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Cochlear Implantation: Vast Unmet Need to Address Deafness Globally

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Sensorineural hearing loss (SNHL) is the most common type of hearing loss (HL), and though novel approaches to treatment are in development, current therapies are limited to assistive devices, such as hearing aids and cochlear implants (CIs). CIs are the most successful neural prostheses of all time and facilitate functional hearing for people with severe to profound SNHL. However, less than 10% of CI candidates worldwide utilize this technology (1). Though conscious, early integration into Deaf culture presents a valuable opportunity for cultural and linguistic development and remains an option that should not be discounted, we provide the calculation of total CI candidates in the world, which has not been previously presented.

Combining reported figures from the ten most populous countries and extending this estimate to the world population, we calculate that 115,000 newborns worldwide experience profound HL (Fig. 1A). Infants with otologic conditions for which implantation is contraindicated, including auditory neuropathy spectrum disorder (1%) and inner ear malformations (1%) can be subtracted from this total, leaving 112,700 CI candidates born each year.

Twenty-five percent of the world population is younger than 15 years old, and 0.2% of children (3.6 million) experience profound HL (2). At this age, the most salient contraindication for cochlear implantation is mental retardation, including autism spectrum disorder, which affects 2–7% of children (3,4). Various other prohibitive disabilities affect 23% of children with profound HL (3). Thus, after conservative elimination of 30% of children with profound HL, 2.5 million children in the world remain CI candidates.

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Globally, 0.2–0.4% of adults suffer from profound HL (2). 75% of the population is over 15 years old, and sixty percent (9.9 million) of these people have experienced adult-onset HL due to factors like noise exposure and presbycusis (5). Most of these individuals are eligible for implantation. Additionally, people over 65 years old make up 7.4% of the world population, of whom 0.9% suffer from profound HL (6). If we eliminate 15% of elderly people from the pool of adult CI candidates to account for the prevalence of Alzheimer's disease (11%) and non-Alzheimer's-related dementia (3%) (7,8), we assume that approximately 9.2 million adults remain eligible for implantation.

Taken together, our estimations suggest that 11.7 million people worldwide are CI candidates (9.2 million adults, 2.5 million children). This number is augmented by 112,700 newborns each year (Fig. 1A). Importantly, these estimates are based on pure tone average thresholds, rather than word recognition scores, which are not reliably reported on the global scale. Profound unilateral hearing loss is another promising new indication for cochlear implantation, but for which prevalence has not yet been established. Regardless, only a fraction of this medical need is currently being met. According to the U.S. Food and Drug Administration (FDA), only 324,000 people worldwide had received CIs by the end of 2012, and one-third of implanted individuals reside in the United States. Fewer than 50,000 CIs are reportedly sold each year.

Financial barriers represent the most significant roadblock to CI distribution and use. Inadequate infrastructure affects most of the developing world, leading to delays in HL assessment and diagnosis, lack of CI-trained surgeons and audiologists, lack of newborn screening programs, and shortage of staff available to train professionals (9). The ratio of gross domestic product (GDP) per capita to CI cost ranges from 0.5 to 3 in high- and upper middle-income economies, but drops to 0.1 or less in lower middle-income economies (Fig. 1B). Although insurance companies will pay for a CI and related surgery, there are many people worldwide who do not have health insurance and cannot afford implantation.

In our opinion, the key factor that would facilitate widespread access to CI technology is modulation of global pricing. At present, though numerous studies affirm the cost-effectiveness of CIs for children and adults (10,11), cost varies by country of origin. Recently, the world's most populous countries, China and India, have begun to manufacture their own implants; for example, the Chinese formulation, Neurotron, has been on the market for six years at half the price of the three dominant products. An affordable Indian version is also in development, with cost aimed at \$2,500.

In the short term, meeting the need for CI-trained surgeons and professionals in developing countries would require a prohibitive amount of time, effort, and money. However, increased reliance on technological improvements such as telesurgery and telerenting could address some aspects of this problem. Remote otologic surgeons can mentor local professionals through telepresence, even in the absence of technological infrastructure. Establishing such mentoring networks would also facilitate the implementation of novel biotechnological therapies as they emerge.

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Fig 1.

(A) Estimated number of infants born with profound hearing loss annually in the ten most populous countries; (B) GDP per capita relative to CI cost in representative high-, upper middle-, and lower middle-income countries.