Estimating the global costs of hearing loss

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Abstract

Objective: To estimate the global costs of hearing loss in 2019.

Design: Prevalence-based costing model. Study sample: hearing loss data from the 2019 Global Burden of Disease study. Additional non-hearing related health care costs, educational support, exclusion from the labour force in countries with full employment and societal costs posed by lost quality of life were determined. All costs were reported in 2019 purchasing power parity (PPP) adjusted international dollars.

Results: Total global economic costs of hearing loss exceeded $981 billion. 47% of costs were related to quality of life losses, with 32% due to additional costs of poor health in people with hearing loss. 57% of costs were outside of high-income countries. 6.5% of costs were for children aged 0-14. In scenario analysis a 5% reduction in prevalence of hearing loss would reduce global costs by $49 billion.

Conclusion: This analysis highlights major economic consequences of not taking action to address hearing loss worldwide. Small reductions in prevalence and/or severity of hearing loss could avert substantial economic costs to society. These cost estimates can also be used to help in modelling the cost effectiveness of interventions to prevent/tackle hearing loss and strengthen the case for investment.

Keywords: Hearing loss, economic cost, global burden of disease, global health policy.

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Introduction

The impacts of hearing loss can be profound (1). Restrictions on the ability to communicate with other people can affect personal relationships, educational development, interactions with services including health, as well as hampering employment and career opportunities. Speech and language difficulties can themselves be stigmatising and also increase the risk of poor psychological health and wellbeing.

In 2019, the Global Burden of Disease Study (GBD) estimated that more than 1.57 billion people have some form of hearing loss (more than 20 decibels of hearing loss) (2). There were adverse impacts associated with all levels of hearing loss, with 35 million years lived with disability, of which more than 11 million were just for people with mild hearing loss. This is still a conservative estimate as it does not include unilateral hearing loss. In the GBD study, even after adjustment for hearing aid use, more than 403 million people still had at least a moderate level of hearing loss (more than 35 decibels). This is also potentially conservative; earlier estimates of almost 500 million people have been made for disabling hearing loss that do not adjust prevalence for hearing aid use and use different definitions on levels of hearing loss (3).

Overwhelmingly, hearing loss goes unaddressed; globally only 17% of people in need of hearing aids make use of them, ranging from 23% in Europe to just 10% in Africa (4). If hearing loss is not to remain a silent burden then it is important not only to highlight its prevalence but also its immediate and longer-term health, social and economic impacts at a global as well as national level. Having an understanding of these impacts, as well as potential costs that might be avoided through effective prevention and intervention, can help policymakers plan how to best make use of their health care budgets, as well as invest in appropriate hearing related measures elsewhere, such as additional support in schools and workplaces in order to promote inclusion and opportunity for all people living with hearing loss.

Although there are estimates on the costs of hearing loss for different population groups at individual country level, e.g. (5-7), systematic reviews reveal that there are very few estimates of the comparative costs of hearing loss across countries, especially comparative

analyses that include low and middle-income countries (8, 9). This paper provides an estimate of the global costs of hearing loss in 2019, covering all levels of hearing loss reported in the GBD after adjustment for the use of hearing aids, refining the approach we used to produce an initial estimate of costs for 2015 (10). Our analysis indicates that these costs go well beyond the health and educational impacts of hearing loss, with the majority related to exclusion from the labour force and poor quality of life.

Methods

A model has been built in Excel to estimate the global costs of hearing loss. We used prevalence-based costing, an approach that is widely used in estimating the costs of chronic conditions in different country settings (11-13). Prevalence and years lived with disability data, by severity of hearing loss, age group and gender for all cause hearing loss for all countries were obtained from the 2019 Global Burden of Disease (2).

To inform our estimate of costs we also undertook a rapid review in Medline to identify studies of the annual incremental economic costs of living with hearing loss. We restricted our analysis of health costs to the excess non-hearing health impacts of hearing loss, thus studies looking solely at costs associated with treatment for hearing loss through the provision of hearing aids or cochlear implants, rather than the excess health costs associated with living with hearing loss, were excluded. Studies looking at costs associated with a sub-group of risk factors such as otitis media, as well as specific causes such as hazardous noise exposure, were not included.

In the absence of estimates of additional health or education costs for people living with hearing loss for most countries we needed to impute these costs. There is a strong relationship between health expenditure and GDP per capita (14) and this relationship has been used by health economists to develop a methodology to estimate comparative country costs in global studies of similar health problems, including visual and cognitive impairment (12, 15-17). This approach assumes that the ratio between observed health costs per person and observed purchasing power parity (PPP) adjusted gross domestic product (GDP) per capita in countries can be used to impute other country specific health costs. PPP is the rate at which the currency of one country would have to be converted into that of another country to buy the same amount of goods and services in each country.

A number of further assumptions were made on health and education costs:

- The ratio between observed education costs per person and observed purchasing power parity (PPP) adjusted gross domestic product (GDP) per capita can also be used to impute the share of GDP per capita spent on hearing-related education services.
- Estimates of health-related costs considered only additional non-hearing health costs incurred for individuals with hearing loss, drawn from studies comparing health care costs for populations with and without hearing loss. We excluded any costs of treating hearing loss, e.g. hearing aids, cochlear implants and therapy. We conservatively assumed that there would only be an impact on these health care costs for individuals with at least moderate levels of hearing loss.
- We conservatively only included education costs for children aged 5 to 14, given a mean of just 8.8 years education in low income countries (18) and that only children with at least moderately-severe hearing loss (loss of more than 50 decibels) might require these additional educational resources.

We also included costs for lost employment for people aged 15 to 64 only in those countries which have full employment. In these circumstances there is no available pool of unemployed labour that can replace any reduction in the employment participation of people with hearing loss. In practice full employment does not mean having zero unemployment as there will always be fluctuations in employment status. We adopted the convention that unemployment rates under 6.0% can be considered as full employment (19). No productivity losses are assumed to be incurred in other countries. Assumptions on the rate of unemployment and the participation of adults in employment in the working population (aged 15-64) were taken from ILO statistics for all countries for the latest available employment rates in 2019 (20). We limited costs to individuals with at least moderately-severe hearing loss; these population levels are similar in size to official national statistical data on labour force participation by people with disabling hearing loss in high-income countries, e.g. in Canada, Ireland and the UK (21-23).

The final element of cost in our analysis is the value of lost quality of life associated with hearing loss. Here we approximate for these costs assuming that all country specific years lived with disability associated with all hearing loss, including mild hearing loss, and reported in the 2019 Global Burden of Disease Study (24), can be valued at PPP adjusted country GDP per capita. To avoid double counting for adverse impacts on quality of life of

exclusion from employment these figures are presented net of any costs of productivity losses in countries with full employment.

All costs are presented using 2019 PPP adjusted international dollars using the IMF's World Economic Outlook GDP Deflator. Results are reported at a global level and for eight geographical regions (See appendix for countries in each region).

Results

Model inputs

1. Health care costs: drawing on literature (see Table 1), the annual additional non-hearing health care costs associated with hearing loss in our model were estimated to be approximately equivalent to 6% of country specific GDP per capita for children aged 0 to 14 and 4% of country specific GDP per capita for all adults aged 15 and over.

For children these excess costs associated with hearing loss were based on expenditure relative to GDP per capita from two English analyses of a birth cohort. The most recent analysis using medical records and parental self-report compared one year hospital primary and community health care costs, excluding any implant related costs, for teenagers with at least moderate hearing loss (25) to normally hearing children. Excluding health care costs associated with implantation and maintenance of devices there were still $2,176 in additional non-hearing health costs per child in the hearing loss group. The same cohort had previously reported additional one year costs of $2,927 for these children when aged between seven and nine (6). No other studies identifying the excess health care costs, excluding use of devices, were found for children; in general, the literature on children focuses on the additional costs associated with the treatment of hearing loss.

For adults, studies looking at the excess general non-hearing health care costs of living with hearing loss, rather than the costs of treating hearing loss, are also limited. Our pooled estimate for excess costs being equivalent to 4% of country specific GDP per capita draws on five studies. We included a Dutch study that used a self-reported health resource use questionnaire from individuals aged 18 to 65 with and without hearing loss (26). Contacts with primary and secondary care, as well as psychosocial, occupational and complementary therapy practitioners were collected, but use of medications and equipment such as hearing aids were excluded. Average annual additional costs for the hearing-loss group were $1,152.

Propensity score matching, a statistical technique used in analysis of observational data to ensure that individuals are similar in key socio-demographic and other characteristics, was applied to US insurance claim data to compare the annual health care costs over ten years for more than 77,000 individuals aged 50 and older with untreated hearing loss to the costs for individuals with untreated hearing loss. Individuals using hearing aids were excluded from the analysis, and average annual additional non-hearing loss related costs in the untreated hearing loss group were $2,379 for non-hearing specific additional health costs (7).

Another US analysis of Medicare claims data matched 440 individuals with hearing aids over the age of 65 who made use of hearing care services with comparable individuals with hearing aids who did not use hearing care services (27). Average annual costs were $2,775 higher in the group not using hearing services. A similar analysis of patients eligible for Medicare or private insurance had estimated annual costs $2,613 higher in individuals with hearing loss but not receiving hearing services compared with patients without hearing loss (28). Another analysis in the US using supplementary Medicare insurance claims data identified additional annual health care costs for individuals aged over 65 with unaided severe hearing loss of $2,322 matched to individuals without hearing loss (29).

2. Education: in our model the principal cost to education systems concerns the potential additional support, over and above the standard costs for education, that would be needed in order to help a child remain integrated within a school for all children, or alternatively to be educated in a special school for children with hearing difficulties. Drawing on a more extensive literature our model assumes that additional costs to the education sector of supporting children with hearing loss are substantial, equivalent to 34% of GDP per capita. Our model conservatively assumes that the economic value of this additional educational support would only be needed for children with at least moderately- severe levels of hearing loss, as most of the studies we identified focused on this population only.

Table 2 provides a summary of literature used to inform our estimates of the value of education. We made use of three studies that used the same approach to estimate expected additional costs of education for severe and profoundly hearing impaired children in six sub-Saharan African countries (30), seven countries in Central and South America (31) and eight low and middle income Asian countries (32). As Table 2 shows there is considerable heterogeneity in cost as expressed in GDP per capita in countries, ranging from just 2% in Colombia to 134% in Nepal. It also includes two UK analyses identifying additional average

annual educational costs in mainstream and specialists schools for hearing impaired 7-9 year olds of $14,313 and teenagers of $10,696 drawing on birth cohort data (6, 25). We also included a US estimate combining data from different sources of mean additional costs of $8,828 to the education system per annum per child with severe to profound hearing loss and no cochlear implant versus standard annual education costs (33-35). Modelled mean incremental costs of special education in China of $5,558 per child who had not received treatment for permanent congenital and early onset hearing loss were also included (36).

3. Productivity losses: in our review we did not identify detailed global information on employment rates for people with hearing loss, and there is considerable variation in estimates for individual (mainly high-income) countries (37), so conservatively to minimise cost estimates we have looked at the employment gap between 'all working age people who are not classified disabled and/or work-limiting disabled' and 'working age disabled people who report their main health problem as difficulty in hearing' in the UK (38). Selecting a high-income country with highly developed regulations on employment discrimination, as well as support to help accommodate individuals with hearing loss in the workplace, should minimise these impacts. While the employment gap used in our model was 18%, much higher rates of employment gap have been reported in other settings, for instance the risk of either being unemployed or under-employed (working less than 35 hours per week) in analysis of US survey data was almost double that of people without hearing loss (39).

4. Quality of life: Monetary values have also been attached to years lived with disability reported in the GBD due to hearing loss to place a value on lost quality of life in some specific country settings (5, 40, 41). To approximate the societal costs associated with reduced quality of life associated with all levels of hearing loss globally, we also valued total years lived with disability due to hearing loss monetarily, assuming that a year without hearing loss could be valued at country specific PPP adjusted GDP per capita. These costs were net of any productivity losses in countries with full employment to avoid double counting. Total years lived with disability estimated in the GBD study due to hearing loss are dependent on the disability weights used. We note in the GBD study that these vary considerably, depending on the severity of hearing loss, from a minimal 0.01 weight attached to each year lived with mild hearing loss to 0.316 for complete hearing loss with ringing (2). In the GBD study, disability weights are also reduced by one grade for the minority of individuals with disabling hearing loss who make use of hearing aids, but we have noted that globally 83% of hearing loss goes unaddressed (4).

Overall costs

We estimate that the overall global economic costs of hearing loss in 2019 to be more than $981 billion (Table 3). 57% of these costs are incurred outside of the high-income region, including 23% in the East Asia region alone. Although children only account for 4.4% of the 1.57 billion people with hearing loss in the GBD study, they incur 6.5% of total costs. The economic value associated with lost quality of life, expressed by valuing country specific years lived with disability in 2019 by country specific PPP adjusted GDP per capita, accounts for 47% of total costs. Our analysis also indicates that productivity losses for moderately-severe hearing impaired adults in the 105 countries and territories in 2019 with full employment, that is with unemployment rates below 6%, still account for 19%, more than $182 billion, of all the costs of hearing loss, with 69% of these costs outside of the high income region, including 33% in East Asia alone. This estimate of productivity losses is conservative as there are likely to be some impacts on productivity in those with mild and/or moderate hearing loss.

Excess non-hearing health care costs account for 32% of global costs. These health care costs for adults were $301 billion, with 51% incurred in low and middle-income countries. Total additional non-hearing health care costs for children with hearing loss, and therefore excluding costs of implants, devices and other treatments, were estimated at $12.9 billion. 85% of child excess health care costs fall outside the high-income region. The value of education-related support that would be needed for children with at least moderately severe hearing loss is $27 billion. While less than 3% of total costs, this is double that of total costs related to the excess health care costs for children. This is also greater than quality of life losses in the model for children of $23.7 billion. This should not be interpreted as meaning that all countries provide this level of educational support as in many countries specialist educational support is very limited; instead it represents the economic value required to provide a level educational playing field for children.

Scenario analyses

We have also explored how these estimates of costs might vary under different scenarios (see Tables S1 to S6 in appendix). In the first scenario if the risk of incurring additional education costs is extended to apply to all children with at least moderate levels of hearing loss then education costs would increase from $27 billion to $60 billion. This would represent almost 6% of total global costs of $1.014 billion (Table S1).

Global costs for productivity loss in our primary analysis were $182 billion when restricted to working age adults who had at least moderately-severe levels of hearing loss. In our scenario analysis we examined the impact of an increased risk of exclusion from the workforce for all working age adults with moderate levels of hearing loss. We assumed this risk of exclusion would be half that used in our baseline model for more severe hearing loss, this risk level falls within the range of employment exclusion reported in some high-income country studies (37). Under this scenario these costs would increase to $253 billion and account for 26% of all costs. Total costs remain unchanged at $981 billion, as quality of life costs in the model are net of all productivity losses to avoid double-counting (Table S2).

We have also examined how using high and low estimates of the prevalence of hearing loss and years lived with disability reported in the GBD would impact on overall costs. Overall costs would fall to $694 billion using the lower GBD estimates or increase to $1,377 billion using the higher estimates (Tables S3 and S4).

We also examined the impact of a uniform change in the prevalence of different levels of hearing loss on region-specific costs. There are potentially substantial societal costs that can be averted from a very modest reduction in hearing loss. For example, a 5% decrease in prevalence would reduce global societal costs to $932 billion, including reduced costs of $1.3 billion in the Sub-Saharan Africa region and $10.9 billion in the East Asian region (Table S5).

We also examined the impact on the model of using the World Bank's uniform average world PPP adjusted GDP per capita rate across all countries, which in 2019 was $16,951, rather than country specific GDP per capita. Global costs would rise to $1,624 billion with 83% of all costs outside of the high-income country grouping (Table S6).

Discussion

Studies have increasingly documented the costs of hearing loss in individual, mainly high-income, country settings (7, 9, 25, 26, 28, 41, 42). However, cross-country estimates of costs are rare, one exception being an estimate across European countries, but this only included productivity and quality of life losses (40). Direct comparison between studies is also difficult because of differences in methods used and types of cost included. Moreover, published systematic reviews indicate that very few studies have estimated the excess health care costs

for people living with hearing loss (8, 9). Such information is a vital element in helping to demonstrate that failure to invest in measures to address hearing loss is not costless, but rather that by investing additional resources in diagnosis, prevention and treatment of hearing loss health care costs that are exacerbated by hearing loss might be avoided. For example, in the case of infants and young children with auditory neuropathy spectrum disorder, early intervention may generate additional long-term health, education and wider sector benefits; but more evidence on these very long-term benefits is needed (43). Better ear health may also be fundamental to healthy ageing. For older people conditions such as cognitive impairment and dementia, diabetes, arthritis and cardiovascular disease have a higher prevalence in people with hearing loss (44). Tackling hearing loss may also be associated with lower levels of depression in people with cognitive impairment (45). More generally, benefits to the health sector are in addition to the potential avoidance of long-term costs related to education, productivity loss and quality of life.

Our analysis seeks to address this gap, providing a global estimate of $981 billion for the costs of hearing loss in 2019, an increase in estimated costs compared to our own earlier estimate of $805 billion for 2015 ($750 billion in 2015 prices) (10). Given the fact that the prevalence of hearing loss is predicted to rise considerably in coming decades, it is likely that its economic impact will continue to rise proportionately, posing a major cause for concern (46). Moreover, it suggests that from a public health perspective, even very modest reductions in the overall prevalence or severity of loss can be valuable. We have highlighted economic benefits that would arise, for example, from a uniform 5% reduction in prevalence of hearing loss would reduce costs by almost $50 billion per annum, with the East Asia region alone potentially avoiding societal costs of $10.9 billion per annum.

We have noted that globally 83% of hearing loss goes unaddressed. Given the fact that most of the estimated costs are attributed to the impact of hearing loss on quality of life and productivity, and that cost-effective interventions are available to address hearing loss, it is likely that costs can be mitigated through timely access to those interventions (4). These factors are further elaborated in the World Health Organization's World Report on Hearing (47).

While our estimate of costs is substantial, we stress it is conservative. Although our analysis indicates that 57% of costs are borne outside of the high-income region in our analysis, these countries contain 85% of all years lived with disability due to hearing loss in 2019. The

relative high level of country specific PPP adjusted GDP per capita in high-income countries has a major influence on the balance of costs globally between high and low-income countries. In our scenario analyses we highlighted that alternatively using mean world GDP per capita for all countries would lead to the total share of costs outside the high-income country grouping rising to 83% of total costs, with overall global costs of $1,623 billion. Using a single global monetary value for costs does not however reflect the opportunity costs of hearing loss in individual countries, but equally it indicates the challenge faced when comparing costs globally and emphasises the importance of also looking at other factors such as epidemiological burden and the level of unmet need in countries.

The model also does not include the adverse impacts of unilateral hearing loss as these are not reported in the GBD study. For mild hearing loss, we have only included costs associated with adverse impacts on quality of life. These quality of life impacts are substantial, but there will also likely be some additional excess costs related to poorer non-hearing health, as well as possible adverse education and employment impacts that we have not included.

We have restricted our main estimates of costs related to educational need or loss of employment to individuals with at least moderately-severe levels of hearing loss. In our scenario analysis we have indicated how these costs might increase substantially if applied to people with moderate hearing loss, but more economic studies focused on these groups worldwide are needed. Our estimate of education costs will also be an underestimate as we do not include any costs for special educational support for pre-school aged children, nor for education beyond the age of 14 even though the school leaving age is higher in many countries. We also omit any costs for educational support for young people attending higher education, including university.

Impacts on productivity losses will also be conservative; our analysis assumes a relatively modest gap in rates of employment worldwide between people with hearing loss and the general population that is based on experience in the UK. However, there is heterogeneity in the conclusions of studies looking at hearing loss and employment (37), and rates will vary by age group and severity of hearing loss. Rates of participation are likely to be much lower in many low and middle-income countries with little legal protection against labour market discrimination. We also have not included any additional costs that may be associated with lower levels of productivity including additional sickness absence while at work. We also do

not account for adverse impacts on career opportunities that lead to lower salaries because of hearing loss (48).

In addition, we do not account for administration costs associated with providing any social welfare benefits that some countries may choose to provide to individuals who are out of work due to hearing loss. There will also be additional productivity losses for all those of working age and older people who are not in employment but contribute to economic output through other activities such as caring for families, subsistence farming, or taking part in further education.

The analysis also does not put any value on productivity losses by family and friends who may have to spend time providing additional support to people with impaired hearing. This may particularly be the case for older people with multiple morbidities including dementia. Other omitted costs include the provision of communication services, such as sign language interpreters in public services and subtitling (close captioning) of public service programming.

More research is also needed to assess the full economic impact of hearing loss on quality of life. Our analysis is based on total years lived with disability reported in the GBD study. The GBD study modelling reduces this disability burden by making adjustments to reflect differences in access to hearing aids. Most of the modelling data to inform this analysis is from high-income settings (2); moreover, there may be variability in the quality of hearing aids that mean some devices are less impactful than others (49). This potentially means that our estimate of costs due to reduced quality of life may be an underestimate. In addition, we do not include any of the quality of life impacts associated with having hearing loss and other morbidities, such as learning disabilities or dementia. Future research at individual country level to quantify these additional impacts and estimate their costs, while taking account of more country specific information on both coverage and the quality of devices, is warranted.

In addition to some uncertainty on years lived with disability, there may be additional adverse impacts beyond poorer quality of life that may not be fully captured by the years lived with disability metric. Examples could include the stigma experienced by individuals experiencing hearing loss, increased levels of loneliness, as well as the grief associated with the loss of the ability to hear sound and all the experiences related to sound. Ideally these costs would be elicited using mechanisms that reveal individual preferences on the value individuals attach to avoid hearing loss in different country contexts, such as through surveys. These values

potentially will be very different in different cultures and settings. They will also reflect the level of accessibility, adaption and social inclusion for people with disabilities that exists in different countries

Going forward, further in-depth country specific work using comparable methodology can help refine these estimates, and address some of the limitations we have noted in the availability and scope of data, especially in low and middle-income countries. It is also important to strengthen longitudinal analysis of the broader impacts of hearing loss, including wider consequences of multimorbidity for health, education and labour force participation across the lifecourse. Another area where more work is required is to understand the long term informal care requirements associated with hearing loss, especially when combined with cognitive decline and other physical frailty.

However, it is important to recognise that while having global estimates of costs highlights the relevance of addressing hearing loss it is essential to subsequently assess the cost effectiveness of prevention and intervention strategies in different countries. Cost effectiveness modelling studies synthesising local data on differences in costs with information on the relative effectiveness of two or more actions are increasingly used to make the case for investment in tackling hearing loss not only in high, but also in some low and middle-income countries (50). Our estimates of the costs of not taking action can be a starting point to inform and help in the replication of cost effectiveness modelling studies in countries where economic evidence on the cost of not taking action has been scant, so that the case for investing in actions to tackle hearing loss receives the attention that it deserves.

Conclusion

The vast majority of hearing loss goes unaddressed, yet hearing loss poses a significant annual economic global burden of $981 billion, as shown in this conservative cost-analysis. Most of these costs are due to the impact of hearing loss on quality of life and loss of productivity. For children additional education costs are substantial, while for all there are also additional, and potentially avoidable, long lasting excess non-hearing health care costs, that may reflect higher levels of multi-morbidity. Further research is needed, especially in low and middle-income countries, to generate country-specific estimates of costs and study the cost-effectiveness of available interventions in mitigating the economic impact of hearing loss.

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Declaration of interests

The authors declare no conflict of interest.

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Table 1: Studies used to estimate % of GDP per capita on excess health care costs in people with hearing loss

Reference	Country	Age Range / Hearing Loss	Methods and scope of costs	Annual health care costs of hearing loss per person (excluding device costs)	% of GDP per capita
(6)	UK	Children aged 7-9 either with at least moderate hearing loss or no hearing loss	Parental self-report of health and social care resource use costs including emergency hospital visits, inpatient and outpatient care, community & social care services	$5,099	6.42%
(25)	UK	Adolescents aged 13 – 20 either with at least moderate hearing loss or no hearing loss	Based on analysis of health records over last 12 months, plus parental self-report of health and social care services including hospital inpatient and outpatient care.	$4,179	5.15%
(26)	Netherlands	Adults aged 18 – 70 with different levels of hearing loss or no hearing loss.	Monthly self-report survey of primary, secondary and complementary health care use cost over 6 months.	$1,115	2.01%
(28)	USA	Adults aged 65 years and older with different levels of hearing loss or no hearing loss.	Propensity-matched cohort study making use of administrative health insurance claims data on inpatient, outpatient and prescriptions over 18 months.	$2,613	4.17%
(7)	USA	Adults aged 50 years and older with different levels of hearing loss or no hearing loss.	Propensity-matched cohort study making use of administrative health insurance claims data on	$2,322	3.70%

			inpatient, outpatient and emergency department use by individuals over 2, 5 and 10 years.		
(27)	USA	Adults aged 65 and older with hearing aids who use hearing services and adults who don't use hearing services	Propensity-matched cohort study of Medicare claims data on inpatient, outpatient, hospice, nursing home and prescription medicine use by individuals over 1 year.	$2,775	4.43%
(29)	USA	Adults aged 65 years and older with different levels of hearing loss who do and do not use hearing aids.	Data from telephone survey and administrative claims data on emergency department visits, hospitalisations and medications	$2,379	3.80%

Table 2: Studies used to estimate % of GDP per capita for additional educational needs of children with hearing loss

Reference	Country	Methods and scope of costs	Annual educational costs of hearing loss per person	% of GDP per capita
(30)	South Africa	Local country expert data collection; specialist services only; 14 years education	$10,628	85.15%
(30)	Nigeria	Local country expert data collection; specialist services only; 17 years education	$1,740	33.89%
(30)	Kenya	Local country expert data collection; specialist services only; 16 years education	$1,235	28.52%
(30)	Rwanda	Local country expert data collection; specialist services only; 16 years education	$402	18.07%
(30)	Uganda	Local country expert data collection; specialist services only; 15 years education	$916	41.98%
(30)	Malawi	Local country expert data collection; specialist services and mainstream education; 16 years education	$315	29.68%
(31)	Brazil	Local country expert data collection; specialist services only; 13 years education	$3,834	26.17%
(31)	Colombia	Local country expert data collection; specialist services only; 13 years education	$364	2.47%
(31)	Ecuador	Local country expert data collection; specialist services only; 14 years education	$1,170	10.29%
(31)	Guatemala	Local country expert data collection; specialist services only; 10 years education	$3,426	39.67%
(31)	Paraguay	Local country expert data collection; specialist services only; 12 years education	$2,688	21.19%
(31)	Trinidad & Tobago	Local country expert data collection; specialist services only; 13 years education	$12,058	46.07%
(31)	Venezuela	Local country expert data collection; specialist services only; 9 years education	$5,484	43.87%
(32)	Nepal	Local country expert data collection; specialist services only; 10 years education	$4,598	134.57%
(32)	Bangladesh	Local country expert data collection; specialist services only; 10 years education	$5,104	107.36%
(32)	Cambodia	Local country expert data collection; specialist services and mainstream education; 15 years education	$652	14.84%

(32)	Pakistan	Local country expert data collection; specialist services only; 16 years education	$2,538	54.12%
(32)	India	Local country expert data collection; specialist services only; 14 years education	$1,875	27.77%
(32)	Philippines	Local country expert data collection; specialist services only; 14 years education	$542	6.09%
(32)	Indonesia	Local country expert data collection; specialist services only; 20 years education	$1,775	15.03%
(32)	Sri Lanka	Local country expert data collection; specialist services only; 14 years education	$1,313	10.04%
(25)	UK	Parental self-report of additional specialist and mainstream educational service use for young people aged 13-20 with hearing loss versus children without hearing loss from a birth cohort	$10,696	22.90%
(6)	UK	Parental self-report of additional specialist and mainstream educational service use for children aged 7-9 with hearing loss versus children without hearing loss from a birth cohort	$14,313	30.65%
(36)	China	Analysis of data from provincial education and health agencies on additional costs of 9 years of specialist compulsory education for children with untreated hearing loss	$5,558	34.49%
(33-35)	USA	Synthesis of data from annual parental questionnaires on mainstream and specialist education services over 6 years extrapolated to 12 years for children with severe to profound hearing loss but no cochlear implantation compared with national data on educational costs for children without hearing loss	$8,828	14.08%

Table 3: Global costs for hearing loss in 2019 (2019 International $ millions)

Region Name	Health Care Children*	Health Care Adults*	Total Health Care Costs*	Education Costs§	Productivity Losses§	Quality of Life Costs β	All Costs
High-income region	1,898,268	146,371,432	148,269,700	4,115,188	57,056,858	215,172,766	424,614,512
Central / Eastern Europe and Central Asia region	822,666	23,330,088	24,152,754	1,646,556	13,292,073	38,957,030	78,048,413
Sub-Saharan Africa region	1,834,228	5,043,063	6,877,291	3,659,754	3,588,040	11,511,306	25,636,391
Middle East and North Africa region	656,682	11,480,989	12,137,670	1,344,013	3,909,690	20,786,906	38,178,279
South Asia region	3,012,968	21,018,826	24,031,793	5,623,361	19,439,085	29,418,199	78,512,438
Asia Pacific region	1,473,967	13,200,983	14,674,950	3,332,240	18,107,216	16,864,824	52,979,229
Latin America and Caribbean region	1,003,852	18,766,640	19,770,493	1,780,973	6,074,895	36,612,775	64,239,135
East Asia region	2,264,038	61,942,889	64,206,928	5,404,896	61,024,020	88,275,564	218,911,407
World	**12,966,669**	**301,154,910**	**314,121,579**	**26,906,979**	**182,491,876**	**457,599,370**	**981,119,804**
% of total costs	1.32%	30.70%	32.02%	2.74%	18.60%	46.64%	100.00%

* At least moderately impaired hearing only

§ At least moderately – severe impaired hearing only.

β All impaired hearing