed activities of daily living (ADLs) and instrumental activities of daily living (IADLs). For ADLs, participants were asked questions about having any difficulty doing the following tasks by themselves and without special equipment: eating, toileting, dressing, bathing/showering, walking, and getting in or out of bed/chairs. For IADLs, participants were asked about using the telephone, managing money, preparing his/her own meals, doing light housework (e.g., dishes, light cleaning), shopping for personal items, and doing heavy housework (e.g., scrubbing floors, washing windows). Based on the number of items that participants had difficulty with, a simple sum score for ADL and IADL difficulties was calculated.

Patient level factors

Patient level factors included barriers to accessing care, satisfaction with healthcare, and self-rated health. Participants were asked if they delayed seeking care because they were worried about cost or had trouble getting health care they wanted or needed. Answering yes to either question was categorized as a barrier to accessing care. Satisfaction with care was assessed by the participant's rating of the overall quality of health care received (very satisfied or satisfied vs. dissatisfied or very dissatisfied). Self-rated health was assessed by asking participants to compare their health to others of the same age. Responses were classified as excellent, very good, or good vs. fair or poor.

Outcome measure:

We defined our primary outcome as the occurrence of any inpatient admission over a one-year period, predefined as the second year in the two-year study unit. The primary outcome was verified by CMS claims codes from the Cost and Use files of the MCBS. Hospitalization could be due to any cause.

Statistical analysis:

Descriptive statistics comparing participants with sensory impairments who did and did not have a hospital admission were presented as means for continuous variables or frequencies for categorical variables. We analyzed the association of all *a priori* selected candidate variables with any hospital admission over the one-year study period using multivariable logistic regression. A parsimonious model was created by eliminating some predictors from the model via variable selection. This was performed using a penalized regression method known as the least absolute shrinkage and selection operator (LASSO) with bootstrapping. Candidate predictors were then ranked based on the proportion of bootstrap samples in which they were identified as independent predictors of the outcome. Predictors that were retained in more than

60% of the 500 bootstrapped models were included in the final model. The cut-off choice of 60% is arbitrary and has been used in prior studies.

Performance of the model was assessed by discrimination and calibration. Discrimination refers to the ability of the model to distinguish participants who did and did not have a hospital admission. This was quantified with the concordance (c) statistic, which is equivalent to the area under the receiver operating characteristic (ROC) curve. Calibration refers to the agreement between the observed risk of inpatient admission and predicted risk. This was assessed graphically in a plot with the predicted proportion of inpatient admission on the x-axis and observed proportion of inpatient admissions on the y-axis. A slope of 1 indicates perfect calibration because the observed proportion matches the predicted proportion of hospitalization.

Model validation was performed to determine the reproducibility of the predictions and quantify any optimism in the prediction model. Internal validation using bootstrapping calculated the apparent performance (as measured by the c-statistic) on the bootstrap samples. Optimism refers to the difference between the test performance and the bootstrap performance. An optimism-corrected estimate of the c-statistic was obtained to give an estimate of how well the model would perform on new data. To present the final model, we created a web application and Excel sheet to facilitate calculation of risk. All statistical analyses were performed using SAS statistical software, version 9.4 (SAS Institute, Inc, Cary, NC).

Supplementary Figure S1: Calibration plot of the final prediction model. Predicted outcome probabilities (on the x-axis) are plotted against observed outcome frequencies (on the y-axis).
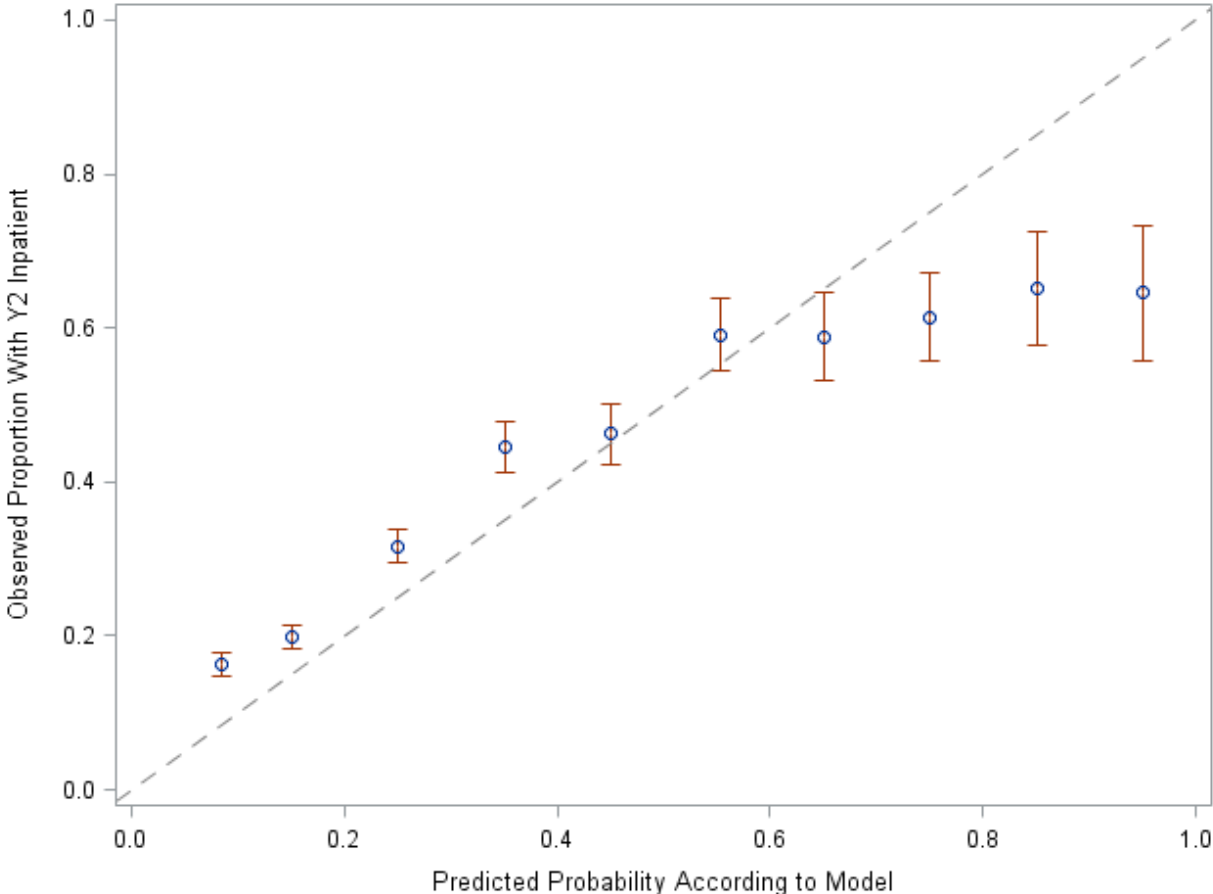
Supplementary Figure S2: A Web application and Excel sheet were created to allow users to calculate the probability of one-year hospital admission using the final prediction model. This can be accessed at: https://mcbspredictionmodel.shinyapps.io/shinyapp/. The Excel file can be provided upon request.

Hospitalization Risk Calculator for Older Adults with Sensory Impairments

Number of hospital admissions in the previous year

| 1 |

Number of emergency department visits in the previous year

| 2 |

Number of activities of daily living dependencies (range 0-6)

| 2 |

Fair or poor self-rated health compared to others of same age?
○ No
⦿ Yes

Self-reported history of myocardial infarction?
⦿ No
○ Yes

Self-reported history of stroke?
⦿ No
○ Yes

Self-reported history of cancer, other than skin cancer?
○ No
⦿ Yes

Result   Instructions

This calculator helps predict the one-year risk of hospitalization among community-dwelling adults aged 65 years and older with hearing and/or vision impairments.

For this patient, the predicted probability of any hospital admission over a one-year period equals:

43.29 %

One-year hospitalization risk calculator among older adults with hearing and/or vision impairments					Formula	
Prgnostic Factor	**Units**	**Values**			Coefficient	Coefficient * Value
# of inpatient admissions in prior year	number	1			0.926700	0.9267000
History of myocardial infarction	yes (1) or no (0)	1			0.559900	0.5599000
Poor self-rated health	yes (1) or no (0)	1			0.355000	0.3550000
History of non-skin cancer	yes (1) or no (0)	0			0.309300	0.0000000
History of stroke	yes (1) or no (0)	1			0.254700	0.2547000
ADL score (range 0-6)	number	3			0.167100	0.5013000
# of ED visits in prior year	number	2			0.074300	0.1486000
Probability of 1-year inpatient admission:		0.599		**Linear predictor**		2.7462000
				Intercept		-2.3435