Modeling the deterioration of hearing ability due to semi-toxic sound levels
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The paper presents a mathematical overview of the impact of prolonged low-pressure sound exposure on hearing health, emphasizing the role of damage to hair cells in hearing loss. By integrating insights from acoustics, physiology, and mathematical studies, the study proposes a mathematical model consisting of the dynamics of hearing levels, hair cells population damage and regeneration, and hearing loss; using ordinary differential equations. In this study, we assume that the growth rate of health hair cells influence hearing levels and the hair cells population. Hence, we analyze the hearing loss dynamics when these two factors grow at a rate equivalent to the steady state of health cells growth. We illustrate the stability of the model system with a backward bifurcation diagram. Our results show that there are periods of natural hearing loss that can only be slowed down, but not averted. We obtain various important measures that give one's auditory health profile such as the Resilience Index, Hearing Sustainability Metric and the Auditory Health Resilience Score, all important in quantifying the process of hearing loss. We simulate these dynamics using artificial sound intensity data to validate our findings. The results in this study can be used to predict hearing impairment outcomes and guide evidence-based interventions to mitigate the adverse effects of prolonged low-pressure sound exposure on auditory health.

Keywords: Hair cells, Sensorinueral Hearing Loss, Low-pressure sound, Cochlear damage, Acoustic exposure.