Premiere Publications from
The Triological Society

Read all three of our prestigious publications, each offering high-quality content to keep you informed with the latest developments in the field.

**The Laryngoscope**
Founded in 1898
Editor-in-Chief: Samuel H. Selesnick, MD, FACS
The leading source for information in head and neck disorders.
Laryngoscope.com

**Investigative Otolaryngology**
Editor-in-Chief: D. Bradley Welling, MD, PhD, FACS
Rapid dissemination of the science and practice of otolaryngology-head and neck surgery.
InvestigativeOto.com

**ENT today**
A publication of the Triological Society
Editor-in-Chief: Alexander Chiu, MD
Must-have timely information that Otolaryngologist-head and neck surgeons can use in daily practice.
Enttoday.org
Relationship of Overall Cardiovascular Health and Hearing Loss in The Jackson Heart Study Population

Steven A. Curti, MD; Joseph A. DeGruy, MD ©; Christopher Spankovich, AuD, PhD, MPH ©; Charles E. Bishop, AuD, PhD ©; Dan Su, MPH; Karen Valle, MS; Emily O’Brien, PhD; Yuan-I Min, PhD; John M. Schweinfurth, MD

**Objectives:** To evaluate the relationships among the overall cardiovascular health scoring tool, Life’s Simple 7 (LS7), and hearing in an African-American cardiovascular study cohort.

**Methods:** Using the Jackson Heart Study’s cohort of African Americans, the relationships between the LS7 scoring metric and hearing of 1314 individuals were assessed. Standard audiometric data was collected and hearing loss was defined as a four-frequency average of 500, 1000, 2000, and 4000 Hz greater than 25 dBHL (PTA4). Measures of reported tinnitus and dizziness were also collected. The LS7 scoring tool, which consists of seven individual categories (abstinence from smoking, body mass index, physical activity, healthy diet, total cholesterol <200 mg/dL, normotension, and absence of diabetes mellitus), was used as measure of overall cardiovascular health. Each category of the LS7 was broken down into poor, intermediate, and ideal subgroups as in accordance with the American Heart Association Strategic Planning Task Force and Statistics Committee. Unadjusted and adjusted gamma regression and logistic regression models were constructed for determining relationships between LS7 and hearing loss.

**Results:** Higher total LS7 scores (per 1-unit increase) were associated with lower PTA4 in gamma regression analyses (RR = 0.942, 95% CI, 0.926–0.958, P < .001). This held true even after adjustments for age, sex, education, and history of noise exposure. Using logistic regression analyses to compare LS7 scores to presence of hearing loss, tinnitus, and vertigo; only hearing loss showed a statically significant relationship after adjustments for age, sex, education, and history of noise exposure.

**Conclusions:** This study shows a significant, graded association between higher life’s simple seven scores and lower incidence of hearing loss.

**Key Words:** Hearing loss, Life’s Simple 7, Jackson Heart Study.

**Level of Evidence:** 2b.

**Laryngoscope, 130:2879–2884, 2020**

**INTRODUCTION**

Hearing loss is the fourth leading cause of years lived with a disability worldwide, with 1.34 billion people living with mild to moderate hearing loss. Several factors play a role in the decline of hearing as we age. Age-related hearing loss is a combination of biological degeneration, genetic predispositions, noise exposure, and toxic or disease-related changes. The aging population is projected to be the fastest growing population in the United States, according to the 2010 US census. With the increasingly large burden on public health in a growing population, the identification of modifiable risk factors that can lead to earlier intervention and prevention is of the utmost importance. Appropriately, in the recent literature there has been an increase in the search for possible lifestyle changes and modifiable risk factors. A recent area of focus, cardiovascular risk factors, has linked increased body-mass index (BMI), smoking, hypertension, diabetes, poor diet, and lack of physical activity to poorer hearing outcomes.

This study aims to show a correlation between Life’s Simple 7 (LS7) and hearing loss. The LS7 is a collection of seven modifiable risk factors, initially proposed by the American Heart Association, to define a person’s overall cardiovascular health. There are four favorable health behaviors (abstinence from smoking, BMI, physical activity, and consumption of a healthy diet) and three favorable health factors (total cholesterol <200 mg/dL, normotension, and absence of diabetes mellitus). The AHA stratified each of these seven health initiatives into poor, intermediate,
and ideal tiers, in order to monitor the population’s cardiovascular health.9 A higher LS7 has been shown to be related to decreased risk of atrial fibrillation10 and hypertension.11 African Americans with higher stress factors had significantly decreased odds of achieving intermediate and ideal LS7 scores.12

Our goal is to determine if the LS7, an indication of overall cardiovascular health, is related to hearing loss in the Jackson Heart Study, an all-African American cohort. Although many of the modifiable risk factors that comprise LS7 have been studied individually, no study to our knowledge has looked at this scoring system and its relationship to hearing loss. We hypothesized that there will be an inverse relationship between favorable scores on the LS7 calculator and hearing outcomes.

METHODS

The following institutional review boards approved the study protocol: The University of Mississippi Medical Center, Jackson State University, and Tougaloo College. All participants provided written informed consent.

Study Population

The Jackson Heart Study (JHS) is a prospective, population-based, longitudinal study aimed at identification of factors that influence the development and worsening of CVD in African Americans. The JHS enrolled a cohort of 5306 African-American participants from the Jackson, MS metropolitan area between the ages of 21–94 years between September 2000 and March 2004.13 Demographic and health information was collected during a series of home interviews and clinical examinations that took place during three exam periods, from the years 2000 to 2012: exam 1 (2000–2004), exam 2 (2005–2008), and exam 3 (2009–2013). The cross-sectional data presented in this report were obtained from a sample of 1314 individuals participating in the JHS cohort who completed hearing evaluations in the ancillary hearing study, which mainly coincided with JHS exams 2 and 3. Both education and income were assessed with patient questionnaires. Education was broken up into three categories: less than high school degree, high school degree equivalent, and greater than high school. Income level was broken up into three categories: poverty level, lower middle class (1–1.5 times poverty level), upper middle class (>1.5 but <3.5 times the poverty level), and affluent (>3.5 times the poverty level).

### Audiologic Assessment

Participants underwent otoscopic exam, middle ear assessment with tympanometry, and were given a detailed hearing- health history questionnaire to determine candidacy and to identify whether any conditions were present that may interfere with further audiologic assessments. This included the presence of external/middle ear disorder, history of radiation therapy and/or use of known ototoxic medications and reported illness or injury that resulted in hearing loss. Additionally, individuals who presented with large pure-tone air-bone gaps in audiometric testing were excluded. Individuals who presented with referable conditions, such as those with active external or middle ear disorders, were eliminated from the study until such conditions were successfully resolved. Individuals who confidently reported loud noise exposure they feel may have affected their hearing were included; however, these data were adjusted for in statistical models where appropriate.

Audiometry was performed with insert earphones (ER-3A, GN Otometrics, Denmark) on a two-channel diagnostic audiometer (Madsen Conera, GN Otometrics, Schaumburg, IL), calibrated yearly to American National Standards Institute (ANSI) specifications for diagnostic audiometers.14 All participants were evaluated in a commercially available test room, which met the ANSI standards for permissible ambient noise.15 Pure-tone audiometric testing was performed in accordance with procedures recommended by the American Speech-Language-Hearing Association.16 Thresholds were determined for octaves from 250 Hz to 8000 Hz by air conduction and for octaves from 500 Hz to 4000 Hz by bone conduction. For this study, hearing loss was defined as a four-frequency average of 500, 1000, 2000, and 4000 Hz (referred here as the PTA4) greater than 25 dBHL. The PTA4 > 25 dBHL is a common clinical and epidemiological cutoff for normal hearing sensitivity.17 The PTA4 of the worse ear was used in the present analyses consistent with Cruikshanks et al.18 to allow inclusion of persons with unilateral/asymmetrical hearing loss.

Presence of tinnitus, history of noise exposure, and dizziness were determined through a questionnaire-based interview with dichotomous responses (yes or no). For tinnitus, “Do you have tinnitus (ringing, buzzing, ‘crickets,’ or other sounds) in your ears?”; for noise exposure, “Have you ever been exposed to loud noise that you think may have affected your ears of hearing?”; for dizziness, “Do you have vertigo (dizzy, spinning

### TABLE I.

Definition of Each Individual Metric in the American Heart Association’s Life’s Simple 7.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>Intermediate</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking status</td>
<td>Current smoker</td>
<td>Quit within past 12 months</td>
<td>Never or quit &gt;12 months ago</td>
</tr>
<tr>
<td>Body mass index</td>
<td>≥30.0</td>
<td>25.0–29.9</td>
<td>&lt;25.0</td>
</tr>
<tr>
<td>Physical activity</td>
<td>None</td>
<td>1–149 mins/wk moderate intensity or</td>
<td>≥150 mins/wk moderate intensity or</td>
</tr>
<tr>
<td>Healthy diet scorea</td>
<td>0–1</td>
<td>2–3</td>
<td>4–5</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>≥240</td>
<td>200–239 or treated to goal</td>
<td>&lt;200 untreated</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Systolic ≥140 or</td>
<td>Systolic 120–139 or</td>
<td>&lt;120/&lt;80 untreated</td>
</tr>
<tr>
<td></td>
<td>Diastolic ≥90</td>
<td>Diastolic 80–89 or treated to goal</td>
<td></td>
</tr>
<tr>
<td>Fasting plasma glucose</td>
<td>≥126</td>
<td>100–125 or treated to goal</td>
<td>&lt;100 untreated</td>
</tr>
</tbody>
</table>

This is based off the American Heart Association’s strategic impact goal through 2020 in Lloyd-Jones et al.9 for adults 20 years of age and older.

*Healthy diet points are based on: ≥4.5 servings/d of fruits and vegetables, ≥7-oz servings/wk of Fish, ≥3 servings/d of grain, ≥4.5 servings/wk of sweetened beverages, and <1500 mg/d of sodium.
sensation, like you are going in a circle in a chair), or do you fell imbalance, or unsteady on your feet?*

**Life Simple 7**

The LS7 is a measure of overall cardiovascular health, as developed by the American Heart Association Strategic Planning Task Force and Statistics Committee. The LS7 consists of smoking status, BMI, physical activity, healthy diet score, total cholesterol, blood pressure, and fasting glucose level. Patients receive scores for each individual category, poor = 0, intermediate = 1, and ideal = 2, as well as a total score out of 14 possible points. We examined the overall score and categorization as poor, intermediate, or ideal cardiovascular health as in Lloyd-Jones et al. Further descriptions of the individual life’s simple seven metrics can be found in Table I.

**Statistical Analysis**

Descriptive data are reported as mean and standard deviation (SD) for continuous measures and n (percent) for categorical measures. When analyzing the JHS data, unadjusted and adjusted gamma regression and logistic regression models were constructed for determining relationships between participant characteristics of interest and hearing loss providing risk ratio (RR) or odds ratio (OR), respectively; confidence intervals (CIs) are also provided. Adjustments were made for age, sex, education, and history of noise exposure. All data management and analyses were performed using SAS software, Version 9.4 (SAS Institute, Inc., Cary, NC).

**RESULTS**

The JHS group is comprised entirely of African Americans. Out of a total of 1314 participants, 69.8% were female and the average age was 61.8. Table II shows the demographic information for the study group as well as the breakdown for each of the LS7 components by total and by sex. There was good distribution of participants between the poor, intermediate, and ideal groups in the BMI, physical activity, total cholesterol, blood pressure, and fasting glucose categories. Smoking had only 14 (1.07%) participants in the intermediate category and nutrition had 10 (0.76%) in the ideal category. The average total life’s simple seven score was 7.3 out of a total 14. Study participants had an average PTA4 of 22.5 (SD 12.3). The prevalence of hearing loss, defined as a PTA 4 of >25 dB, was 30% (n = 386). Of the participants, 388 (30%) reported tinnitus and 317 (24%) reported dizziness (Table III). Logistic regression models (results reported in odds ratio) shown in Table III revealed a statistically significant relationship between LS7 and hearing loss (OR = 0.823; 95% CI, 0.76–0.88, P < .001), tinnitus (OR = 0.934; 95% CI, 0.87–0.99, P = .044) and vertigo (OR = 0.908; 95% CI, 0.84–0.97, P = .008), however when adjusting for age, sex, education, noise exposure only hearing loss (OR = 0.882; 0.84–0.97, P = .001) and vertigo (OR = 0.908; 95% CI, 0.84–0.97, P = .008) remained statistically significant.
Based on the statistically significant relationship between the overall LS7 score and hearing status we further examined the individual components of LS7 using logistic regression (Table IV). Adjusting for age, sex, education, and history of noise exposure, participants who scored in the ideal categories of the BMI (OR = 0.605; 95% CI, 0.81–0.96, \(P = .033\)), blood pressure (OR = 0.484; 95% CI, 0.29–0.79, \(P = .004\)), and fasting glucose (OR = 0.878; 95% CI, 0.59–0.98, \(P = .043\)) had lower odds of hearing loss. Participants in the intermediate category of the physical activity metric also showed lower odds of hearing loss (OR = 0.666; 95% CI, 0.48–0.91, \(P = .017\)).

**DISCUSSION**

Our analysis from this large community-based population of African Americans showed that patients with lower LS7 scores (worse cardiovascular health) had elevated (poorer) pure tone average (PTA4) of 500, 1000, 2000, and 4000 Hz and an increased risk of hearing loss (PTA4 > 25 dB). Breaking down the LS7 score, better scores on the BMI, physical activity, blood pressure, and fasting glucose components were all individually statistically related (\(P < .050\)) to better hearing outcomes. There was no statistically significant relationship discovered between LS7 scores and tinnitus or dizziness in adjusted models. When comparing the individual LS7 metrics of our study population made up of only African American participants to a population representative of the US population, our population was less healthy. Less percentage of participants met the ideal category for BMI, blood pressure, fasting glucose, cholesterol, and physical activity.

Our results agree with previous studies that looked at cardiovascular risk factors. Upon review of the literature, each of the seven factors in LS7 has been individually linked to hearing loss. There is a well-studied association between smoking and hearing loss in the literature.\textsuperscript{19,20} A meta-analysis performed by Nomura et al. analyzed 15 papers and showed a positive association between smoking and hearing loss.\textsuperscript{21} It is unclear the mechanism of how smoking causes hearing loss, but it is theorized that nicotine causes vasoconstriction and atherosclerotic changes of the vessels of the cochlea.\textsuperscript{22} In the present study we did not find a significant relationship between smoking and hearing loss. This is likely due to a poor distribution of

<table>
<thead>
<tr>
<th>TABLE III.</th>
<th>Odds Ratios for Life’s Simple 7 and Hearing Loss, Tinnitus, and Dizziness.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hearing Loss</strong></td>
<td><strong>Tinnitus</strong></td>
</tr>
<tr>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>Total LS7</td>
<td>0.823</td>
</tr>
<tr>
<td>(P &lt; 0.001)</td>
<td>(P = 0.003)</td>
</tr>
<tr>
<td>(0.76, 0.88)</td>
<td>(0.81, 0.95)</td>
</tr>
</tbody>
</table>

Model 1 unadjusted.
Model 2 adjusted for age, sex, education, and history of noise exposure.
LS7 = Life’s Simple 7.

<table>
<thead>
<tr>
<th>TABLE IV.</th>
<th>Life Simple 7 Components and Odds Ratio for Hearing Loss (PTA4 &gt; 25 dBHL).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smoking</strong></td>
<td><strong>Body mass index</strong></td>
</tr>
<tr>
<td>Poor</td>
<td>Ref</td>
</tr>
<tr>
<td>Int</td>
<td>1.496</td>
</tr>
<tr>
<td>Ideal</td>
<td>0.873</td>
</tr>
<tr>
<td>(0.615, 1.129)</td>
<td>(0.620, 1.140)</td>
</tr>
<tr>
<td>Poor</td>
<td>Ref</td>
</tr>
<tr>
<td>Int</td>
<td>0.868</td>
</tr>
<tr>
<td>Ideal</td>
<td>2.331</td>
</tr>
<tr>
<td>(0.558, 1.284)</td>
<td>(0.568, 1.314)</td>
</tr>
<tr>
<td>Poor</td>
<td>Ref</td>
</tr>
<tr>
<td>Int</td>
<td>0.875</td>
</tr>
<tr>
<td>Ideal</td>
<td>0.847</td>
</tr>
<tr>
<td>(0.282, 0.758)</td>
<td>(0.294, 0.794)</td>
</tr>
</tbody>
</table>

Int = intermediate.
Model 1 unadjusted.
Model 2 adjusted for age, sex, education, and history of noise exposure.
patients within the metric with the large majority falling into the ideal category (non-smokers) and only 1% (14/1295) in the intermediate category (quit within the past 12 months). There have been conflicting reports as to whether BMI influences hearing loss or not. The relationship between BMI and hearing loss may be confounded by age; older age is strongly associated with hearing loss, but BMI tends to decrease with older age.35 Fransen et al.23 found a positive relationship between high BMI and hearing loss, whereas Hwang et al.24 found that central obesity, but not BMI was associated with hearing loss. We found a statistically significant association between worse BMI scores and hearing loss in the present study. There are several theories as to why an increased BMI leads to hearing loss. One of the most accepted is that adipocytes disrupt the capillary lining leading to decreased blood supply in the middle and inner ear.35

Individuals who participate in physical activity, defined by the American Heart Association as ≥150 min/wk moderate intensity or ≥75 min/wk vigorous intensity or a combination, have been shown to have improved hearing outcomes when compared to inactive individuals.26,27 Another study demonstrated improvement of PTA in inactive individuals who participated in an 8-week long, twice weekly aerobic exercise regimen.28 Physical activity is thought to decrease inflammatory markers, improve insulin tolerance, and improve lipid profiles.29 Interestingly we found an association between hearing loss and the intermediate category of physical activity, but not the ideal category. This could be due to the limited number of study participants who were in the ideal category affecting the power.

An association between healthier eating and better hearing at high frequencies has been shown.30,31 Due to poor distribution within the poor, moderate, and ideal categories for the nutrition component, we were not able to demonstrate a relationship. There is contradictory evidence to the relationship between hypercholesterolemia and hearing status,32,33 but hypercholesterolemia has been strongly associated with worse cardiovascular health.34 Hypertension is a well-documented cause of cochlear damage and peripheral hearing loss in both rats and humans.35-38 Hypertension causes many changes in the circulatory system that effect hearing. Increased blood viscosity reduces capillary blood flow, which reduces oxygen transport and causes tissue hypoxia. Ionic changes in cells causing hearing loss has also been described.39 High blood pressure is also recognized as one of the most modifiable risk factors for dementia, cognitive impairment, and central auditory processing.35 Diabetes is another risk factor with an abundance of data showing its effects on hearing loss. It is thought that patients with diabetes mellitus have hearing loss resulting from cochlear microangiopathy, degeneration of the stria vascularis, and loss of cochlear OHCs.39 There has been some data showing a positive correlation between the duration of diabetes and degree of hearing loss.40,41 Our study also shows an association between hearing loss and fasting blood glucose levels. As there was a significant difference between the ideal and reference groups. This is important as improved blood glucose management could represent another potentially modifiable risk factor.42

Although it is important to identify risk factors, it is equally important to establish methods these risk factors can be used for early identification. To our knowledge this is the first study to look at the AHA’s LS7 as a risk assessment tool. The LS7 was initially adopted by the AHA as a tool to define the “ideal” cardiovascular health as well as to calculate and individuals overall cardiovascular health. Improvement in the United States population’s overall LS7 scores by 2020 was named a major impact goal by the AHA. Given the strength of associations between the health behaviors and health factors included in LS7, and the added emphasis placed on it by the AHA, it may be a useful tool in identifying patients who are at risk of developing hearing problems.

In general, most causes of hearing loss are not reversible, so prevention should be a crucial strategy for physicians. While many otolaryngologists and audiologists are not routinely screening for cardiovascular risk factors, or calculating a patients LS7 score, it is important to understand the relationship and place referrals to capable physicians if necessary. It is also important for primary care physicians and specialists who may be screening for, preventing, and treating cardiovascular risk factors to recognize high-risk patients and have them screened for hearing loss when appropriate. Ultimately the goal of using such a tool, would be to identify high-risk patients before hearing loss develops or worsens and to intervene.

Our study is limited by its cross-sectional design, future longitudinal studies will be needed to show the usefulness of the LS7 as a risk assessment tool. The advantage of our study lies in the large sample size and thorough data collection, but there are several other limitations. All of the study participants were African Americans, and the majority female, which may limit the ability to make comparisons to the general population. Interestingly, the African American population has higher cardiovascular risk with lower incidence of hearing loss.43 Similarly, the study participants were all from a largely rural southeastern state, which may not be representative of the general population. The cross-sectional design of our study cannot lead to casual relationships, but can just show an association. Finally, due to how they were defined by the AHA, both the smoking and nutrition categories had poor distribution in between the poor, intermediate, and ideal categories. This distribution may have precluded accurate assessment of their relationship to hearing.

**CONCLUSION**

This study shows a significant, graded association between higher LS7 scores and better hearing outcomes. This agrees with previous studies showing a significant link between cardiovascular risk factors and hearing loss. Although further work is needed to invent and validate risk assessment tools, persons who have cardiovascular risk should be screened, and intervened on if necessary, for hearing loss.
BIBLIOGRAPHY


