BRIEFING PAPER

Hearing Care, cognitive decline and dementia:

A public health challenge, or an opportunity for healthy ageing?

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What do we know about hearing loss, cognitive decline and dementia?[1]

As the ageing population grows, the numbers of those with hearing loss, cognitive decline and dementia are increasing across the world, leading to urgent public health and social issues. *(Kingston et al 2018)*

- Over 466 million adults experience disabling hearing loss and this number is rising, with a cost globally of $750 billion per annum. *(World Health Organization 2016a)*
- Over 50 million people above 65 years of age have been diagnosed with dementia, and that number is expected to triple by 2050 due to the rising number of older people. The cost of caring for those with dementia in 2015 was approximately $820 billion, and 85% of those costs were related to family and social costs. *(Livingston et al 2017, World Alzheimer Report 2016)*

Hearing loss is now understood to be mechanistically linked with the risk of cognitive decline and dementia, but these implications of hearing loss often go unrecognized. *(F Lin, M Albert 2014)*

Hearing loss and its association with cognitive decline and poor health therefore presents one of the largest public health challenges we face but the implications often go unrecognised and unaddressed. We need to address this growing challenge, in line with the WHO resolution on hearing loss *(World Health Organization 2016b)* and to develop new approaches to hearing care in the context of updated approaches to healthy ageing. *(Beard et al 2016)*

Research shows:

Hearing loss is believed to directly increase the risk of cognitive decline and dementia through the effects of hearing loss on the brain and social isolation. *(F. Lin, M. Albert 2014)*

In Europe, over 52 million people suffer from hearing loss. *(EHIMA 2016, Lamb et al 2017)*

Approximately one-third of people over 65 years of age experience disabling hearing loss.

In developed countries, hearing loss is the fourth most common cause of years lived with disability. *(Wilson et al 2017)*

For those over 70 years of age, hearing loss is the most common cause of years lived with disability. *(YLD) (GBD 2015 Disease and Injury Incidence and Prevalence Collaborators 2016)*

Hearing loss in adulthood is linked to higher rates of unemployment, depression, greater cognitive decline, greater risk of falls and co-morbidities when compared with peers with normal hearing.

As with hearing loss, dementia and cognitive dysfunction contribute to falls, length of stay in hospital, more intensive nursing care, and poorer recovery after surgery. *(Pichora-Fuller et al 2015)*

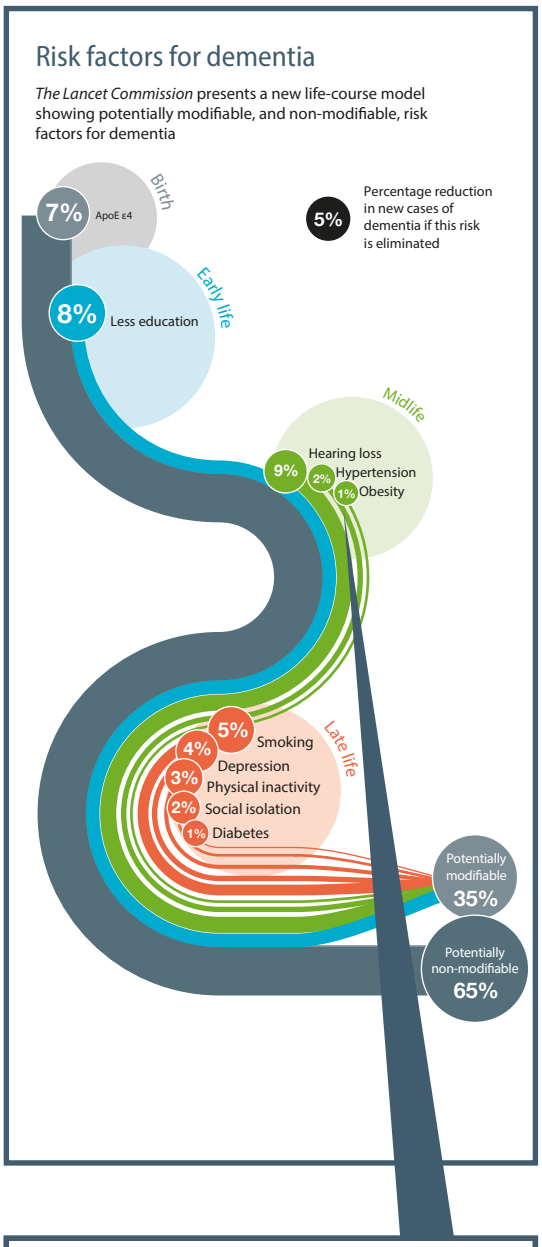
1 Some degree of cognitive decline (loss of thinking and memory abilities) can be normal as we age. When a cognitive impairment becomes severe enough to interfere with daily activities, a person is considered to have dementia. Multiple different risk factors and diseases can damage the brain and lead to cognitive decline and dementia over time.

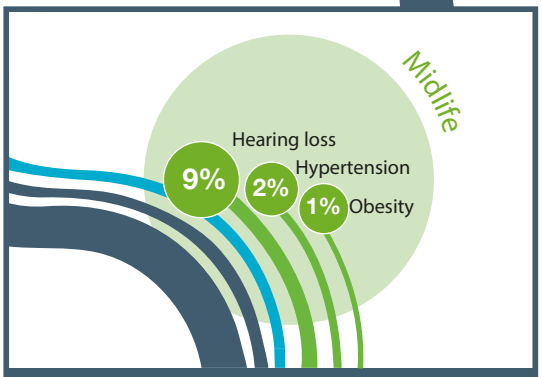
Links between hearing loss and cognition

Emerging evidence has provided new insights into hearing health as a key part of healthy ageing. Hearing loss impairs communication, has been linked to reduced social support from others and loneliness which, in turn, could increase health risks. More specifically, communication and social connectedness are critical to brain health, addressing dementia and maintaining cognition. Hearing well matters.

Focusing on hearing loss presents major opportunities for health systems to invest in healthy aging and for the public to take action about their hearing, particularly as they age.

- An analysis of studies found that age-related hearing loss is a potential risk factor for cognitive decline, cognitive impairment, and dementia. *(Loughrey et al 2018)* In other meta-analyses *(Ford et al 2018, Thomson et al 2017)* and in longitudinal studies, *(Davies et al 2017)* an increased risk of incident dementia was associated with hearing impairment.
- People with mild hearing loss are twice as likely to develop dementia as people without hearing loss, and the risk increases fivefold for people with severe hearing loss. *(Lin et al 2011, 2013)*
- Evidence from imaging studies showing that individuals with hearing impairment have higher rates of brain atrophy in the right temporal lobe and reductions in total brain volume, compared to individuals without hearing impairment. *(Lin et al 2014)*
- A large study among nearly 38,000 older Australian men found a 69% increased risk of dementia for those who report having a hearing loss compared to counterparts with normal hearing. *(Ford et al 2018)*
- In a matched cohort study using administrative claims data, hearing loss was significantly associated with an increased 10-year risk of dementia. *(Deal et al, 2019)*
- Over 60% of adults living with dementia will have also have a hearing impairment *(Nirmalasari et al 2017)* and over 90% of adults living with dementia in aged care will have a hearing impairment. *(Hopper et al 2016)*
- People who have dementia and hearing impairment have poorer functional ability *(Guthrie et al 2018)* and a more severe communication impairment *(Slaughter & Bankes 2007)* as compared to individuals who have dementia and no hearing impairment.





Source: Livingston et al 2017, The Lancet

The recent and globally-acclaimed "Lancet Study" *(Livingston et al 2017)* concluded that mid and late-life hearing loss may account for up to 9.1% of preventable dementia cases worldwide and is one of the most potentially modifiable risk factors for dementia.

Can addressing hearing loss help maintain cognitive function?

"Unaided, a person may often seem vague and uncommunicative whereas with the hearing aids they may be much more actively involved in a conversation. Therefore if someone is socially more stimulated their dementia can seem to be less severe."
(Audiologist quoted in Wright et al 2014)

Declines in hearing and cognitive functioning are both strongly associated with each other and with increasing age. Although the causal relationships between these two age-related declines are still unclear, we do know that optimal cognitive performance can depend on hearing well. For example, remembering information in noise is more difficult than in quiet. If a person with a hearing loss has to concentrate more to hear information then they may have more trouble remembering it than someone with normal hearing would have in the same situation. In the short-term, hearing loss can hamper memory and it is possible that prolonged hearing loss can exacerbate declines in cognition. It is also possible that a common factor causes declines in both cognition and hearing. *(Uchida et al 2018)*

More research needs to be undertaken; however, a growing body of evidence suggests that those with hearing loss who use hearing aids, cochlear and other hearing implants, may have a reduced risk of cognitive decline and other poor health outcomes than those who do not use hearing aids. However, because past studies have not been randomized control trials, it is difficult to know if those who self-selected to use hearing aids have other characteristics that may protect cognitive health. Ongoing research is investigating the possibility that hearing technology may be able to attenuate cognitive decline. Preliminary evidence comparing those who use to those who do not use hearing devices is promising.

- Self-reported hearing loss was associated with accelerated cognitive decline in elderly adults and the use of hearing aids and the consequential improvements in social connectedness , almost eliminates this cognitive decline. *(Amevia et al 2015, 2018)*
- A large scale study found that hearing loss had a negative association with cognition. However, this association was seen only in the individuals with who did not use hearing aids. Cognitive decline associated with ARHI may be preventable for older adults by early rehabilitation and increased opportunistic screening for the elderly. *(Ray et al 2018)*
- One longitudinal study found that hearing aids may have a mitigating effect on trajectories of cognitive decline in later life. *(Maharani et al 2018)*
- Another longitudinal study found "that HI may be a risk factor for cognitive decline in older adults and that hearing aid use could possibly reduce that risk." *(Deal et al 2015 p688)*
- While another large scale population study found that "Hearing aid use was associated with better cognition in a large cross-sectional study of UK adults." The association was independent of social isolation and depression. *(Dawes et al 2015, p7)*
- Hearing rehabilitation using cochlear implants in older adults was also associated with improvements in impaired cognitive functioning *(Mosnier et al 2015, 2018, Castiglione 2016 et al)* and improved cognitive performance. *(Volter et al 2018)*

Better hearing through the latest technology

Hearing technology has never been more sophisticated. Technologies include digital hearing aids, cochlear implants and bone-anchored implants, and many types of personal and public venue amplification systems, all of which deliver ever-better quality of sound. We also have new ways of supporting people remotely via the Internet, providing personalised care while saving families time and costs. *(Lamb et al 2017)* Ancillary audiological rehabilitation programs (including devices, counselling and cognitive therapy) are available to optimize the use of technology. *(Johnson et al 2016, Cox et al 2016)*

Increased acceptance of hearing technology

The increasing synergy between hearing technology means greater integration with other technologies such as mobile phones, headphones and speakers. This is radically changing the way people think about and use such technology, leading to easier and more confident adoption. In addition the current generation of those coming to older age are confident in using technology in everyday life and using the Internet, and are keen to take action to address quality of life as they age. More people are accepting hearings aids, using them for longer than before and valuing the benefit of better hearing. *(EHIMA 2016)* People fitted with a cochlear implant highly value the associated positive impact on social isolation, greater employability and general wellbeing. *(Ng et al 2016)*

There are also increasing numbers of interventions which support communication needs when combined with hearing technology: loop systems, personal listening devices which ensure greater access in public spaces and with family and friends. Audiological rehabilitation programs (including counselling and auditory cognitive therapy) can help mitigate the negative effects of hearing loss. *(Johnson, Xu & Cox 2016, Cox, Johnson & Xu 2016)*

Early adoption of hearing technology hearing can ensure continued ease of communication so as to prevent social isolation and increased risk of cognitive decline. Hearing loss may be misdiagnosed as dementia with damaging consequences for the individual. *(Weinstein 2013, et al 2016)* The best possible hearing can support independence for longer and healthy living into older age.

Addressing hearing loss earlier, including putting in place adult hearing screening, is a challenge, and an opportunity, for the whole of the public health and care system as our ageing population grows. *(Lamb et al 2016)*

The costs of not addressing hearing loss and dementia

Not addressing hearing loss has very significant costs to society associated with additional health and social care. *(Huddle et al 2017, Lamb et al 2016, O'Neil et al 2016, Mick et al 2018, Reed et al 2019, Shield 2019)* Hearing impairment is generally associated with increased use of primary and secondary healthcare services in European counties, whereas those with the best take up of hearing instruments have the lowest relative additional costs. *(Xiao & O'Neill 2018, Reed et al 2019)* Investing in prevention, early support for individuals, increasing hearing accessibility in the community, and changing social attitudes towards hearing loss is a much more cost-effective solution than dealing with the consequences of unaddressed hearing loss. *(Archbold et al 2015)* It is only by investing early in developing new approaches to living well with hearing loss that we can fully realise the gains in terms of increased independence, better health and cognition while taking the strain off other public services provided by hospitals, *(Mahmoudi et al 2018)* doctors, and social care. *(O'Neil et al 2016, Xiao & O'Neill 2018, Crealey & O'Neill 2018)* We also know that money invested in hearing care gives a 1:10 return in savings on health, social care and other costs. *(Decal/AoHL 2013, Archbold et al 2015, Kervasdoue 2016)* A recent study of the cost benefit ratios of using Hearing Aids to reduce the symptoms of dementia found that the total benefits, mainly coming from the direct benefits, were extremely large relative to the costs, with benefit-cost ratios over 30. *(Brent 2018)* It is estimated that a 1-year delay in dementia for individuals would lead to a 10% reduction in prevalence by 2050. *(Brookmeyer et al 2007, Pichora-Fuller et al 2015)* Thus, if we can mitigate the onset or effects of dementia through addressing hearing loss this could make a large impact on reducing the overall costs associated with dementia and the burden on caregivers.

The cost of the additional costs associated with hearing loss in the UK: £30bn per year
(Archbold et al 2015)

As we learn more about the connection between hearing loss and dementia and cognitive decline, we also have abundant evidence relating hearing loss treatment to improved communication, reduced social isolation and increased independence and activity. Since good hearing supports cognition, hearing loss treatment (amplification) may also have a preventative aspect in respect of dementia.

However there is a lack of understanding of how to screen for hearing loss and dementia in older adults with complex needs. *(Guthrie et al 2018)* There is no standard screening process for dementia or cognitive ability in current audiology practice. *(Ladduwahetty et al 2013)* Moreover, there are few inter-professional teams linking specialists in cognition, hearing and gerontology. Audiologists have little experience or training in assessing or managing the hearing of those with dementia or cognitive decline. *(Wright et al 2014)* Conversely, other health professionals dealing with the older population have little experience of understanding or managing hearing loss. We need a greater understanding that good hearing helps people stay connected, reduces loneliness and supports health and wellbeing. *(Kricos 2009, Pichora-fuller et al 2013, Beck et al 2018, Weinstein B 2013).*

National health strategies need to reflect the huge gains in health and the financial savings that can be potentially achieved, by promoting good hearing health and the benefits which follow.

Recommendations

Actions for Government

- Each country needs to develop a specific National Action Plan on Hearing Loss, linked to other national strategies e.g, age-friendly community initiatives, improved accessibility for disabled people and dementia strategies. *(DoH & NHSE 2015)*
- Public health campaigns on preserving hearing and taking early action to address hearing loss are needed to promote healthy ageing. *(Wilson et al 2017)*

National Screening programmes for hearing loss

- National screening programmes for adult hearing loss, improving early access to hearing aids and implants. *(Lamb & Archbold, WHO 2016)*
- Screening programmes need to be sensitive to the association between hearing loss, dementia and cognitive decline. *(Weinstein 2013, Weinstein et al 2016)*
- Targeted screening programmes for those receiving home care or living in residential homes. *(DeCAL/AoHL 2013, Lamb & Archbold 2016, Ray et al 2018)*

Training

- Training for health and social care professionals in identifying and manging hearing loss for those with or at the risk of dementia. *(Cox et al 2016, Weinstein et al 2016, Speech-Language & Audiology Canada 2018)*
- An enhanced role for the Audiology and hearing professionals in inter-professional teams involved in the diagnosis and management of dementia and cognitive decline. *(Beck et al 2018, Weinstein 2018)*
- Supporting personal advocacy in the ongoing management of hearing loss for adults living with dementia.

Managing hearing loss well in later life improves communication and independence, and reduces loneliness, social isolation and may help to alleviate cognitive decline. The challenge for health systems, commissioners and professionals working in hearing loss is to support healthy aging by ensuring good hearing health. Investments in early intervention and early provision of hearing aids and implants will not only improve quality of life for older people, but will also save health systems additional medical and social care costs in the future.

References

Amieva H, Ouvrard C, Giulioli C, Meillon C, Rullier L and Dartigues, J.F 2015. Self-Reported Hearing Loss, Hearing Aids, and Cognitive Decline in Elderly Adults: A 25-Year Study. Journal of the American Geriatrics Society, 63(10), p.2099

Amieva H, Ouvrard C, Meillon C, Rullier L, Dartigues JF (2018). Death, Depression, Disability and Dementia Associated with Self-Reported Hearing Problems: a 25-Year Study.J Gerontol A Biol Sci Med Sci. 2018 Jan 3. doi: 10.1093/gerona/glx250. [Epub ahead of print]

Archbold S, Lamb OBE B, O'Neill C, Atkins J (2015). The Real Cost of Adult Hearing Loss: reducing its impact by increasing access to the latest hearing technologies. Ear Foundation http://www.earfoundation.org.uk/research/adult-strategy-reports

Beard J R, Officer A, Carvalho I, MD, Sadana R et al (2016). The World report on ageing and health: a policy framework for healthy ageing. Lancet. 2016 May 21; 387(10033): 2145–2154. Published online 2015 Oct 29. doi: 10.1016/S0140-6736(15)00516-4

Beck D L, Weinstein B E, Harvey M A. Dementia Screening: A Role for Audiologists. Audiology & Neuroscience. July 2018 Hearing Review

Brent, Robert, J (2019). A cost–benefit analysis of hearing aids, including the benefits of reducing the symptoms of dementia, Applied Economics, DOI: 10.1080/00036846.2018.1564123

Brookmeyer R, Johnson E, Ziegler-Graham K, Arrighi HM. Forecasting the global burden of Alzheimer's disease. Alzheimers Dement 2007; 3(3):186–191

Castiglione A, Benatti A, Velardita C, Favaro D, Padoan E, Severi D et al (2016). Aging, cognitive decline and hearing loss: effects of auditory rehabilitation and training with hearing aids and cochlear implants on cognitive function and depression among older adults. Audiol. Neurootol. 21(Suppl. 1), 21–28

Crealey, Grainne E. O'Neill, Ciaran (2018). Hearing loss, mental well-being and healthcare use: results from the Health Survey for England (HSE). Journal of Public Health | pp. 1–13 | doi:10.1093/pubmed/fdy209

Cox R, Johnson J & Xu J (2016). Impact of hearing aid technology on outcomes in daily life I: The Patients' Perspective. Ear and Hearing, 37(4), 224-37

Dawes P, Emsley R, Cruickshanks KJ, Moore DR, Fortnum H, Edmondson-Jones M et al (2015). Hearing Loss and Cognition: The Role of Hearing Aids, Social Isolation and Depression. PLoS ONE 10(3): e0119616. doi:10.1371/journal.pone.0119616

Davies HR, Cadar D, Herbert A, Orrell M, Steptoe A. Hearing impairment and incident dementia: findings from the English longitudinal study of ageing. J Am Geriatr Soc. 2017;65(9):2074–2081

DCAL and Action on Hearing Loss (2013). Joining Up: Why people with hearing loss or deafness would benefit from an integrated response to long-term conditions. Available from: www.actiononhearingloss.org.uk/

Deal JA, Reed NS, Kravetz AD et al. Incident Hearing Loss and Comorbidity: A Longitudinal Administrative Claims Study. JAMA Otolaryngol Head Neck Surg. 2019;145(1):36–43. doi:10.1001/jamaoto.2018.2876

Deal J.A, Sharrett A R, Albert M S, Coresh J, Mosley T H, Knopman D, Wruck L M and Lin F R (2015). Hearing impairment and cognitive decline: a pilot study conducted within the atherosclerosis risk in communities neurocognitive study. American journal of epidemiology, 181 (9) pp. 680-690

Department of Health & National Health Service England (2015). Action Plan on Hearing Loss https://www.england.nhs.uk/wp-content/uploads/2015/03/act-plan-hearing-loss-upd.pdf

EHIMA (2016). Getting our numbers right on Hearing Loss. Hearing Care and Hearing Aid Use in Europe

Ford AH, Hankey GJ, Yeap BB, Golledge J, Flicker L, Almeida OP. Hearing loss and the risk of dementia in later life. Maturitas. 2018 Jun;112:1-11. doi:10.1016/j.maturitas.2018.03.004. Epub 2018 Mar 13

GBD 2015 Disease and Injury Incidence and Prevalence Collaborators (2016). Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet, 388 (10053), 1545–602

Gurgel R K, Ward P D, Schwartz S, Norton M C, Foster N L and Tschanz J T (2014). Relationship of hearing loss and dementia: a prospective, population-based study. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology, 35(5), p.775

Guthrie DM, Davidson JGS, Williams N, Campos J, Hunter K, Mick P et al (2018). Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: Analysis of interRAI data for home care and long-term care recipients in Ontario. PLoS ONE 13(2): e0192971. https://doi.org/10.1371/journal.pone.0192971

Hopper T, Slaughter S E, Hodgetts B, Ostevik A, & Ickert C (2016). Hearing Loss and Cognitive-Communication Test Performance of Long-Term Care Residents With Dementia: Effects of Amplification. Journal of Speech, Language, and Hearing Research, 59(6), 1533-1542. doi:10.1044/2016_JSLHR-H-15-0135

References continued:

Huddle, Matthew G, Goman, Adele M, Kernizan, Faradia C, Foley Danielle M, Price Carrie, Frick Kevin D, Frank Lin, R. The Economic Impact of Adult Hearing Loss A Systematic Review. JAMA Otolaryngology–Head & Neck Surgery Published online August 10, 2017

Jaydip Ray, Gurleen Popli, Greg Fell, Association of Cognition and Age-Related Hearing Impairment in the English Longitudinal Study of Ageing. JAMA Otolaryngol Head Neck Surg. 2018;144(10):876-882. doi:10.1001/jamaoto.2018.1656

Johnson J, Xu J, Cox R (2016). Impact of Hearing Aid Technology on Outcomes in Daily Life II: Speech. Understanding and Listening Effort. Ear and Hearing, 37(5), 529-40

Kervasdoue J (2016). Economic Impact of Hearing Loss in France and Developed Countries. A survey of academic literature 2005-2015. https://www.ehima.com/wp-content/uploads/2016/05/FinalReportHearingLossV5.pdf

Kingston A, Comas-Herrera A Jagger (2018). Forecasting the care needs of the older population in England over the next 20 years: estimates from the Population Ageing and Care Simulation (PACSim) modelling study. Lancet Public Health volume 3, issue 9, pe447-e455, September 01, 2018

Kricos P.B (2009). Providing hearing rehabilitation to people with dementia presents unique challenges. The Hearing Journal, 62(11), pp.39-40. Available from http://journals.lww.com/thehearingjournal/

Ladduwahetty S, Dowell R C and Winton E (2013). Dementia and cochlear implant outcomes: can we screen for dementia effectively using the mini mental state examination in implant candidates? Australian and New Zealand Journal of Audiology, Vol. 33 No. 1, pp. 88-102

Lamb B, Archbold S (2016). Adult Hearing Screening: Can we afford to wait any longer? Ear Foundation. http://www.earfoundation.org.uk/research/adult-strategy-reports

Lamb B, Archbold S, O'Neill C (2015). Bending the Spend: Expanding access to hearing technology to improve health, wellbeing and save public money. Ear Foundation

Lamb B, Archbold S, O'Neil C (2017). Spend to save: Investing in hearing technology improves lives and saves society money. A Europe Wide Strategy. Ear Foundation. http://www.earfoundation.org.uk/research/adult-strategy-reports

Lin, F R & Albert M (2014). Hearing loss and dementia - who is listening? Aging & mental health, 18(6), 671-3

Lin F R, Metter E, O'Brien R J, Resnick S M, Zonderman A B, Ferrucci L (2011). Hearing Loss and Incident Dementia. Arch Neurol. 68 (2) pp. 214-2 2011. Available from http://hearingpro.com.au/wp-content/uploads/2016/08/Research-Hearing-loss-and-incident-dementia-2011-1.pdf

Lin F R, Yaffe K, Xia J, Xue Q L, Harris, T B Purchase-Helzner, E et al (2013). Hearing loss and cognitive decline in older adults. JAMA Internal Medicine. 173 (4) pp.293-299. Available from http://jamanetwork.com/journals/jamainternalmedicine/fullarticle/1558452

Lin FR, Ferrucci L, An Y, Doshi J, Metter E, Davatzikos C (2014). Association of hearing impairment with brain volume changes in older adults. Neuroimage;15(90):84

Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D et al. Dementia prevention, intervention, and care. The Lancet. 2017. https://doi.org/10.1016/s0140-6736(17)31363-6

Loughrey DG, Kelly ME, Kelley GA, Brennan S, Lawlor BA (2018). Association of Age-Related Hearing Loss With Cognitive Function, Cognitive Impairment, and Dementia: A Systematic Review and Meta-analysis. JAMA Otolaryngol Head Neck Surg. 2018 Feb 1; 144(2):115-126

Maharani A, Dawes P et al (2018). Longitudinal Relationship Between Hearing Aid Use and Cognitive Function in Older Americans. Journal of the American Geriatric Society. 10 April 2018 https://doi.org/10.1111/jgs.15363

Mahmoudi E, Zazove P et al (2018). Association Between Hearing Aid Use and Health Care Use and Cost Among Older Adults With Hearing Loss. JAMA Otolaryngol Head Neck Surg. Published online April 26, 2018. doi:10.1001/jamaoto.2018.0273

Mick P, Foley D, Lin F, Pichora-Fuller, M. K. Hearing Difficulty Is Associated With Injuries Requiring Medical Care Ear & Hearing 2018;39;631–644

Mosnier I, Bebear J P, Marx M et al (2015). Improvement of cognitive function after cochlear implantation in elderly patients.JAMA Otolaryngol Head Neck Surg. 2015;141(5):442-450

Mosnier I et al (2018). Long-Term Cognitive Prognosis of Profoundly Deaf Older Adults After Hearing Rehabilitation Using Cochlear Implants: Cognitive prognosis after hearing rehabilitation.Journal of the American Geriatrics Society · August 2018

Nirmalasari O, Mamo S K, Nieman C L, Simpson, A, Zimmerman J, Nowrangi M A, Oh E S (2017). Age-related hearing loss in older adults with cognitive impairment. Int Psychogeriatr, 29(1), 115-121. doi:10.1017/s1041610216001459

Ng ZN, Lamb B, Harrigan S, Archbold S, Athalye S & Allen S (2016). Perspectives of adults with cochlear implants on current CI services and daily life, Cochlear Implants International, 17:sup1, 89-93

O'Neill C, Lamb B and Archbold S (2016). Cost implications for changing candidacy or access to service within a publicly funded healthcare system? Cochlear implants international, 17(sup1), pp. 31-35

Pichora-Fuller K M, Dupuis K, Reed M and Lemke U (2013). Helping Older People with Cognitive Decline Communicate: Hearing Aids as Part of a Broader Rehabilitation Approach. Seminars in Hearing (Vol. 34, No. 4, pp. 308-330)

Pichora-Fuller M, Mick P, Reed M (2015). Hearing, Cognition, and Healthy Aging: Social and Public Health Implications of the Links between Age-Related Declines in Hearing and Cognition. Semin Hear 2015; 36(03): 122-139

Ray J, Popli G, Fell G (2018). Association of Cognition and Age-Related Hearing Impairment in the English Longitudinal Study of Ageing. JAMA Otolaryngol Head Neck Surg. 2018;144(10):876-882. doi:10.1001/jamaoto.2018.1656

Reed NS, Altan A, Deal JA, et al. Trends in Health Care Costs and Utilization Associated With Untreated Hearing Loss Over 10 Years. JAMA Otolaryngol Head Neck Surg. 2019;145(1):27–34. doi:10.1001/jamaoto.2018.2875

Shield, B. (2019). Hearing Loss – Numbers and Costs Evaluation of the Social and Economic Costs of Hearing Impairment. A report for Hear-It AISBL

Speech-Language & Audiology Canada (SAC): Submission to the Public Health Agency of Canada to Inform the National Dementia Strategy May 4, 2018

Slaughter S E & Bankes J (2007). The Functional Transitions Model: Maximizing ability in the context of progressive disability associated with Alzheimer's disease. Canadian Journal on Aging, 26(1), 39-47. doi:10.3138/Q62V-1558-4653-P0HX

Thomson RS, Auduong P, Miller AT, Gurgel RK (2017). Hearing loss as a risk factor for dementia: a systematic review. Laryngoscope Investig Otolaryngol. ;2(2):69–79

Uchida Y, Sugiura S, Nishita Y, Saji N, Sone M, Ueda H (2018). Age-related hearing loss and cognitive decline — The potential mechanisms linking the two. Auris Nasus Larynx online

Völter C, Götze L, Dazert S, Falkenstein M, Jan Thomas P (2018). Can cochlear implantation improve, neurocognition in the aging population? Clinical Interventions in Aging 2018:13 701–712

Weinstein B (2013). Geriatric Audiology, Chap 3 P.62 Psychosocial Changes with Ageing, Thieme, Publishers.NY

Weinstein B E, Sirow L W, Moser S (2016). Relating hearing aid use to social and emotional loneliness in older adults. American Journal of Audiology, 25:54-61

Weinstein, B.E. (2018) A Primer on Dementia and Hearing Loss. Perspectives of the ASHA Special Interest Groups Article 1.

Wilson B, Tucci D, Merson M, O'Donoghue G (2017). Global hearing health care: new findings and perspectives. The Lancet. Published online July 10, 2017 http://dx.doi.org/10.1016/S0140-6736(17)31073-5 7

World Alzheimer Report (2016). Improving healthcare for people living with dementia: Coverage, quality and costs now and in the future. Available: https://www.alz.co.uk/research/WorldAlzheimerReport2016.pdf

World Health Organization (2016a). Global costs of Unaddressed Hearing loss and Cost-effectiveness Of interventions.www.int/pbd/deafness

World Health Organisation (2016b). Development of a new Health Assembly resolution and action plan for prevention of deafness and hearing loss.www.int/pbd/deafness

Wright N, Stickley T, Mulla I, Bradshaw E, Buckley L and Archbold S (2014). Hearing loss and dementia: an exploratory study of the views of audiologists. Quality in ageing and older adults journal vol. 15 no. 4 2014, pp. 220-231

Xiao, M & O'Neill, C (2018). A comparative examination of healthcare use related to hearing impairment in Europe. Global & Regional Health Technology, Assessment,2018, Vol. 2018: 1–22

Acknowledgements:

Many thanks to a number of reviewers who informed our understanding. The work was supported by an educational grant from Cochlear.

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