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The value of British Sign Language

An economic analysis

Marco Hafner, Daniel Lee, Katie Sykes and Erez Yerushalmi

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Preface

The objective of this study is to assess the broader socio-economic value of access to British Sign Language (BSL) for deaf children and their families, alongside other interventions to address hearing loss commonly applied in the UK, such as cochlear implants. The report's findings directly contribute to the evidence base in deaf studies and economic value assessments of hearing-loss interventions more broadly. They should be of interest to policymakers and decision makers in health, labour-market and sign-language policies.

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Marco Hafner (mhafner@rand.org)

Eastbrook
Shaftesbury Road
Cambridge
CB2 8BF
United Kingdom

Executive summary

S.1. Introduction

Over 430 million people worldwide, including 34 million children, live with disabling hearing loss. Individuals who are deaf or hard of hearing face persistent barriers to education, employment and social participation, which are associated with lower qualifications and higher risks of economic marginalisation.

In the United Kingdom (UK), each year around 1 to 2 children out of 1,000 are born deaf, with the majority to hearing parents with limited prior experience of deafness. Early screening ensures that most are identified within weeks of birth, and families are offered the choice of different interventions, including access to hearing technologies (such as hearing aids or cochlear implants), speech and language therapy, and sign-language support. Consistent and accessible exposure to a language, whether spoken or signed, is critical for early childhood development between birth and the age of five. Hearing technologies, such as cochlear implants or hearing aids, are generally regarded as cost-effective interventions in supporting children with severe to profound hearing loss and improving their auditory access to spoken language. There are, however, challenges associated with these technologies, particularly adherence and technology failures that can lead to their inadequate use. Therefore, while hearing technologies can provide auditory access to spoken language, they do not guarantee successful language development, especially in the absence of speech therapy and family involvement. This poses a risk for early language deprivation, which can have long-term adverse cognitive, social and emotional impacts for the child.

British Sign Language (BSL) provides a complementary or alternative pathway to early language acquisition for deaf children. The British Sign Language Act 2022 formally recognised BSL as a language of the UK. Despite its legal recognition and potential to provide comprehensive linguistic input for deaf children from the early years onwards, especially when spoken language access is incomplete or delayed, uptake remains low. For example, based on school-reported figures, only about 9 per cent of severely to profoundly deaf children in the UK use BSL in education. Parents of deaf children are often encouraged to prioritise spoken language over sign language, while frequently lacking information or guidance on the full range of options available to support their child’s linguistic, cognitive and social development. From an economic perspective, like the acquisition of a spoken language, early sign-language acquisition can be viewed as an investment in human capital. For example, an economic analysis of the benefits of Auslan (Australian Sign Language) suggests that sign language can generate measurable economic returns through better educational attainment, increased labour-market participation, and health and well-being improvements. Such evidence positions early BSL access as an alternative or complement to technological interventions, highlighting its ability to expose deaf children early to a first language and thereby reduce the risk of adverse early childhood development outcomes.

S.2. Objectives and approach

This study examines and quantifies the potential costs and benefits of providing early access to BSL for deaf children as an alternative or complement to the predominant access to hearing technologies and spoken-language pathway. The analysis focuses on early childhood (birth to age five), a critical period for language acquisition, and assesses whether early BSL acquisition can generate measurable improvements in health, employment and quality-of-life outcomes over the lifetime of children born with permanent severe to profound hearing loss.

To address these objectives, the study combined a targeted literature review with economic modelling. The review of the existing literature on the role of sign language in the development of human capital across domains such as early childhood development, education, employment and health informed the economic model. The economic model simulates and tracks a cohort of deaf children over their lifetime to estimate the long-term costs and benefits of early BSL access. The quantified benefits include: (i) improvements in quality of life; (ii) improved employment outcomes (higher probability of being in employment, higher productivity); and (iii) reduced healthcare expenditures for long-term health conditions associated with early language deprivation (diabetes, cardiovascular disease, depression and anxiety). These benefits are then compared against the costs of: (i) early-years BSL acquisition in a sign-supporting family environment; and (ii) employment support for those with improved employment outcomes.

The analysis assesses the economic value of early access to BSL by comparing the cumulative lifetime costs and benefits under two distinct scenarios. Scenario 1 evaluates early BSL acquisition relative to a counterfactual in which children have no access to either BSL or hearing technologies. This scenario estimates the economic return of early BSL acquisition in cases where it represents a stand-alone intervention supporting early language acquisition, without any other interventions (e.g. where BSL is the individual's primary and preferred mode of communication). Scenario 2 models early BSL acquisition as a complementary intervention delivered alongside hearing technologies. This scenario assumes universal acquisition of early BSL across the cohort of deaf children, but restricts the benefits to those who either (i) use BSL as their primary and preferred mode of communication, or (ii) belong to the subgroup of hearing-technology users who remain at risk of insufficient early language exposure. In this case, early BSL acquisition is assumed to mitigate the risk of language deprivation among deaf children in the economic model who, despite access to hearing technologies, may experience inadequate auditory or linguistic input.

For each scenario, the model estimates the cumulative lifetime benefits of early BSL acquisition and compares these with the associated costs. Results are reported for two different time horizons (80 years and 50 years). A primary outcome metric is the Benefit–Cost Ratio (BCR), which represents the economic return per £1 invested in early-years BSL acquisition. To reflect uncertainty around model inputs, main results are presented for three sets of parameter combinations: (i) a base case using central input values; (ii) a pessimistic case assuming higher costs and lower benefits; and (iii) an optimistic case assuming lower costs and higher benefits.

S.3. Strengths and limitations

This study provides new estimates of the potential economic returns associated with early-years BSL acquisition using the available evidence in the literature to inform the economic model. Several limitations should be considered, however, when interpreting this study's findings. First, many key economic model input parameters are derived from cross-sectional or retrospective studies that rely on self-reported data and lack causal identification, including estimates of the relative risks of adverse health outcomes associated with early language deprivation and employment outcomes linked to sign-language proficiency. The absence of longitudinal data directly linking early sign-language exposure to long-term socio-economic outcomes limits the strength of causal inference. Second, because of limited UK-specific evidence, several input parameters, particularly health risks and employment effects, were drawn from US-based studies and applied to the UK context. Differences in healthcare access, education systems, labour-market structures and disability legislation between the two countries may affect the direction and magnitude of the effects. While these uncertainties are to some extent addressed through sensitivity analyses, they remain an inherent limitation that can be addressed in the future if more UK-specific evidence becomes available. Third, the economic model follows a representative group of deaf children over their lifetime, assuming uniform transitions between different life stages such as employment or retirement. This model simplification abstracts from individual heterogeneity and dynamic movements over time, as individuals differ in their behaviour and decision making. Fourth, the economic model tracks cumulative benefits and costs over the long-term but assumes that other factors or trends, such as technological change, are constant. That is, the model inherently assumes that technological change or policy changes will not impact model inputs such as costs and benefits over time. Fifth, a further limitation concerns the valuation of quality-of-life benefits. Like existing studies, this analysis quantifies outcomes using Disability-Adjusted Life Years, but a more appropriate and broader well-being valuation approach (e.g. Wellbeing-Adjusted Life Years) could not be applied because existing data sources do not reliably identify sign language users, limiting the ability to capture wider effects on identity, inclusion, and social participation associated with sign language. Finally, the economic analysis excludes several potential benefits that could not be robustly quantified, including improvements in healthcare access, educational attainment, social participation and parental well-being, among others. These exclusions of potential benefits likely result in a conservative estimate of the total benefits associated with early acquisition of BSL.

S.4. Key findings

The findings of this study suggest that early acquisition of a sign language such as BSL can be considered a human-capital investment that could yield positive economic returns.

For Scenario 1, the base-case analysis estimates a BCR of 2.34, indicating that early-years BSL acquisition yields approximately £2.34 in benefits for every £1 invested over an 80-year time horizon. When the time horizon is shortened to 50 years, the corresponding BCR declines modestly to 2.04. Under pessimistic assumptions, the BCRs are 0.51 (80 years) and 0.44 (50 years), implying that even in a highly conservative case roughly half of the economic investment would be recouped over the lifetime horizon. Conversely, under optimistic assumptions, the estimated BCRs increase to 16.5 (80 years) and 14.84 (50 years). The wide range between these pessimistic and optimistic assumptions highlights the inherent uncertainty surrounding the input parameters used in the economic analysis. The midpoints between these pessimistic and optimistic ranges suggest a potential return of about £7–£8 per £1 invested. These values exceed the base-case estimates, indicating that these may represent a conservative approximation of the true economic return in contexts where early-years BSL provision can be delivered more cost-effectively or where its benefits are more fully realised.

For Scenario 2, in which universal early acquisition of BSL among all deaf children is modelled as an insurance mechanism against the risk of early language deprivation, the estimated economic returns depend on the assumed size of the at-risk subgroup, namely those for whom hearing technologies alone may not provide sufficient auditory access for language development. Existing evidence suggests that this group could comprise up to approximately 30 per cent of deaf children, depending on the technology used and the specific context. In the base-case analysis, the estimated BCR increases from 0.78 (80-year horizon) and 0.64 (50-year horizon), when no children are assumed to be at risk, to 1.30 (80 years) and 1.11 (50 years) when 30 per cent are assumed to be at risk. The break-even threshold, where benefits equal costs (BCR = 1), occurs when approximately 15–20 per cent of deaf children at risk are assumed to benefit directly from early BSL acquisition. Under pessimistic assumptions, BCRs range from 0.21 (0 per cent at risk) to 0.31 (30 per cent at risk) for the 80-year horizon, and from 0.17 to 0.26 for the 50-year horizon. Under optimistic assumptions, BCRs range from 3.34 to 7.05 (80 years) and from 2.84 to 5.52 (50 years). Taken together, the results suggest that universal early acquisition of BSL, when implemented as a complement to hearing technologies, could yield positive economic returns, particularly in contexts where a substantial proportion of children remain at risk of incomplete language acquisition despite technological support.

S.5. Considerations

Based on these findings, the study offers the following three recommendations for policy and future research.

First, ensure early access to BSL for deaf children. Hearing parents of deaf children are often guided towards oral and technology-based approaches without receiving complete information about sign-language options. Ensuring that all families can make informed decisions is essential. Normalising access to BSL from infancy could help prevent language delays and mitigate the risk of language deprivation when hearing technologies are insufficient or inconsistently used. The findings from this economic analysis suggest that such early access to BSL is likely to represent value for money.

Second, invest in research on BSL outcomes. Dedicated research funding is needed to address key evidence gaps concerning the long-term effects of early BSL exposure. Many of the benefits identified in this study, ranging from improved educational attainment to enhanced well-being and employment outcomes, are based on limited or cross-sectional data. The UK currently lacks longitudinal and causal studies capable of isolating the specific effects of BSL exposure from other contributing factors. Strengthening this evidence base would enable more confident assessment of the societal returns to BSL investment and support more efficient policy design.

Third, integrate BSL into data-collection efforts. At present, few UK data sources consistently record BSL use. The Census remains one of the only instruments to do so; however, these data are collected only once a decade and cannot capture all the potential dynamic pathways or barriers faced by BSL users. To gain a better understanding of the economic situation of deaf BSL users, major surveys and administrative datasets, such as the Labour Force Survey, could improve the inclusion and identification of BSL users to enable longitudinal tracking and outcome analysis. Improving data availability would facilitate better research and policy monitoring going forward.

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Abbreviations

ACER	Average Cost-Effectiveness Ratio
ASL	American Sign Language
AtW	Access to Work
BCR	Benefit–Cost Ratio
BSL	British Sign Language
CGE	Computable general equilibrium
CI	Cochlear implant
CRIDE	Consortium for Research into Deaf Education
CVD	Cardiovascular disease
DALY	Disability-Adjusted Life Year
DHH	Deaf or hard of hearing

ACE	Adverse Childhood Experience
DoD	‘Deaf of deaf’ (referring to a deaf individual with deaf parents)
DoH	‘Deaf of hearing’ (referring to a deaf individual with hearing parents)
DW	Disability weight
GBD	Global Burden of Disease
GDP	Gross domestic product
ICER	Incremental Cost-Effectiveness Ratio
NHS	National Health Service
NHSP	Newborn Hearing Screening Programme
NICE	National Institute for Health and Care Excellence
NPV	Net present value
QALY	Quality-Adjusted Life Year
RR	Relative risk
SAM	Social Accounting Matrix
SEND	Special educational needs and disability
ToD	Teacher of the Deaf
WELLBY	Wellbeing-Adjusted Life Year
YLD	Years lived with disability
YLL	Years of life lost

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The authors, of course, assume full responsibility for the study's findings.

Chapter 1. **Introduction**

1.1. Deafness: from medical impairment to cultural-linguistic identity

Deafness and hearing loss are often referred to as ‘invisible disabilities’ because they are not immediately apparent unless an individual wears visible hearing aids or uses sign language (Davis 2005; Shohet & Bent 1998). Despite this invisibility, hearing loss is a very prevalent impairment. Globally, over 5 per cent of the population, or 430 million people worldwide, suffer from disabling hearing loss, including 34 million children (WHO 2025). Individuals who are deaf or hard of hearing (DHH) often face significant risks of economic and social marginalisation due to structural and institutional barriers. For example, studies have consistently shown that deaf individuals tend to leave school with fewer qualifications, have lower rates of further education, and are more likely to experience workplace discrimination (Luft 2015; Winn 2007). A recent comprehensive economic analysis estimates the total global costs of hearing loss at $981 billion (McDaid, Park & Chadha 2021).

While many health impairments are generally associated with debates about what is the appropriate terminology, the case of deafness or hearing loss is unique, given the relative importance of linguistic differences between spoken and signed languages (Ladd 1991; Padden & Humphries 1988; Padden 1989). Far from being merely a descriptive term, the words ‘deaf’ or ‘hearing loss’ encompass a range of identities. Thus, to be ‘deaf’ or ‘hard of hearing’ does not imply a singular fixed identity. The medical model views hearing loss as an impairment that requires medical or technological intervention, such as cochlear implants or hearing aids (Denmark 1994; Sacks 1990). The social model, in contrast, views deafness as a form of disability created by societal barriers rather than a medical deficiency (Conama 2004). Meanwhile, the cultural-linguistic model emphasises the linguistic and cultural identity of the deaf community, where deaf individuals are those who use sign language and identify with a distinct cultural group (Conama 2004). Individuals who use sign language and socialise with other sign-language users often identify themselves as ‘Deaf’, where the capital ‘D’ represents the community identification as a cultural and linguistic minority. While many deaf individuals identify with one or more of these models, policies and legal frameworks often classify them under the broader category of disability, without acknowledging their unique cultural and linguistic identities. This is important as individuals in the Deaf community generally do not consider themselves as hearing impaired, but as part of a cultural-linguistic minority group with a unique language and cultural values. In the context of a diverse society, establishing frameworks that recognise and support linguistic and cultural identities is crucial as language plays a fundamental role in individual well-being and identity formation, as well as social and economic integration (Grenier 2021).

1.2. Early intervention and language development: the UK context

Approximately 1 or 2 per 1,000 children are born with permanent hearing loss each year (Rashbrook & Perkins 2019). Children born deaf in the United Kingdom (UK) follow life pathways that are shaped by medical, educational and policy frameworks that influence their access to communication, inclusion and long-term outcomes. About 90 per cent of deaf children are born to hearing parents, meaning most families with deaf children have no prior experience of deafness and must quickly navigate a complex system of decisions concerning communication, education and support services (Young & Tattersall 2007).

Universal newborn hearing screening ensures that most deaf children are identified within the first few weeks of life. The National Health Service (NHS) Newborn Hearing Screening Programme, introduced in the early 2000s, with full coverage in England and Wales by 2006, screens over 98 per cent of children and can effectively identify those with permanent hearing loss shortly after birth (Wood, Sutton & Davis 2015). Following diagnosis, families are guided towards different interventions and approaches, including hearing aids, cochlear implants, speech and language therapy, and sign-language support, but not all of these are universal services available to all families.

The National Institute for Health and Care Excellence (NICE) recommends bilateral cochlear implantation for children with severe-to-profound hearing loss who do not receive sufficient benefits from hearing aids with regards to speech, language and listening skills development (NICE 2019).[1] According to these recommendations, children with severe-to-profound deafness should trial first with fitted acoustic hearing aids before being assessed further for cochlear implantation eligibility. Cochlear implants (CIs) can provide oral linguistic exposure to children during a crucial period of language acquisition, with an emphasis on developing speech and spoken language through technology-enabled residual or restored hearing (Nicholas & Geers 2018). In 2024, more than 6,000 children in the UK had at least one cochlear implant (Cullington 2024). While these hearing technologies are regarded as a cost-effective intervention in helping children with severe and profound hearing loss, there are challenges in terms of inconsistent or limited device use or technology failure (Borre et al. 2021). Furthermore, cochlear implants are relatively resource intensive as they involve surgery, device hardware and post-implantation therapy. While hearing aids and cochlear implants can provide auditory access to spoken language, they do not guarantee successful language development, especially in the absence of intensive speech and language therapy and committed family involvement (Swanwick & Gregory 2007).

Simultaneously, families may be introduced to British Sign Language (BSL) and bimodal bilingualism, where both spoken English and BSL are used to support language acquisition and development. The British Sign Language Act 2022 has granted BSL legal recognition across the UK, requiring public bodies to accommodate the use of BSL in their services, although implementation is still in its early stages (UK Public General Acts 2024). The Special Educational

1 NICE applies the following definition of severe-to-profound deafness for its guidance: hearing only sounds louder than 80 decibels Hearing Level at two or more frequencies (500 Hz, 1,000 Hz, 2,000 Hz, 3,000 Hz and 4,000 Hz) bilaterally without acoustic hearing aids.

Needs and Disability (SEND) Code of Practice emphasises the role of early intervention programmes, which often include sign-language instruction to support language development from a young age (UK Government 2024). Uptake of BSL is, however, relatively low. Based on school-reported data, about 9 per cent of children with severe-to-profound deafness use BSL in education, whereas about 26 per cent use signed support with spoken English. In comparison, about 49 per cent of children with severe-to-profound deafness are estimated to have at least one CI (CRIDE 2023b). Parents of deaf children are often encouraged to prioritise oral language development approaches over sign language, while generally not being fully aware of or receiving no general advice on the range of choices available to them in supporting their deaf child's linguistic and social development (Young et al. 2006). Prior to school, deaf children have several options for acquiring BSL, although access can vary based on location and available resources. Families may access BSL through community programmes, local deaf organisations or private tutors (National Deaf Children's Society 2020), but generally these interventions are not publicly funded, unlike, for example, the provision of hearing aids and CIs to support spoken-language development. Independent of whether a child has access to hearing technologies such as CIs, however, existing evidence suggests that early exposure to sign language can have a positive influence on cognitive development and educational success. Deaf children exposed to sign language from an early age can exhibit advantages in language acquisition, educational achievements and lifelong learning outcomes (Schick et al. 2007; Cummins 2007; Humphries et al. 2014). Despite these opportunities, barriers such as limited availability of programmes in certain areas and the cost of private instruction can affect the availability, access, consistency and quality of early-years BSL exposure for deaf children (Swanwick & Marschark 2010).

1.3. The socio-economic value of sign language

Existing economic evaluations consistently find that existing interventions to address hearing loss, such as hearing technologies or educational and communication approaches (e.g. sign language and rehabilitation services), are cost-effective, meaning they deliver health and social benefits at a 'socially acceptable' level of resource cost (Emmett et al. 2015; Tordrup et al. 2022). Specifically, hearing technologies have been found to have the ability to improve the quality of life for recipients, whether children or adults, who would otherwise experience a significant level of hearing loss (Borre et al. 2021; Tordrup et al. 2022). While technological devices have received considerable attention in existing economic evaluations, hearing-loss interventions that focus on facilitating communication through sign language or educational accessibility measures are relatively scarce. Some studies have shown that investments in specialised education for deaf children, particularly when incorporating sign-language instruction, can be economically justified through improved long-term outcomes in literacy, educational attainment and labour-market participation (Saunders et al. 2015; Emmett et al. 2015).

From an economic perspective, providing access to sign language through early exposure for deaf children and their families can be regarded as an intervention that supports human-capital formation. 'Human capital' can broadly be defined as the stock of skills, knowledge, health and abilities embodied in individuals and is considered a central determinant of economic growth and productivity (Becker 1964; Goldin 2024). It encompasses not only formal education and training but also the cognitive and communicative capacities that allow individuals to participate effectively in social and economic interactions more broadly. While sign language is sometimes marginalised in discussions of interventions addressing hearing loss, recent research has begun to quantify the economic value of sign language. For example, a study estimated the economic benefits of Auslan (Australian Sign Language) at AUD 380 million per year, which corresponds to an average monetised benefit of more than AUD 12,000 per deaf individual per year (D'Rosario & Dawson 2022). The monetised benefits of sign language encompass various channels of value, including improved health literacy, enhanced educational attainment, better labour-market participation and improved well-being and health benefits. Indeed, there is some evidence that sign-language fluency is associated with improved academic performance and literacy in deaf children, even when controlling for factors such as the use of hearing aids or parental hearing status (Hall 2017; Humphries et al. 2014). The timing of language exposure is a critical factor, however, as acquiring any language (signed or spoken) early in life is key for cognitive and social-emotional development (Friedmann & Rusou 2015). Thus, from a human-capital perspective, early exposure to sign language for deaf children could act as insurance for language development, ensuring that in the early years the child does not miss the window for acquiring crucial language skills, independent of hearing-technology use. Therefore, investments in sign-language provision – in the UK context, BSL – could address some of the challenges associated with hearing loss that technology alone cannot solve.

1.4. Research objectives and approach

The objective of this study is to assess the potential costs and benefits of providing early access to BSL for children born with permanent severe-to-profound hearing loss. From a human-capital-development perspective, the analysis aims to better understand the potential value of BSL over the lifetime of an individual, with an emphasis on whether sign-language acquisition in early childhood is associated with quantifiable benefits, and if so, whether these benefits outweigh the costs of investing in early-years BSL acquisition. The emphasis is on the critical period of cognitive development between birth and age five, as the inability to acquire a first language (whether signed or spoken) in these early years can be associated with long-term adverse outcomes.

To address these objectives, the study employs two research methodologies:

- First, a targeted non-systematic literature review of peer-reviewed academic as well as publicly available grey literature, including policy reports. The focus of the literature review is on the potential areas where sign language supports human-capital development for deaf individuals, such as early childhood development, education, employment, quality of life and healthcare access.
- Second, an economic model to quantify the costs and benefits associated with early access to BSL. Drawing on parameter inputs identified in the literature review, the model simulates and tracks a cohort of deaf children over their lifetime to estimate the potential economic returns of early sign-language acquisition by comparing the long-term costs and benefits. The quantified benefits include: (i) improvements in quality of life (value of living a year with good life quality); (ii) improved employment outcomes (higher probability of being in employment, higher productivity); and (iii) reduced healthcare expenditures for long-term health conditions associated with early language deprivation (diabetes, cardiovascular disease, depression and anxiety). These benefits are then compared against: (i) the costs of early-years BSL

acquisition in a sign-supporting family environment; and (ii) employment support for those with improved employment outcomes.

1.5. Structure of this report

Chapter 2 reports on the findings of the targeted literature review across the different domains in which sign language supports human-capital development, including early childhood development, education, employment and health. It also discusses the potential cultural value of BSL more broadly. Chapter 3 outlines the methodology of the economic analysis and Chapter 4 reports the findings of the economic analysis. Chapter 4 concludes and provides policy recommendations.

Chapter 2. **The role of sign language in human-capital development – a review of the evidence**

The economic literature considers language as an integral component of human capital, enabling individuals to participate in economic, social and political life. Economic interactions, whether in markets, workplaces or educational institutions, are predicated on the ability to process, interpret and communicate information and instructions (Ginsburgh & Weber 2020). Language proficiency supports the accumulation of skills and knowledge. Furthermore, languages can foster the development of cultural capital, generating positive externalities that are increasingly valuable in globalised economies by supporting cultural understanding, social cohesion and the exchange of knowledge across diverse groups (Bleakley & Chin 2010; Throsby 1999). Within this framework, sign languages occupy a distinctive position. While often framed narrowly as a compensatory tool for hearing loss, sign languages also represent a unique linguistic system that contributes to the cognitive development, cultural identity and economic participation of Deaf communities (Emmorey 2001). Sign languages can help to reduce the risk of language deprivation in deaf children and thereby prevent long-term adverse effects in human-capital formation (Hall, Hall & Caselli 2019).

This chapter presents the findings of a targeted literature review aimed at identifying areas where sign language can support human-capital development for deaf individuals over the course of their life, including:

- Early childhood development
- Education
- Employment
- Health and well-being

Beyond considerations of human capital, the chapter also briefly discusses the ability of sign language, specifically BSL, to foster cultural capital.

2.1. Early childhood development

Access to language, whether spoken or signed, during the first few years of life is critical for optimal linguistic and cognitive development. Research has consistently emphasised the significance of language exposure during the 'critical period' for language acquisition, which lays the groundwork for long-term educational, social and economic outcomes (Humphries et al. 2024; Mayberry & Kluender 2018). Children with inadequate exposure to language during early childhood are at risk of 'language deprivation', a term used to describe a set of neurodevelopmental challenges characterised by language dysfluency, deficits in general knowledge, and mood disorders (Hall 2017).

Deaf children experience large heterogeneity in relation to their early access to a first language. Residual hearing or early intervention through hearing aids or CIs enables some deaf children to access spoken language in ways comparable to their typically hearing peers. Deaf children born to deaf parents (often referred to as DoD, 'deaf of deaf') who use a sign language, such as BSL, have access to a fully developed language from an early age and therefore can acquire language at a similar age to typically hearing children. These children may also obtain a spoken or written language, such as English, as they grow. Evidence suggests that their linguistic development can align with that of typically hearing bilingual children (Goodwin & Lillo-Martin 2023; Wilkinson & Morford 2020).

In contrast, deaf children of hearing parents (DoH, 'deaf of hearing') frequently face a more limited language exposure. This is primarily because their parents' or caregivers' spoken language may be inaccessible to them, and it is uncommon for these children to have access to a signed language from birth. As a result, their early linguistic environment often lacks the richness necessary for optimal language development, which may contribute to disparities in educational and social outcomes. Studies comparing the linguistic proficiency of DoD and DoH children consistently show that DoH children lag behind their DoD peers in both sign-language ability and broader linguistic skills (Morere & Allen 2024; Henner et al. 2016).

Beyond proficiency, late exposure to language is also linked to delays in reading development, which may have broader implications for educational attainment and workforce readiness. Children whose first language is a signed language often learn to read in their second language (e.g. English), making some delay in reading development expected (Goodwin & Lillo-Martin 2023). Research has shown, however, that DoH children tend to develop reading skills more slowly than DoD children (Novogrodsky et al. 2014; Clark et al. 2016) and that the relationship between delayed exposure to language (typically experienced by DoH children, but not DoD children) and adverse linguistic outcomes potentially persists into adulthood. For instance, delays in acquiring a first (signed) language have been shown to impact syntax comprehension (Hauser, Aristodemo & Donati 2023; Mayberry et al. 2024; Cheng & Mayberry 2021), sign recognition and phonological processing (Caselli, Emmorey & Cohen-Goldberg 2021), and grammatical judgement (Boudreault & Mayberry 2006). Late exposure also appears to influence brain structure in regions critical for language processing (Cheng et al. 2019; Cheng et al. 2023). Furthermore, late acquisition of a first (signed) language might also be associated with reduced proficiency in a second (spoken/written) language. For example, Mayberry and Lock (2003) found that adults who acquired a first (signed) language late in life performed significantly worse on grammar tests in their second language (English) compared to adults who learned sign language early, the latter achieving near-native proficiency.

Furthermore, for many deaf children, especially in the UK, cochlear implantation is recommended as a means of enhancing deaf children's access to sound, improving speech perception and facilitating oral communication. There remains considerable debate, however, regarding the role of sign language in the development of spoken language for children with CIs. Specifically, researchers disagree on whether exposure to sign language supports or hinders speech outcomes. The evidence base on this issue is highly inconsistent, with methodological limitations such as small sample sizes and inadequate control of confounders complicating efforts to draw firm conclusions. Some studies suggest a positive association between sign-language exposure and early childhood development outcomes for those with CIs. Delcenserie et al.

(2024), for example, administered French-language and memory tests to 40 children from Quebec, including 30 deaf children with CIs and varying levels of sign-language exposure. Their findings indicate that even short-term exposure to sign language has a positive effect on general language, phonological memory and non-verbal working memory, with total exposure duration being the strongest predictor of performance. Conversely, other studies suggest that the use of sign language may be associated with poorer spoken language outcomes for deaf children with CIs. Geers et al. (2017), for instance, followed 97 DoH children with CIs through elementary school and found that over 70 per cent of children with no sign-language exposure achieved age-appropriate spoken-language skills, compared to only 39 per cent of children exposed to sign language for more than three years. Others, such as Hall et al. (2019), have highlighted limitations in this research, noting that it establishes correlation rather than causation. Children with better access to spoken language may gravitate towards speech-dominant environments, while those struggling with speech rely more on sign language. Given the contradictory findings, it remains uncertain whether sign-language use promotes or hinders spoken-language development in children with CIs. A systematic review by Fitzpatrick et al. (2016) similarly concluded that the evidence base is insufficient to determine whether combining sign language with spoken language is more effective than focusing solely on spoken language. While marginally higher-quality studies have emerged since 2016 (Delcenserie, Genesee & Champoux 2024; Geers et al. 2017), methodological weaknesses continue to limit the reliability of the conclusions. As the outcomes of cochlear implantation are variable across deaf children and not entirely predictable (Atılgan, Kalcioglu & Gubbels 2024), Kermit (2010) advocates for the application of the ‘precautionary principle’ by providing all deaf children with access to sign language to guard against the worst-case scenario of language deprivation in cases where cochlear implantation fails to provide sufficient access to speech.

In summary, early access to language, whether spoken or signed, is crucial for mitigating the risks associated with language deprivation and promoting positive outcomes in children who are deaf. These findings highlight the critical importance of early language exposure for deaf children in mitigating long-term disparities. Delayed language acquisition has implications for literacy, cognitive development and workforce readiness, all of which may impact societal costs and economic productivity. This emphasises the need to prioritise early intervention programmes and resource allocation to support language development in deaf children, particularly those at risk of delayed or inadequate exposure, to reduce disparities and improve outcomes across the lifespan. The precautionary approach prioritises early sign-language access as a protective measure even for deaf children with access to hearing technologies, ensuring they have a foundation for linguistic and cognitive development regardless of the success of access to spoken language. Until more robust longitudinal data and high-quality research become available, this strategy may represent the most effective way to mitigate risks and optimise outcomes for deaf children.

2.2 Education

In the UK, the educational landscape for deaf children is predominantly characterised by integration into mainstream schools. According to data from the Consortium for Research into Deaf Education (CRIDE) in 2023, approximately 78 per cent of school-aged deaf children are enrolled in mainstream schools without specialised provision, while an additional 6 per cent attend mainstream schools with specialist units (CRIDE 2023a). Only 3 per cent of deaf students attend schools specifically designed for them. This distribution reflects national policy priorities that emphasise inclusive education, as mandated by legislation such as the Equality Act 2010 and the SEND Code of Practice, which advocates for the education of children with disabilities in mainstream environments whenever feasible (UK Government 2024; CRIDE 2023a). Furthermore, CRIDE reports that within the UK, deaf children are distributed across different age groups as follows: 12 per cent are in the early years or preschool (3–5 years old); 38 per cent are of primary-school age (5–11 years old); 36 per cent are of secondary-school age (11–16 years old); and 13 per cent fall into the post-16 but under-20 category (CRIDE 2023a). This shows an even distribution across the school years, highlighting the sustained need for tailored resources and support throughout a deaf child's educational journey. Despite the push for inclusion, challenges persist in ensuring that deaf children receive equitable access to education and achieve outcomes comparable to those of their hearing peers. To address these challenges, schools often employ a range of support mechanisms, including the use of BSL interpreters, assistive listening technologies such as hearing aids and specialist teaching staff trained in deaf education. The availability and quality of these resources vary significantly across the country, however, leading to disparities in educational experiences and outcomes for deaf children (CRIDE 2023a).

The CRIDE report (2023a) sheds light on language use and the prevalence of CIs among deaf students in the UK. In 2023, 9 per cent of deaf children had CIs, with approximately 48 per cent of children with profound or severe deafness using them. The report also highlights the distribution of signed communication methods in educational settings, revealing varying levels of sign-language use among children with severe or profound deafness:[2]

- Spoken language with signed support: 25%
- Spoken language with sign language or signed support: 34%
- Sign language: 9%

These statistics highlight the diverse linguistic and technological profiles of deaf students in the UK and underscore the importance of tailoring educational approaches to meet their needs. While CIs and spoken language dominate educational settings, the relatively small proportion of students using sign language suggests that its potential benefits may be under-utilised. For children with severe or profound deafness, the higher reliance on signed support and sign language demonstrates the critical role of visual communication methods in facilitating access to education.

The academic outcomes for deaf individuals in the UK exhibit variability across educational stages. In primary education, studies have evaluated the reading and mathematics performance of nearly 1,000 deaf children, yet gaps remain in understanding the precise academic impact (Tymms et al. 2003). As deaf students progress to secondary education, disparities become more pronounced, with examination results and mathematics assessments consistently revealing lower scores compared to their hearing peers. Research has shown that background factors significantly contribute to the variance in exam results, underscoring the impact of external conditions on academic performance (Powers & Thoutenhoofd 1999). Performance

2 The statistics from Table 17 within the CRIDE report (2023a) reflects a sub-group of children with severe or profound deafness using sign language in the UK, and therefore does not add up to 100%.

data for English examinations highlight significant educational challenges for deaf children, with attainment gaps compared to their hearing peers that widen as they progress through the stages of education. In 2019, the attainment gap for deaf children at Key Stage 1, assessed at age 7, was equivalent to 8.8 months of learning. By Key Stage 2, evaluated at the age of 11, this gap had grown to 12.0 months, and by Key Stage 4, assessed at the age of 16, the gap had expanded further to 17.5 months. At the GCSE level, this gap was expressed as an average difference of 1.3 grades per subject in English and mathematics (Hutchinson 2023). These widening gaps highlight the mounting challenges deaf students face as they navigate a curriculum that demands greater cognitive and linguistic complexity. Previous studies confirmed similar gaps, demonstrating that the mathematical abilities of deaf students lag by an estimated 2 to 3.5 years compared to those of hearing school-leavers, indicating decrements in performance (Swanwick, Oddy & Roper 2005).

Upon completing secondary education, a notable proportion of deaf school-leavers pursue further education, with approximately 56 per cent enrolling in college-level courses and around 17 per cent advancing to university studies. Research conducted in the UK highlights, however, that deaf learners are more likely to leave school at 16 and attend further education colleges, where they often engage in part-time courses and experience higher drop-out rates compared to their hearing peers (Young et al. 2015). In tertiary and further education, outcomes are more nuanced. For example, an existing study examining distance learning among deaf university students suggests that completion rates are comparable to those of hearing students, with similar pass rates and slightly higher rates of achieving good grades (Richardson et al. 2010). This suggests that in supportive academic environments, deaf students can achieve outcomes comparable to their hearing peers. Contrasting findings, however, indicate that many deaf students leave further education settings without a recognised qualification, and drop-out rates surpass those of the general population (Young et al. 2015).

The potential of sign language to enhance educational outcomes for deaf students, particularly at the secondary level, has been a topic of considerable debate and research. Studies in the US context have explored this relationship, with some research indicating no association or a slight negative association between sign-language use and academic performance at secondary and college levels (Convertino et al. 2009; Crowe et al. 2017; Marschark et al. 2015). These findings may not fully capture the nuanced benefits of sign language in educational settings, and highlight the complexity of assessing its impact on academic achievement. Research from Australia provides evidence of the benefits of sign language for school and collegiate completion, where deaf children exposed to natural sign languages in culturally and linguistically deaf environments acquire native competence, gaining the advantages of early language acquisition. This linguistic foundation is crucial for educational success and facilitates second-language acquisition (D’Rosario & Dawson 2022). Moreover, studies on language development and theory of mind in deaf children demonstrate that proficiency in sign language enhances cognitive skills related to understanding and attributing mental states (Schick et al. 2007). This cognitive benefit is crucial for academic success, as it fosters better communication, social interaction and problem-solving abilities. Further research considering the US context supports the notion that proficiency in a signed language, such as American Sign Language (ASL), can have a positive impact on English academic development. Strong ASL skills provide a foundation for literacy and academic achievement in English, suggesting that similar benefits could extend to BSL users in the UK context (Cummins 2007).

In the UK context, the role of Teachers of the Deaf (ToDs) remains critical in the education of deaf children. ToDs provide specialised support to deaf students and their families, as well as guidance to mainstream teachers on how to adapt their teaching methods to meet the needs of deaf learners. According to CRIDE, there has been a decline in the number of qualified ToDs in the UK, with mandatory qualifications in 2023 falling by 23 per cent since 2011 and specialist staff other than ToDs seeing a 7 per cent reduction between 2022 and 2023, raising concerns about the sustainability of educational support for deaf children (CRIDE 2023a). Furthermore, according to CRIDE, in 2023 9 per cent of teaching assistants and communication support workers employed by local authority services had no formal BSL qualification, while 56 per cent had either Level 1 or Level 2 BSL qualifications, which cover only basic themes of communication and therefore offer limited communication support and participation in teaching activities. A further 23 per cent had Level 3 BSL qualifications, which cover more social and professional interactions and are considered the minimum to provide teaching support, while only 13 per cent had Level 4 BSL and above or were first-language users, offering advanced communication and enabling adequate support for deaf students. This shows that while there is some BSL support within educational settings in the UK, this is typically limited to lower-level qualifications, which may restrict the depth and quality of communication support available to deaf students. The lack of higher-level BSL qualifications among the majority of teaching assistants and communication support workers suggests that many educational services may struggle to meet the complex communication needs of deaf learners, potentially impacting students' inclusion, academic achievement (due to an inability to communicate complex concepts) and overall educational experience. This highlights the need for increased investment in BSL training and professional development to ensure that support staff are equipped to provide meaningful and practical assistance to deaf students.

Furthermore, services that provide support for career advice and transitioning into employment demonstrate varied levels of engagement among deaf young people in the UK (CRIDE 2023a). While 69 per cent of services engage with careers advisors in schools and 47 per cent engage with careers advisors in colleges, support is more prominent in areas related to workplace accessibility and rights. Specifically, 66 per cent of services offer advice on the accessibility of work placements, 80 per cent provide information about the Access to Work scheme for employment support, and 78 per cent deliver guidance on reasonable adjustments under equality legislation. These statistics suggest that services are more focused on equipping deaf young people for workplace inclusion than on providing comprehensive career advice within educational settings, while also highlighting gaps in the provision of post-16 support available for deaf students seeking to transition into employment or further education.

In summary, the UK education system and its support for deaf children, specifically for those who use BSL as their preferred mode of communication, is a complex and often unequal landscape. Despite the general policy commitment to inclusion, attainment gaps persist at every stage of education, widening significantly in secondary school. Some evidence suggests that these disparities are linked to inconsistent communication support and a lack of BSL-proficient staff which can hinder language acquisition, social development and academic engagement. Studies that link hearing-technology adoption or sign-language exposure in childhood with longer-term educational outcomes within a sample of deaf children do not exist. Therefore, it is currently not possible to identify the causal factors that result in deaf children in the UK education system underperforming relative to their hearing peers, or whether early childhood risk factors such as delays or insufficient language development play a role.

2.3 Employment

Deaf individuals have historically faced significant challenges in the labour market. A body of literature covering different countries suggests that deaf individuals experience lower employment rates, higher unemployment rates, and earnings gaps compared to their hearing counterparts (Willoughby 2011; Winn 2007). In the UK, only about 63 per cent of deaf or hard-of-hearing working-age adults are employed, compared to 75 per cent of the general population (DWP 2023a). Focusing specifically on sign-language users, some existing data suggests even starker employment disparities, with only 37 per cent of people who report BSL as their primary language being in employment (RNID 2023). Such figures align broadly with international findings. In the United States, for example, an analysis based on census data reports that approximately 53 per cent of deaf individuals were employed, compared to 76 per cent of hearing individuals (Garberoglio et al. 2019).

As applies for the general hearing population too, existing evidence suggests that education may play a significant role in influencing employment outcomes for deaf individuals, and that access to sign language in education is closely tied to later employment. A US study analysing the outcomes of young deaf adults found that those with more years of post-secondary education had substantially better employment rates and greater career mobility than those with only high-school qualifications or less. Importantly, even deaf individuals who did not complete their college programme had better job outcomes than those who never enrolled (Palmer et al. 2020). These findings suggest that any post-secondary education may provide an advantage in the labour market for deaf people. It is essential, however, to consider the types of education or training that best support deaf people's employment, and to acknowledge that gaps in employment between deaf individuals and their hearing peers persist. Evidence from Sweden shows that deaf adults have lower employment rates than hearing adults despite a formally equivalent educational system, highlighting an enduring employment disadvantage even when access to education for deaf individuals is at similar levels as for the hearing population (Rydberg, Gellerstedt & Danermark 2010). Consistent findings are reported from Denmark's labour market, where deaf individuals, independent of whether they are signers or not, face lower employment probabilities than the general population. Specific factors, such as levels of educational attainment, absence of additional disabilities, or earlier age of hearing loss identification, can, however, moderate these outcomes (Dammeyer et al. 2019).

For deaf individuals using sign language, employment outcomes are also intimately linked to educational trajectories. For many deaf children, especially those born deaf or with early profound hearing loss, access to a natural sign language in early childhood can support language development and academic achievement. Research in deaf education has shown that deaf children who acquire sign language from an early age tend to have stronger literacy and educational outcomes than those who are denied access to an accessible language model (Humphries et al. 2022). Among deaf sign-language users, sign-language proficiency is likely associated with better employment outcomes. For example, evidence from the United States and Denmark suggests that better sign-language proficiency may be correlated with a higher likelihood of being employed (Dammeyer et al. 2019). The findings by Dammeyer et al. (2019) suggest that among a sample of relatively well-educated deaf adults with higher levels of educational attainment than a more representative deaf population in the United States, those with better sign-language skills, independent of the use of hearing technologies, were more likely to be employed. This indicates that sign-language proficiency can be a positive predictor of employment, but due to the cross-sectional nature of the survey data, the study does not enable more insights into the different channels via which sign-language skills drive employment outcomes. On the one hand, deaf individuals fluent in sign language likely possess stronger overall language skills and potentially have better access to deaf networks and resources that can aid in job-seeking. Moreover, better sign-language skills likely are a predictor of better educational outcomes, which subsequently lead to better employment outcomes, all else equal. In the Danish sample of the same study (Dammeyer et al. 2019), deaf signers who were diagnosed with hearing loss earlier, and within the Danish system for that generation likely had access to language and language support earlier, reported higher odds of being in employment by the time they were surveyed. Overall, this evidence suggests that while deaf signers as a group face disadvantages, the presence of sign language in a deaf person's life, especially if introduced early, is not inherently a barrier to employment but could be an enabler for full language development, better access to education and better educational attainment, all of which are critical for career success.

Whether an individual is in employment or not is only one dimension of labour-market outcomes. Levels of income and job quality are other important indicators. The existing evidence suggests that deaf individuals likely earn less on average than their hearing peers. A US study quantified the lifetime earnings deficit experienced by deaf workers in the United States, demonstrating that, on average, a deaf person earns between $356,000 and $609,000 less over their lifetime than a hearing person with the same level of education (Luft 2000). The lifetime earnings differential is explained by lower salaries, a higher risk of underemployment or unemployment, and fewer promotions over a deaf individual's career (Dong, Meros & Seenath 2023).

Similarly to employment outcomes, evidence from the US suggests that education may mitigate adverse earning outcomes, as the wage gap between deaf and hearing workers is most prominent among those with lower levels of education and narrows for those with higher levels of education (Punch 2016), whereas the earnings gap for deaf college graduates and their hearing counterparts is smaller than for deaf individuals without a college degree (Walter & Dirmyer 2013). The remaining earnings gap may be due to factors beyond educational attainment, such as communication difficulties and limited networking opportunities. For example, when a deaf employee cannot communicate fluently with supervisors or clients due to a lack of accommodations, they may be passed over for higher-paying positions or find themselves stuck in roles below their skill level (Luft 2000). Underemployment is a recurring theme in qualitative accounts of deaf workers. Many deaf individuals feel they are working in jobs beneath their skill or education level, or are not given responsibilities commensurate with their abilities. A few existing studies have documented such occupational mismatches, where deaf employees have higher education or training than their job requires, often because they could not secure a job that fully uses their qualifications (Punch 2016; Barnes 2017). Some of the earnings disparity might also be explained by occupational selection. If, for example, deaf graduates are channelled into public-sector or non-profit-sector jobs, an earnings difference will persist as these sectors tend to pay lower salaries on average. Deaf and hard-of-hearing people cluster in certain occupations and are underrepresented in others, reflecting both personal choices and structural constraints. Deaf workers often find employment in sectors or roles that minimise communication demands with the public, including skilled trades, manufacturing, manual labour or back-office roles (Shield 2019; Winn 2007). While the income gap between deaf and hearing individuals persists, some US evidence suggests that the gap might be closing, with median annual earnings for full-time deaf workers being close to those of full-time hearing workers in 2017 (Garberoglio et al. 2019).

In summary, evidence consistently indicates that employment disparities persist between deaf and hearing individuals. Studies also suggest, however, that early access to sign language, a strong educational foundation and inclusive workplace environments are associated with improved employment outcomes. Sign-language proficiency – particularly when acquired early in life – appears to support higher educational attainment, which in turn enhances employability. Nonetheless, most existing studies rely on qualitative data or cross-sectional analyses that preclude causal interpretation. More rigorous, longitudinal research is needed to identify the specific pathways via which sign-language exposure and proficiency influence labour-market outcomes, including employment probabilities and earnings trajectories for deaf individuals.

2.4 Health and well-being

Deaf individuals often experience health inequalities in comparison to the hearing population and face numerous health challenges that contribute to poorer overall health outcomes. For example, obesity rates among deaf populations are disproportionately high, compared to a lower proportion in the hearing population (Emond et al. 2015; Barnett et al. 2011). Cardiovascular disease and hypertension also present significant health risks, and deaf individuals are more likely to have high blood pressure than hearing individuals (Emond et al. 2015). Deaf cancer patients are more likely to be diagnosed at later stages than hearing patients, resulting in worse outcomes (Druel et al. 2018). Moreover, there is evidence that health disparities between deaf and hearing populations could already be determined in the early years. For example, Kushalnagar et al. (2020) argue that for deaf children, the inability to communicate effectively with family members and wider society constitutes an adverse childhood experience (ACE) with potentially long-term health consequences, including higher risks of chronic health conditions such as diabetes, cardiovascular disease or depression.

Access to healthcare remains a significant barrier for the deaf population, leading to delayed treatment and increased rates of suicide and suicidal ideation (Emond et al. 2015; Barnett et al. 2011; Rogers et al. 2024). Beyond direct health outcomes, several social determinants have a significant impact on the well-being of deaf individuals. Education levels play a crucial role in shaping health outcomes, and individuals who are deaf with higher educational attainment report better psychological well-being and a lower risk of cardiovascular disease compared to those with lower educational levels (Peñacoba et al. 2020; McKee et al. 2014). Employment and income disparities also contribute to health inequities, and unemployed deaf individuals report lower well-being scores compared to those who are employed (Rogers, Ferguson-Coleman & Young 2018; Wahlqvist et al. 2016).

Equally, to the broader population affected by hearing loss, deaf individuals who use sign language experience substantial health disparities compared to the general population. Healthcare systems often fail to provide adequate linguistic and culturally appropriate services for this population. The consequences are significant: poor health literacy, limited access to preventive healthcare, and disparities in both physical and mental health outcomes (Rogers et al. 2024). For example, recent evidence from the NHS suggests that approximately two-thirds of surveyed deaf or hard-of-hearing individuals indicated that they missed a substantial portion of key information during medical consultations, while only about one in three reported satisfaction with the communication skills of NHS staff (Parmar et al. 2025). Parmar et al. (2025) further found that deaf or hard-of-hearing individuals depend on relatives to facilitate communication with healthcare professionals, raising issues of confidentiality and informed consent. The study highlighted that communication challenges occur throughout the healthcare pathway, from appointment scheduling to the communication of test results. Routine procedures, such as being called from the waiting area or receiving instructions during diagnostic imaging, are experienced as stressful in the absence of appropriate communication adjustment. This leads to frequent miscommunication, misdiagnosis and lower patient satisfaction (Emond et al. 2015; Fellinger et al. 2005). Written communication is not always a viable alternative, as literacy levels among deaf individuals can vary significantly due to educational barriers (McKee et al. 2014). Health literacy disparities exacerbate these challenges even further. Deaf signing individuals may have more limited access to mainstream health education, which is typically disseminated through spoken and written language. Studies indicate that deaf people have lower health literacy rates than hearing populations, which can contribute to poorer self-care and health-seeking behaviours (Kushalnagar et al. 2020). As a result, a deaf individual may delay seeking medical attention until their condition becomes severe (Margellos-Anast, Estarziau & Kaufman 2006). Delayed diagnoses and treatment also result from these communication challenges, particularly for situations that require patient-reported symptoms, such as cancer or mental health disorders. The lack of accessible diagnostic tools in sign language means that deaf individuals are often underdiagnosed or misdiagnosed (Druel et al. 2018). The prevalence of mental health issues among deaf signing populations is significantly higher than in hearing populations. Studies included in the review found that depression and anxiety rates are consistently elevated in deaf adults, with nearly a quarter of deaf adults reporting being diagnosed with depression or anxiety, a higher proportion than that observed in hearing adults (Kushalnagar et al. 2019; Kvam, Loeb & Tambs 2007). Suicidal ideation and attempts are also reported at disproportionately high rates, with the prevalence of suicide attempts among deaf individuals over five times higher than that of their hearing counterparts (Barnett et al. 2017). Psychological well-being scores among deaf individuals also tend to be lower than those found in the general population, and deaf individuals experience significantly higher levels of emotional distress, emphasising the need for accessible mental health services that consider the linguistic needs of the deaf community (Peñacoba et al. 2020; Fellinger et al. 2005).

In summary, current evidence indicates that deaf individuals, including those who primarily communicate through sign language, experience higher risks of mental health disorders and chronic conditions such as cardiovascular disease, as well as delays in cancer diagnosis. These disparities are commonly linked to persistent communication barriers, lower health literacy and limited access to linguistically and culturally appropriate healthcare services. Some studies also suggest that health problems emerging later in life may be associated with early adverse experiences, including language deprivation and communication difficulties during childhood. The existing literature is, however, constrained by methodological limitations. For example, studies rely on retrospective or cross-sectional data, which restricts the ability to draw causal inferences about the relationship between early language exposure and subsequent health outcomes.

2.5. The cultural value of British Sign Language

For many deaf people, acquiring and using BSL is closely linked to the formation of a positive identity. Deaf communities are therefore understood as linguistic and cultural minorities rather than disability groups, with Deafness representing membership in a community that perceives and interacts with the world primarily through visual means and shares a common language and social bonds (Ladd 2005).

Language and culture are deeply intertwined, and BSL serves as the principal medium that unites the British Deaf community. Deaf communities exemplify ‘communities of practice’, bound by shared language use and lived experience (Kristoffersen & Simonsen 2016). In the UK, the Deaf community has a long history of collective organisation, including Deaf clubs and sports associations, all conducted in BSL. These institutions have provided inclusive environments that are often unavailable in wider society, enabling full access to communication, information and social participation through sign language. During the 20th century, particularly in the aftermath of the 1880 Milan Conference, which prohibited the use of sign language in schools, local Deaf clubs became essential cultural spaces (Park 2025). Within these venues, BSL survived and flourished through artistic exchange, storytelling and conversation, allowing Deaf individuals to maintain their language, heritage and identity. In recent times, this sense of community has extended into digital and online spaces, further strengthening social networks among Deaf individuals.

Rather than viewing deafness as a deficit to be corrected, Deaf studies reconceptualise it as a positive dimension of identity that contributes to both individual and societal enrichment. Bauman and Murray (2010) describe this idea as ‘Deaf Gain’, emphasising the unique cognitive, cultural and creative contributions of deaf people and sign languages to human and cultural diversity. From this perspective, BSL is not merely a communication tool for a ‘disabled group’, but a medium that preserves and expands human heritage, stimulates social innovation and fosters cultural values and resilient communities. Deafness represents a distinct way of experiencing and interpreting the world, offering insights that differ from those of most hearing individuals. For example, deaf people often demonstrate enhanced spatial and facial recognition and peripheral visual processing skills. The influence of these perceptual differences is evident beyond the Deaf community. For instance, ‘Deaf space’ design principles, favouring open sight lines and well-lit environments, have informed architectural and technological innovations that benefit broader society (Bauman & Murray 2014).

Culturally, the concept of Deaf Gain highlights the ways in which Deaf arts, narratives and traditions enrich the wider national cultural landscape. BSL serves as the medium through which a distinct cultural heritage is transmitted, with stories and folklore passed across generations forming the collective memory of British Deaf history (BDA.org.uk 2015). BSL poetry and storytelling create visual forms of artistic expression unparalleled in spoken-word traditions, broadening the scope of human creativity. The increasing presence of BSL in British arts and media exemplifies this contribution. For example, the BBC’s long-running programme ***See Hear***, produced by and for Deaf audiences, has been broadcast for over three decades. Conducted primarily in BSL, the programme evolved from basic interpreted content to original productions addressing issues relevant to Deaf viewers (Kelly 2006). It has also helped reshape public perceptions of deafness, from a condition requiring correction to a distinct and valuable cultural identity, while attracting audiences beyond the Deaf community (Kelly 2006). Similarly, Deaf-led theatre companies producing bilingual performances in BSL and English bring Deaf actors and narratives to broader audiences, fostering inclusion and mutual understanding (Kelly 2006; Park 2025). By engaging with sign-language arts, hearing audiences gain access to new forms of aesthetic and cultural experience. Ultimately, the concept of Deaf Gain positions BSL as a cultural asset that represents a source of creativity, identity and human diversity.

2.6. Discussion

The evidence reviewed indicates that sign language can function as a component of human-capital formation across a deaf individual's lifespan. Early access to a first language, whether signed or spoken, supports linguistic and cognitive development and lowers the risk of language deprivation, whereas delayed exposure is associated with persistent deficits in literacy and language processing. In education, most deaf children, specifically in the UK, are educated in mainstream settings where communication support and BSL proficiency among staff are uneven, and attainment gaps widen through secondary school. In the labour market, deaf adults experience lower employment and earnings on average, with better educational attainment and stronger language skills associated with improved outcomes. Sign proficiency appears complementary to these pathways rather than a barrier. Health evidence points to higher prevalence of mental ill-health and some chronic conditions, with communication barriers as plausible mechanisms. Findings on interactions between sign language and hearing technologies remain mixed, which motivates a precautionary approach to early language access while stronger longitudinal evidence accumulates. It is important, however, to highlight that conclusions drawn from the reviewed studies have to be considered with caution, as there are significant limitations in terms of data availability and the ability to follow deaf individuals over time.

Chapter 3. **Quantifying the economic value of early access to sign language: the methodological approach**

Understanding the benefits of sign language in early childhood requires situating deaf children within their broader language environments. In the UK, despite rising trends in multilingual households (ONS 2022), most children (deaf or hearing) grow up monolingual. Only a small fraction of children who are born deaf or become deaf in early life have a deaf parent, and, in most cases, deaf children are the only deaf member of their family. While deaf parents often raise their children, hearing or deaf, using sign language as a first language, the majority of deaf children are born to hearing parents, which inhibits the direct intergenerational transmission of a first language, whether it is spoken or signed, within the family.

In the UK, hearing parents of deaf children are generally informed about different communication approaches, including sign language. The approach most commonly chosen by hearing parents is to use spoken language alongside hearing technologies such as hearing aids or CIs. Consequently, most deaf children with access to hearing technologies are exposed only to spoken language in their early years. A minority of hearing parents opt for sign language; many of these later switch to exclusively spoken language, while others persist with varying levels of sign-language fluency. This results in substantial heterogeneity in both the quantity and quality of sign-language input available to deaf children raised in hearing families (Young et al. 2025).

The existing evidence, discussed in the previous chapter, highlights that a deaf child's ability to communicate through sign language can potentially reduce the likelihood and effects of a range of future adverse events. Deaf children who can communicate in sign language are more likely to experience better physical and mental health outcomes, improved employment prospects, and other benefits, including enhanced social inclusion and a higher quality of life.

The aim of the economic analysis presented in this chapter is to quantify the costs and associated long-term benefits of early sign-language acquisition for children born in the UK with permanent severe-to-profound deafness to hearing parents. The focus is on the early years, defined as the period from birth to age five, which represents a critical period for language acquisition and cognitive development. As discussed, there is large heterogeneity among deaf children born to hearing parents with regards to the quantity and quality of sign-language exposure they experience. The analysis recognises the heterogeneity in current practice and language provision and aims to assess the potential economic returns associated with acquiring adequate sign-language skills within a supportive and sign-friendly family environment, which can reduce the risk of early language deprivation while providing deaf children with fundamental language abilities that can create lifelong benefits.

3.1. Approach to quantifying the economic value associated with early access to BSL

The economic analysis simulates the life courses of a cohort of children born in the UK to hearing parents and identified early with permanent severe-to-profound deafness. In doing so, it sets out to provide cost estimates of the resources required for these deaf children to acquire adequate levels of BSL within their family environment to prevent early language deprivation, and to quantify the potential individual future lifetime returns of such an investment. The underlying assumption is that early-years BSL acquisition reduces the risk of language deprivation and supports human-capital formation, creating potential benefits at various stages of an individual's life, including improved quality of life, as well as better health and employment outcomes, which can then be compared against the total cost of achieving these benefits. A positive Benefit–Cost Ratio (BCR) would suggest that the intervention delivers more benefits than it costs, resulting in a positive return on investment. Beyond BCRs, which apply a monetary value for each unit of quality of life gained, average incremental cost-effectiveness ratios (ACERs) are also reported. The incremental cost-effectiveness ratio (ICER) is a common metric used in health economic valuations and is defined as the difference in costs between an intervention and its comparator divided by the difference in quality-of-life outcomes (Drummond et al. 2005). The ACER reflects the average additional cost required for one unit of quality-of-life gain when comparing an intervention against a baseline of no intervention (Edejer et al. 2005).

The analysis only considers costs and benefits where adequate evidence was available to quantify them. Due to data limitations and lack of evidence, several other potential cost and benefit factors have not been included in the analysis. For example, while the analysis considers quality-of-life aspects from the health perspective, broader well-being benefits, such as those generated from a sense of belonging or Deaf identity, were not quantifiable. There might also be well-being benefits for hearing parents when acquiring BSL as a second language, either through better caregiver/child relationships or through being able to communicate in a second language more broadly, but evidence about the existence of these effects is scarce in the existing literature. Furthermore, the analysis could not directly quantify potential educational benefits that may arise due to better experience and support for deaf sign-language users in the education system, which subsequently could have positive productivity effects. Omitting such potential benefits means that the reported BCRs are likely underestimated or the ACERs overestimated.

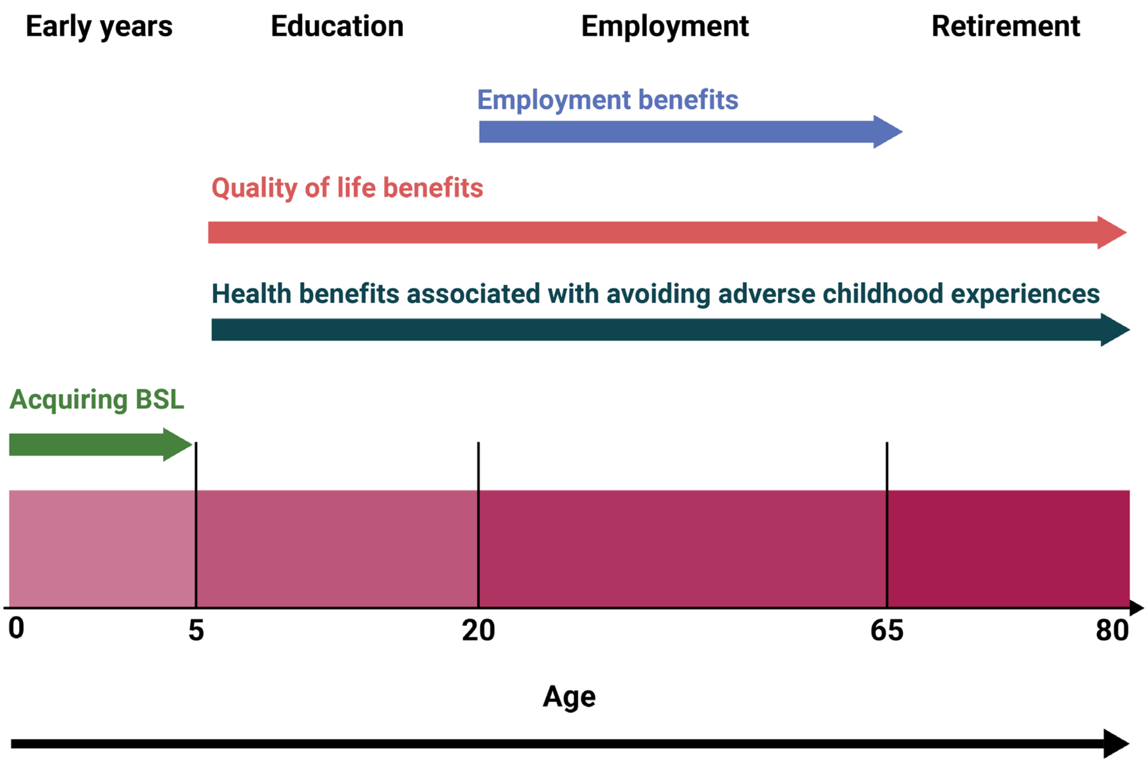
It is important to highlight that the economic analysis simulates the cumulative costs and benefits over the lifetime horizon, which, based on current UK life expectancy, is assumed to be 80 years. While this adopted lifetime horizon is consistent with health economic evaluation practice, HM Treasury's Green Book (HM Treasury 2024) advises against horizons beyond 50 years where possible. To test sensitivity with regards to the modelled time horizon, all analyses are conducted by altering time horizons: the full-time horizon of 80 years as well as a horizon of 50 years. All monetary values for costs and benefits are reported in pound sterling (£) adjusted for the reference year 2024 via the UK GDP deflator (HM Treasury 2025). The following sections outline the methodological approach in more detail.

3.2. Modelling a cohort of deaf children over their lifetime

Figure 3.1 provides a non-technical overview of the applied cohort simulation model, while technical details are reported in Annex 1. In essence, the simulation follows a hypothetical cohort of deaf children from birth through death. Crucially, in the model it is assumed that the early years (between birth and age five) determine key lifetime outcomes. Depending on the modelling scenario, the cohort either acquires adequate BSL proficiency within a sign-friendly family environment to mitigate the risks and adverse outcomes of language deprivation, or does not. The ability to communicate in BSL is then assumed, all else equal, to be associated with different benefits in health, employment and quality of life across the life course. Within the model, at each annual cycle, the cohort progresses based on age-specific survival probabilities.[3]

From age five, all individuals in the model are assumed to enter the education system, where they remain until age twenty. Between ages twenty and sixty-five, they are of working age, and thereafter they transition into retirement until death. To reflect average UK life expectancy, the model assumes a terminal age of eighty. These age thresholds are stylised and do not capture individual heterogeneity: in practice some individuals remain in education beyond twenty, retire earlier than sixty-five, or live past eighty, for example. For tractability, however, the model applies uniform cut-offs to all members of the simulated (homogeneous) cohort of deaf children across different scenarios.

Figure 3.1. Simulating a hypothetical cohort of children born deaf over their life course: modelled effects



3 Note that the survival probabilities are derived from the UK national population projections. Although deaf individuals may exhibit different mortality risks than the general population, for example due to inherited medical conditions associated with deafness, among others, the model abstracts from such differences. Because the analysis compares outcomes only within a cohort of deaf individuals rather than between deaf and hearing populations, the use of general UK survival rates is adopted as a simplifying assumption.

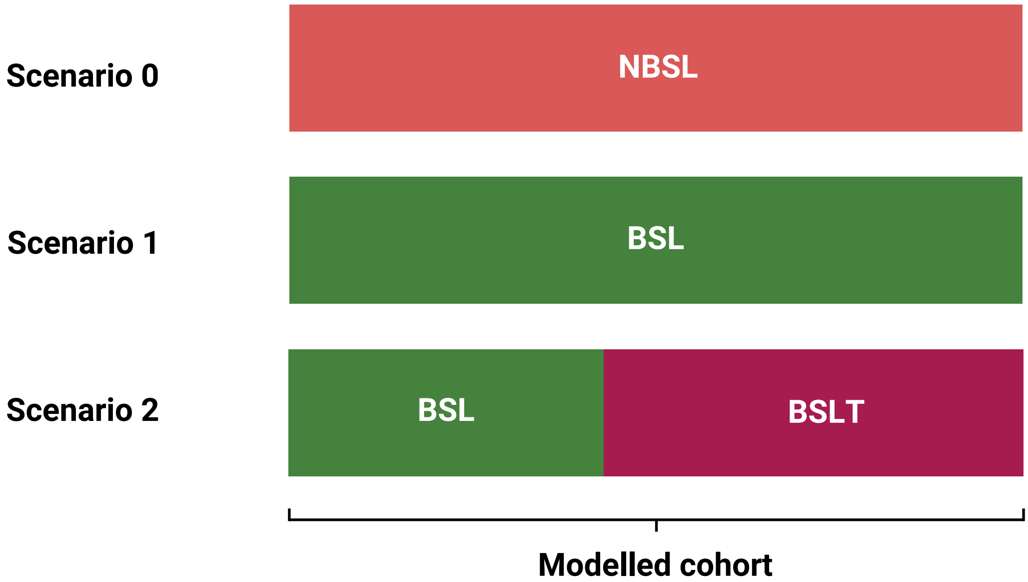
Applied economic modelling often requires simplifying and abstracting from real-world complexities. This is equally true for the purpose of this analysis, which requires the application of some key modelling assumptions.

First, as discussed, there is currently substantial heterogeneity in the language environments in which deaf children are raised, and no consensus definition exists as to what level of BSL proficiency is sufficient to reduce the risk of language deprivation and its associated adverse consequences. For tractability, the analysis adopts a simplifying assumption: if a deaf child grows up in a family environment where the parents engage in structured BSL learning activities, such as group classes and private tutoring, sufficient to reach an adequate proficiency (e.g. Level 3), and the child acquires BSL consistently from birth to age five through interactions with parents and specialist tutors, then the risk of language deprivation is effectively eliminated. In this framework, the cost side of the model is driving this assumption through the application of a range of monetised parental and child inputs required to achieve this proficiency (a higher cost implies a higher level of proficiency achieved, all else equal), while the benefit side reflects the avoidance of downstream adverse outcomes through adequate sign-language acquisition.

Second, the analysis faces the challenge of quantifying costs and benefits that are both uncertain and potentially occur only in the future, particularly the benefits, which materialise largely in adulthood. Standard practice in economic evaluation requires discounting future costs and benefits, recognising that resources are generally valued more today than in the future due to time preferences and uncertainty. To express future costs and benefits in present value terms, we apply a social discount rate of 3.5 per cent for all cost and benefit parameter inputs, and a 1.5 per cent discount rate for the modelled health effects following HM Treasury's Green Book (2024). Beyond the issue of discounting, there is a notable lack of robust empirical evidence on the long-term societal benefits of early sign-language exposure in general, and BSL in particular. Most available studies rely on cross-sectional data, relating current sign-language skills to contemporaneous outcomes such as employment or health (e.g. Dammeyer et al. 2019), rather than tracking individuals over time. This absence of longitudinal data means that assumptions must be introduced regarding how early-years BSL exposure and acquisition translates into lifetime skills and outcomes. Accordingly, the modelling assumptions regarding specific parameter inputs, outlined in what follows below, are explicitly stated. Moreover, as there is substantial uncertainty surrounding the model's inputs, the analysis applies a range of parameter values for model inputs, including, for example, a 'base case' analysis (denoted as ***Base*** in what follows), as well as analyses using lower- and higher-value input parameter assumptions for both costs and benefits (denoted as ***Low*** and ***High***, respectively). The results are then presented for three parameter combinations: (i) base costs and benefits; (ii) high costs/low benefits; and (iii) low costs/high benefits.

Third, the evidence base is considerably richer with respect to the cost-effectiveness of technological interventions such as hearing aids and CIs than for sign language. Crucially, there is a lack of studies that compare long-term developmental and socio-economic outcomes between deaf children who receive hearing technologies alone and those who receive hearing technologies alongside early sign-language support or those who only receive sign-language support. This lack of directly comparable interventions complicates efforts to evaluate the marginal value of sign-language acquisition in the early years. Considering this gap, the present analysis adopts a scenario-based approach comparing three different scenarios (see Figure 3.2).

Figure 3.2. Simulating a hypothetical cohort of children born deaf over their life course: overview of scenarios



Note: NBSL = baseline group in modelled cohort without BSL acquisition or hearing technologies; BSL = group of modelled individuals with early-years BSL acquisition; BSLT = group of modelled individuals with early-years BSL acquisition and access to hearing technologies

The hypothetical baseline (Scenario 0) assumes that none of the deaf children in the modelled cohort acquire BSL or have access to hearing technologies. This group of children (denoted the NBSL group) reflects cases where deaf children lack access to hearing technologies, or do not experience their benefits and do not acquire the ability to communicate in sign language and are therefore at high risk of language deprivation. Against this 'no intervention' baseline scenario, two counterfactual scenarios are simulated.

First, Scenario 1 assumes that all deaf children in the modelled cohort acquire BSL in the early years within a sign-supportive family environment (denoted as BSL group), thereby reducing the risk of language deprivation. The analysis then calculates the total cumulative cost for early-years BSL acquisition and the total monetised cumulative value of the employment, health and quality-of-life benefits for Scenario 1 and compares them against the total monetised value of the same outcomes for the modelled cohort in Scenario 0. That is, the difference in modelled outcomes between Scenario 1 and Scenario 0 provides estimates of the economic return for a deaf child acquiring BSL within the first five years of life, relative to the child not acquiring BSL nor having access to hearing technologies. In essence, the reported BCRs and ACERs for Scenario 1 represent the average return on investment or relative cost-effectiveness for an individual deaf child with BSL as their main mode of communication without simultaneously receiving other interventions to address their permanent hearing loss.

Second, following the 'precautionary principle', Scenario 2 assumes that all deaf children in the modelled cohort universally acquire BSL in the early years to an adequate level to avoid the risks of language deprivation in cases where access to hearing technologies fails to provide adequate access to language. While all deaf children in the modelled cohort acquire BSL, however, it is assumed that only those who adopt BSL as their preferred mode of communication and those who adopt hearing technologies but for which there is still a risk of language deprivation due to inadequate technology use (denoted the BSLT group) will derive measurable benefits. That is, the scenario assumes that for those adopting hearing technologies and a spoken-language approach, BSL only provides a benefit if they remain at risk of language deprivation, despite the technology. For example, some existing evidence suggests that the at-risk population among those accessing hearing technologies could be relatively large as the daily use of hearing aids among permanently deaf children in the UK could be substantially lower than what is considered optimal for children between birth and the age of two (Gosnell et al. 2023). Similar applies to CIs, where some studies suggest that non-use among children with implants is also a concern, with non-use rates ranging from 3 to 27 per cent, depending on the context (Ray et al. 2006; Joshi et al. 2024). The analysis then calculates the total cumulative cost for early-years BSL acquisition and the total monetised cumulative value of the employment, health and quality-of-life outcomes for Scenario 2 relative to the total monetised value of the same outcomes for the modelled cohort in Scenario 0. In essence, the reported BCRs and ACERs for Scenario 2 represent the average return on investment or relative cost-effectiveness of universal early-years BSL acquisition among the population of children born with permanent severe-to-profound hearing loss to hearing parents in a population that simultaneously also could adopt hearing technologies. It is conservatively assumed that the benefits from the ability to communicate in BSL would not apply to those that adopt hearing technologies without being at risk of language deprivation due to adequate use of the technology. Within this scenario, investing in universal early-years BSL acquisition represents the equivalent of an insurance policy against the potential risks of language deprivation and the associated adverse outcomes, but it is important to highlight that Scenario 2 does not constitute a direct cost-effectiveness comparison of BSL versus hearing technologies. Instead, it is designed as a structured experiment to estimate the broader societal costs and benefits of universal early-years BSL provision under restrictive assumptions, namely, that costs are borne by the entire cohort, but benefits materialise only for a smaller sub-population.

It is important to note that both Scenarios 1 and 2 implicitly assume that, in the absence of hearing technologies or access to a signed language, a deaf child would face a high likelihood of language deprivation. In reality, some alternative communication methods, such as Cued Speech, which visually represents the phonemes of spoken language through specific handshapes and placements near the mouth, may partially mitigate the risk of language deprivation even without full sign-language acquisition or auditory language access. Robust evidence on the long-term effectiveness of these approaches in supporting language, cognitive or socio-economic outcomes remains limited, however, and they were not included in the current model. As a result, the findings reported from the scenario analyses should be interpreted as upper-bound estimates of the potential benefits of early-years BSL acquisition, since some children in real-world contexts may achieve partial language development through alternative communication strategies even in the absence of hearing technologies or full sign-language proficiency.

The following sections provide further details on the modelling of costs and benefits associated with these different scenarios.

3.3. Parameter inputs to the economic model

3.3.1. Cohort size

Accurate figures on the number of children in the UK born each year with permanent severe-to-profound hearing loss to hearing parents from publicly available data sources are difficult to establish. Existing estimates suggest that approximately 1–2 per 1,000 children are born deaf each year across a broad spectrum of deafness (Rashbrook & Perkins 2019). Applying this prevalence to the 591,072 live births recorded in England and Wales in 2023 (ONS 2024) would imply between 591 and 1,182 newborns annually. Administrative data from the NHS Newborn Hearing Screening Programme (NHSP) provide somewhat lower numbers: in 2018, approximately 534 infants were confirmed with bilateral permanent childhood hearing impairment by six months of age, including children born in England or resident there within three months of birth (Public Health England 2019). A clear distinction in this data about the level of hearing loss, however, is not available.

An alternative source, the Global Burden of Disease (GBD) study, offers prevalence-based estimates for hearing loss by severity (Institute for Health Metrics and Evaluation 2024). According to the GBD 2021 data, around 30.37 per 100,000 children aged 28 days or less are estimated to have severe-to-complete hearing loss. The uncertainty range for the GBD estimates is between 11.51 (Low) and 64.9 (High). When applied to the United Nations' 2025 population estimate of 689,845 live births in the UK (United Nations 2024), this equates to between 79 and 448 newborns annually, with a base-case estimate of approximately 210 (see Table 3.1).

Table 3.1. Prevalence of hearing loss among newly born (GBD, 2021)

	Base	Low	High
Complete hearing loss rate (per 100,000)	1.68	0.25	4.86
Severe hearing loss rate (per 100,000)	2.54	0.95	5.03
Profound hearing loss rate (per 100,000)	26.16	10.31	55.01
Severe-to-complete hearing loss rate (per 100,000)	30.37	11.51	64.90
Children born deaf in 2025	**210**	**79**	**448**

Note: Entries represent the prevalence of hearing loss by severity in terms of people affected out of a population of 100,000. The GBD 2021 data (Institute for Health Metrics and Evaluation 2024) for the prevalence among children up to 28 days after birth is used.

These figures are substantially lower than those implied by some national prevalence rates or the NHSP data. Given this variation, our economic analysis adopts a cohort size of 250 children born with severe-to-profound hearing loss to hearing parents. This figure is intentionally conservative, aligning more closely with the GBD base case while remaining below the higher estimates derived from UK national prevalence and screening data. It should be emphasised that the assumed cohort size matters only when calculating the total aggregate costs and benefits at the cohort level. The per-child estimates of the specific costs and benefits, which are a central focus of the analytical scenario outputs, remain unaffected by the cohort size assumption.

3.3.2. Estimating the costs of early-years BSL acquisition

Acquiring high-quality early-years BSL abilities requires investment in both early sign-language support for the child and parental BSL training. Families may start with low-cost or even free introductory classes provided by local charities or other services, such as a 'Family Sign Language' programme (NDCS 2025). These relatively low-cost programmes are an essential first step for hearing parents, but focus predominantly on more basic vocabulary. Specifically, hearing parents without prior BSL communication abilities may have to take up additional accredited BSL courses to gain conversational fluency. Beginner Level 1 courses may cost up to £500 per person per year, whereas more advanced Level 3 courses could cost up to £3,000 per person (Petition.Parliament.UK 2018). Some families may also decide to use one-on-one tutors or invite Deaf mentors to accelerate learning at home. Funding availability for some of these courses is inconsistent and varies according to location (British Association of Teachers of Deaf Children and Young People 2022). For the child, early exposure to sign language comes primarily via the parents, but as the child grows, specialist sessions including, for example, with Teachers of the Deaf (ToDs) or Deaf tutors, become part of the learning journey. From about age two, this may include one to two hours per week of structured lessons with a BSL tutor. Calculating cost estimates for a deaf child and their family to acquire BSL proficiency adequate to protect from adverse childhood experiences such as language deprivation is not straightforward, as costs will vary by location and will most likely vary for each individual family. For modelling purposes, however, a central cost estimate that then can be compared against any potential future benefits of early-years BSL acquisition needs to be applied.

Based on cost estimates available online, a bottom-up costing approach is used to estimate the costs of acquiring BSL in the early years in a sign-friendly family environment. Therefore, the analysis makes the following assumptions with regards to the resources required at each age interval: (i) from birth to year one, the focus is on parents' BSL training, which includes engagement in group classes and some private tutoring; (ii) between year one and two, parents continue in group classes and private tutoring while the child receives their first interaction with specialists such as ToDs; (iii) from age two to three, parents continue group classes and private tutoring to enhance their level of BSL proficiency while the child receives weekly specialist sessions; (iv) from age three to four, parents are advancing to good BSL proficiency and the child is growing up in a sign-rich family environment, while continuing to have specialist sessions each week; (v) from age four to five, parents only require some refresher courses and the child receives more weekly intensive hours of BSL specialist engagement.

While there is limited published data on the full cost of acquiring BSL in the early years for deaf children, the following benchmarks provide some foundation. The cost for adult BSL group tuition has been advertised at rates of £45 per hour for a group of up to six people, resulting in an hourly cost per person of £7.50.[4] In comparison, individual tuition fees are advertised at rates of between

4 For example, see (as of 31 October 2025): https://heathlands.herts.sch.uk/bsl-courses/

£20 to £30 per hour per person.[5] On this basis, the analysis assumes a more conservative hourly cost of £20 per hour per parent for BSL group tuition. Other sources quote an hourly cost between £35 to £45 per hour for adult one-to-one BSL tutoring.[6] On this basis, the analysis assumes a £50 hourly cost per parent for one-to-one private BSL tutoring. With regards to child specialist support, the salary range for special educational needs (SEN) teachers working with children and young people who have special educational needs or disabilities is between £33,000 and £51,000 a year. According to the Department for Education, full-time teachers are contracted to work 195 days per year, comprising 190 teaching/contact days and 5 in-service training (INSET) days and a total of 1,265 hours a year (DfE 2025). On this basis, the hourly rate for the upper-range annual salary is £40.30. Considering additional potential costs to the employer, such as national insurance or pension contributions, the analysis assumes a £60 hourly cost for child specialist support. In addition, the analysis assumes annual resource costs for the purchase of course materials ranging between £50 and £200 a year. This is based on taking a fraction for a full BSL Level 1 course, which are advertised by some providers at £400 a year and assumed to include some course materials.[7] As most available information on cost inputs for early-years BSL acquisition is limited and based on various sources, these cost assumptions should be interpreted as illustrative. The uncertainty around these inputs is addressed through sensitivity analysis with regards to the parameter inputs and their effect on the reported outcomes, such as the BCRs and ACERs. Taking these cost estimates in combination with assumptions on the annual hourly input for parents and the deaf child to acquire BSL proficiency in the early years adequate to minimise the risk of language deprivation and associated long-term adverse consequences, Table 3.2 presents the estimated net present value (NPV) of acquiring adequate BSL proficiency from birth to age five for the base case and lower and higher input value assumptions.

For the base case, it is assumed that parents participate in around 1.5–2 hours of group tuition per week across 30 weeks for the first three years each year, with both parents attending. In addition, parents receive 10–12 hours of one-to-one tuition annually up to age 3, declining to around 4 hours by age 5 as BSL abilities improve. Specialist support for the child is initially modest, with up to 20 hours per year in the first 2 years, but rises substantially to 80 hours per year from age 3 onwards, ensuring more direct language exposure in the critical preschool period. Annual resource costs for BSL books or apps are set at £150. Applying these hourly input assumptions and multiplying them with the costs for parent group classes, as well as one-to-one tutoring and child specialist support, the total cost of early-years BSL acquisition is estimated at £23,850 undiscounted, or £22,012 discounted over five years (see Table 3.2).

For the lower-cost input value case, it is assumed that only one parent attends group tuition for 25–30 weeks per year, and one-to-one tuition is restricted to 4–6 hours annually in the first 3 years, with none thereafter. Specialist support for the child is more limited, beginning with just 2 hours in the first year, increasing to 10–20 hours in years 1 to 3, and increasing to 40 hours annually from age 3 onwards. Resource costs are set at £50 per year. As outlined in Table 3.2,

5 For example, see (as of 31 October 2025): https://bslnow.co.uk/

6 For example, see (as of 31 October 2025): https://www.teachmesign.co.uk/one-to-one-bsl-tutoring/; or https://heathlands.herts.sch.uk/bsl-courses/

7 For example, see (as of 31 October 2025): https://heathlands.herts.sch.uk/bsl-courses/

under these hourly input assumptions and multiplied with the assumed unit costs, this results in a total cost of £11,120 undiscounted, or £10,277 discounted.

By contrast, the higher-cost input value case assumes that both parents attend 2 hours of weekly group tuition for 35 weeks each year, supplemented by 14–20 hours of one-to-one tuition annually in the first 3 years and 8–10 hours per year thereafter. Furthermore, it is assumed that the child is provided with extensive specialist support, including 10 hours in the first year, 40–80 hours annually in ages 1 to 3, and up to 120 hours per year from age 3 onwards, equivalent to multiple weekly sessions. Resources are costed at £200 annually to reflect more costly learning materials. As outlined in Table 3.2, this more resource- and time-intensive case implies a total cost of £37,900 undiscounted, or £35,030 discounted, representing the level of sustained investment required to maximise the probability of age-appropriate BSL proficiency.

Together, these three sets of cost input assumptions outline the potential variation in resource requirements depending on the intensity of BSL provision. It is important to highlight, however, that they need to be considered as illustrative cases based on resource cost and time input assumptions, whereas in reality these costs likely vary for every child depending on their inherent language abilities, the family environment and the types of BSL resources available locally. Furthermore, while the cost figures reported in Table 3.2 capture a broad range of potential inputs, they do not include all possible cost components. For instance, the opportunity cost of parental time is not explicitly valued. Parents attending BSL group classes could alternatively allocate this time to paid employment or leisure, both of which carry economic value, either through income or utility from leisure time. The analysis implicitly assumes that parents attach sufficient value to the acquisition of BSL to prioritise this activity over alternative uses of their time, and thus no explicit time trade-off is incorporated. Similarly, costs such as travel to group sessions or additional childcare for families with multiple children where both parents attend have not been considered due to insufficient evidence on their magnitude and relevance. Given these uncertainties, and to enhance transparency, the analysis reports BCR and ACER estimates not only for the base case, high-cost/low-benefit and low-cost/high-benefit parameterisations, but also across a wide range of alternative BSL-acquisition cost assumptions (e.g. from a total cost of £5,000 to £80,000).

Table 3.2. Estimated cost per child/family acquiring adequate BSL proficiency from birth to age five

Age	Parent group: hours/week by parent	Parent group: weeks/year	Parents in group	Parent group: total cost (£/year)	Parent 1:1 hours (total/year)	Parent 1:1 cost (£/year)	Child specialist: hours (total/year)	Child specialist: cost (£/year)	Resources cost (£/year)	Annual cost (£) – not discounted	Annual cost (£) – discounted
Base											
0–1	1.5	30	2	1,800	10	500	5	300	150	2,750	2,750
1–2	1.5	30	2	1,800	10	500	20	1,200	150	3,650	3,527
2–3	2.0	30	2	2,400	12	600	40	2,400	150	5,550	5,180
3–4	1.0	20	2	800	6	300	80	4,800	150	6,050	5,457
4–5	1.0	20	2	800	2	100	80	4,800	150	5,850	5,098
									TOTAL	**23,850**	**22,012**
Low											
0–1	1.5	30	1	900	4	200	2	120	50	1,270	1,270
1–2	1.5	30	1	900	6	300	10	600	50	1,850	1,787
2–3	2.0	25	1	1,000	6	300	20	1,200	50	2,550	2,380
3–4	1.0	15	1	300	4	200	40	2,400	50	2,950	2,661
4–5	0.3	10	1	50	0	0	40	2,400	50	2,500	2,179
									TOTAL	**11,120**	**10,277**
High											
0–1	2.0	35	2	2,800	20	1,000	10	600	200	4,600	4,600
1–2	2.0	35	2	2,800	14	700	40	2,400	200	6,100	5,894
2–3	2.0	35	2	2,800	20	1,000	80	4,800	200	8,800	8,215
3–4	1.5	25	2	1,500	10	500	120	7,200	200	9,400	8,478
4–5	1.5	20	2	1,200	8	400	120	7,200	200	9,000	7,843
									TOTAL	***37,900***	***35,030***

Note: Entries represent calculations based on hourly input assumptions for parent group sessions (£20 per hour), parent one-to-one tutoring (£50 per hour) and child specialist support costs (£60 per hour).

3.3.3. Quantifying the health effects associated with avoiding early-years language deprivation

As outlined in Chapter 2, deaf individuals often encounter barriers in accessing healthcare services, which may translate into poorer health outcomes relative to the hearing population. For deaf children, the inability to communicate effectively with family members and wider society constitutes an adverse childhood experience (ACE) with potentially long-term health consequences. Kushalnagar et al. (2020) document that deaf adults who experienced childhood language deprivation or communication neglect exhibit higher prevalence of chronic conditions in later life. For instance, limited parent–child communication in childhood was associated with a 61 per cent higher risk of cardiovascular disease and a 12 per cent higher risk of diabetes in adulthood, while exclusion from family communication was linked to a 34 per cent higher risk of depression and anxiety disorders. Several caveats accompany the use of these estimates. The Kushalnagar et al. (2020) study is retrospective, based on a US sample of deaf and hard-of-hearing adults who were either born deaf or became deaf before age 13, to both hearing and deaf parents, and who reported different communication modalities, including speech and sign language. More than half of the sample reported not using hearing devices. Although relative risk estimates are adjusted for parental hearing status (and thus partially account for language modality), they do not adjust for hearing-device use, and the age of sign-language acquisition among signing participants is unknown. These limitations limit the transferability of the risk estimates to the UK context. Nevertheless, in the absence of more directly applicable data, these estimates provide the best available evidence, and the direction of the effects is likely to hold even if their precise magnitudes may differ. To account for the uncertainty, the analysis applies different ranges of the relative risk estimates based on reported confidence intervals in Kushalnagar et al. (2020).

Drawing on the estimates provided by Kushalnagar et al. (2020), the economic analysis incorporates three health conditions as negative consequences of early language deprivation: diabetes, cardiovascular disease (CVD) and depression/anxiety disorders. These conditions are modelled as age-specific, time-dependent comorbidities that affect both quality-of-life and labour-market outcomes. The underlying assumption is that deaf children acquiring adequate BSL proficiency in the early years within a supportive family environment (the BSL group) do not bear elevated risks of these conditions, whereas those without early BSL exposure (the NBSL group) face increased risks. Annual age-specific incidence rates for the three conditions are taken from the Global Burden of Disease (GBD) 2021 study for the general population with the associated uncertainty ranges for the lower- and higher-input value assumptions (see Table 3.3). For the NBSL group, these rates are adjusted using relative risk (RR) estimates from Kushalnagar et al. (2020): 1.12 for diabetes; 1.61 for CVD; and 1.34 for depression. In contrast, the BSL group is assumed to face the baseline GBD risks.[8] Diabetes and CVD events are modelled from age 20

8 Assuming effectively RR = 1.0, on the assumption that early sign-language access mitigates the excess risk associated with language deprivation. This is a simplification, as deaf individuals may have elevated relative health risks across all three health conditions compared to the hearing population. As the model compares the relative difference in outcomes between the BSL and the NBSL group across different scenarios, however, setting the RR for the BSL group at 1.0 does not impact the overall result.

onwards, while depression and anxiety disorders are effective from age 10 onwards.[9] Incidence for all three health conditions prior to the specified starting ages is set to zero. Given that diabetes and CVD are chronic conditions, it is assumed that, once developed, individuals incur ongoing disease management costs throughout their remaining lifetime. Cost estimates have been sourced accordingly to capture these long-term expenditures. In contrast, for depression and anxiety, it is assumed that onset leads to treatment within the corresponding year, with condition-specific medical costs applied. Individuals remain at risk of subsequent episodes in future model cycles, however, based on the applied age-specific annual incidence rates. The model framework allows for comorbidity, meaning that individuals may concurrently experience multiple conditions, such as diabetes and depression or anxiety. Nonetheless, the healthcare cost parameters are condition-specific and do not incorporate potential cost interactions between coexisting diseases. For instance, the model assumes that the cost of treating depression is equivalent for individuals with and without diabetes, thereby not accounting for potential variations in treatment complexity or resource use arising from comorbidities.

The three adverse health conditions – diabetes, cardiovascular disease and depression – affect individuals in the modelled cohort in several ways. First, each condition increases mortality risk. In each annual model cycle, individuals face an age-specific probability of death that rises if they are affected by any of these conditions. Premature mortality reduces the number of individuals alive at each time point and, depending on the age at death, influences cumulative measures such as lifetime health-adjusted life years and employment outcomes across the cohort. Second, the onset of these conditions generates direct healthcare costs. For every year an individual lives with a condition, the model applies disease-specific annual costs to reflect the additional burden on the healthcare system relative to a disease-free state. These costs accumulate over time and are compared across modelled scenarios. Third, the conditions increase morbidity among survivors. Even when individuals remain alive, their health-related quality of life is reduced due to the illness. Moreover, if the condition arises during working age, it may adversely affect labour productivity and employment participation, given that individuals with chronic or mental health conditions typically exhibit lower work performance and higher rates of absenteeism relative to healthy counterparts.

The key input parameters for the three health conditions associated with the adverse childhood experience of language deprivation are summarised in Table 3.3. Relative mortality risk estimates were obtained from published literature and applied to the baseline age-specific mortality probabilities of individuals without the respective health conditions to derive condition-specific mortality risks. Wang et al. (2019) report that diabetes is associated with an 83 per cent higher all-cause mortality risk, Prugger et al. (2023) estimate a 2.5-fold increase in mortality following CVD events, and Walker, McGee & Druss (2015) find that severe mental health conditions are associated with a 122 per cent higher mortality risk.

Direct healthcare costs are also incorporated as follows. For diabetes, costs are taken from Hex et al. (2024) and conservatively restricted to diagnosis and ongoing management (£1,815 annually), excluding major complications. CVD costs are derived from Danese et al. (2017), who estimate long-term annual costs of £3,032 following a CVD event. For depression, costs

9 Note that the incidence of diabetes and CVD events follows an age-specific distribution where incidence increases with age.

are based on UK estimates for major depressive disorder (£2,650–£4,715 per year; Kailey et al. 2020), with the model conservatively assigning half of the lower bound (£1,325) and which then is converted into 2024 values using the UK GDP deflator resulting in £1,764 per event. Depression is modelled as recurrent, with costs accruing each year an episode occurs, while diabetes and CVD are assumed to persist once diagnosed – that is, as they are long-term conditions, annual disease management costs are applied but the pool of individuals with new onset conditions are limited to the population without diabetes or CVD.

Table 3.3. Applied parameter inputs for health conditions related to early-years language deprivation

Health condition	Input	Base	Low	High	Source
Diabetes	**Incidence**				
	Age 5–20 (of 100,000)	0	0	0	Model assumption
	Age 20–54 (of 100,000)	399.9	353.9	455.3	*GBD (2021)*
	Age 55+ (of 100,000)	476.6	399.0	562.1	*GBD (2021)*
	Relative ACE risk	1.12	1.01	1.24	*Kushalnagar et al. (2020)*
	Relative mortality risk	1.83	1.76	1.91	*Wang et al. (2019)*
	Healthcare cost (£, 2024)	£1,815	£907.70	£2,723	Hex et al. (2024)
CVD	Incidence				
	Age 5–20 (of 100,000)	0	0	0	*Model assumption*
	Age 20–54 (of 100,000)	257.8	223.0	295.9	GBD (2021)
	Age 55+ (of 100,000)	2,684.9	2,468.9	2,923.6	*GBD (2021)*
	Relative ACE risk	1.61	1.39	1.87	*Kushalnagar et al. (2020)*
	Relative mortality risk	2.49	2.34	2.66	*Prugger et al. (2023)*
	Healthcare cost (£, 2024)	£3,032	£1,516.20	£4,548.60	Danese et al. (2017)
Depression	Incidence				
	Age 5–20 (of 100,000)	2,986.7	2,131.8	4,001.6	*GBD (2021)*
	Age 20–54 (of 100,000)	8,886.1	7,293.1	10,868.7	*GBD (2021)*
	Age 55+ (of 100,000)	6,774.3	5,537.3	8,411.6	*GBD (2021)*
	Relative ACE risk	1.34	1.25	1.44	*Kushalnagar et al. (2020)*
	Relative mortality risk	2.22	2.12	2.33	*Walker et al. (2015)*
	Healthcare cost (£, 2024)	£1,764	£881.90	£2,645.80	Kailey et al. (2020)

It should be emphasised that these estimates capture only a subset of the potential health effects of early-years BSL acquisition. Additional benefits, such as improved health literacy and reduced healthcare barriers, have been quantified by other studies (e.g. D'Rosario & Dawson 2022) and are likely to occur for the UK context as well, but cannot be quantified reliably given current evidence. Robust estimation would require detailed data on BSL users' healthcare access and its direct link to health outcomes, which are presently lacking. Consequently, these additional health benefits are not included in the analysis. The link between the three health conditions and quality-of-life and productivity effects are discussed further in what follows.

3.3.4. Quantifying quality-of-life effects

Support for BSL, or more broadly a bilingual approach in which deaf children acquire both a signed language and the spoken language of their family, enhances not only communication but also cultural identity and belonging within the Deaf community. In this context, hearing loss is not necessarily conceptualised as a health problem or a disability, but rather as a form of cultural identity or a skill. Nevertheless, from an economic perspective, the valuation of quality-of-life impacts associated with BSL or hearing-loss interventions such as cochlear implants or hearing aids often proceeds through established health economic frameworks, such as quantifying and valuing units of life quality through the Disability-Adjusted Life Year (DALY) or Quality-Adjusted Life Year (QALY).

A DALY consists of two components: (i) years of life lost (YLL) due to premature mortality; and (ii) years lived with disability (YLD). While hearing loss is associated with other risk factors, such as cardiovascular disease, that may elevate mortality risks (Baiduc et al. 2023), hearing loss itself is not directly linked to significantly higher mortality, making the YLL component less relevant. Instead, the central parameter for estimating YLDs is the disability weight (DW), which quantifies the severity of health loss on a scale from 0 (perfect health) to 1 (death) (Murray 1994). This approach has been applied to estimate the value of sign-language provision in D'Rosario & Dawson (2022), who used DALYs to estimate the quality-of-life benefits of Auslan (Australian Sign Language). The DALY framework has also been applied to auditory-verbal therapy (Auditory Verbal UK 2016) and in economic evaluations of hearing technologies such as cochlear implants and hearing aids (Tordrup et al. 2022).

Beyond DALYs, QALYs remain a frequently applied metric in health economics. QALYs, like DALYs, assign a value between 0 and 1 to reflect health-related quality of life, but they are typically reported as QALYs gained rather than DALYs prevented (Rogers et al. 2016). More recently, the Wellbeing-Adjusted Life Year (WELLBY) has been applied to value broader dimensions of a person's well-being beyond just health considerations (Frijters et al. 2024). A WELLBY reflects a one-point increase in self-reported life satisfaction (e.g. on a 0–10 Likert scale) for one person for one year. Applying this method, recent economic analyses have shown that receipt of disability benefits generates an equivalent income gain of £12,300 per person, corresponding to £42 billion in aggregate well-being benefits compared to £28 billion in disability programme costs (Understanding Society 2025). Though the WELLBY framework is increasingly applied in economic valuations to monetise individual well-being aspects, due to the lack of data availability to identify and differentiate well-being differentials among individuals with hearing loss and sign-language use, it was not applicable for the purpose of this study. The approach illustrates a promising avenue for future research, provided that ongoing data-collection efforts allow for robust identification of BSL users.

For the purpose of this analysis, the DALY approach taken by D'Rosario & Dawson (2022) to value the quality-of-life component of sign language is applied. The Green Book guidance of 2021 valued a QALY at £70,000 (HM Treasury 2024), whereas NICE values a QALY gained through a health intervention at between £20,000 and £30,000. The Green Book guidance of 2021 valued one WELLBY at £13,000. To put these values into perspective, using the lower NICE valuation threshold of a QALY, this would mean that a 5 per cent reduction in disability or improvement in quality of life corresponds to a monetary value of £1,000 (in 2021 prices). Table 3.4 reports DWs from the GBD 2021 study for hearing loss and three major health conditions applied in the model. Note that GBD provides DWs for a range of hearing-loss severity, from moderate to complete hearing loss. For the purpose of this analysis, we grouped together complete and profound hearing loss, as the GBD estimates for both levels of hearing-loss severity are very similar and the value of acquiring a signed language such as BSL likely also benefits those with complete hearing loss. As outlined in Table 3.4, according to GBD, for complete or profound hearing loss, DWs range across the uncertainty range between 0.168 and 0.354, for severe hearing loss between 0.140 and 0.293, and for moderate hearing loss between 0.089 and 0.180. In line with D'Rosario & Dawson (2022), we assume that early-years BSL acquisition reduces disability severity from complete/profound to severe – i.e. from 0.168–0.354 to 0.140–0.293 – or the equivalent of a reduction of the DW of 2.8–7.1 percentage points, with a base-case value of 4.3 percentage points (0.253 minus 0.210). This represents a relatively conservative assumption, as studies on cochlear implants, for instance, have assumed a reduction from profound to moderate hearing loss, or approximately 12.3 percentage points (Tordrup et al. 2022). Hence, the approach taken in this analysis assumes conservatively that BSL yields smaller reductions in disability than CIs. Based on the GBD (2021) data, the DWs for the three health conditions associated with early-years language deprivation are estimated as 0.148 for diabetes to 0.185 for cardiovascular disease and 0.314 for depression.

Table 3.4. Disability weights associated with hearing loss and three health conditions (GBD, 2021)

	Base	Low	High
Severity of hearing loss			
Complete/Profound	0.253	0.168	0.354
Severe	0.210	0.140	0.293
Moderate	0.130	0.089	0.180
Diabetes	0.148	0.100	0.205
Cardiovascular disease	0.185	0.128	0.247
Depression	0.314	0.219	0.409

Note: Entries represent the disability weights (DWs) of hearing loss by severity and three other health conditions sourced from the GBD 2021 data. A DW of 0 means perfect health and a DW of 1 means death.

Within the model, the cohort's discounted DALYs are tracked annually according to the scenario and associated language status of the modelled cohort. For those who acquire BSL in the early years, for example, it is assumed that the disability weights improve through a shift from profound to severe hearing loss and through a lower incidence risk of comorbid conditions (diabetes, cardiovascular disease and depression) over time. The monetary valuation of DALYs averted follows standard health economic practice to apply a monetary value for a unit of quality of life, but assumes that QALYs and DALYs are interchangeable, like a previous analysis on the value of auditory-verbal therapy (Auditory Verbal UK 2016). The base-case analysis applies £25,000 per DALY averted, with sensitivity analysis at £13,000 (low) and £70,000 (high). Under these value assumptions, a 4.3-percentage-point improvement in quality of life per person per year equates to £1,075, with an applied range of £559 to £3,010. Other studies have applied different DALY valuation thresholds in line with international recommendations valuing a DALY at 1.5 times the country's GDP per capita, with a lower valuation threshold of 0.5 times the GDP per capita (Tordrup et al. 2022). Assuming a GDP per capita in 2024 of £40,172 (Statista 2025) would result in a monetary value for a DALY averted of between £20,086 and £60,258, with the latter substantially higher than the £25,000 assumed in the base-case analysis and closer to the £70,000 assumed for the higher-value input assumption, whereas the former figure is closer to the base-case assumption applied in this analysis. It is important to highlight that for Scenario 2 it is assumed that the quality-of-life gains are only applied to the proportion of children using BSL as their preferred mode of communication (BSL group) or those that are at risk of language deprivation despite having access to hearing technologies (BSLT group), implicitly assuming that the quality-of-life improvements for the latter are attributable to the ability to communicate in BSL rather than the inadequate use of the technology.

3.3.5. Quantifying employment effects

As discussed in Chapter 2, the existing evidence suggests that deaf individuals are on average faced with lower employment rates than their hearing peers, but having good sign-language skills and using them as a preferred communication mode can be associated with a higher probability of working-age deaf individuals being employed. For example, using a US sample of deaf or hard-of-hearing individuals, Dammeyer et al. (2019) find that a deaf individual's odds of being employed, adjusted for age of diagnosis and the use of hearing technologies, are 2.09 times higher for each (self-reported) level of sign-language skills (ranging from 'poor or very poor' to 'good or very good'), with an associated 95 per cent confidence interval for the odds between 1.36 and 3.88. It is important to highlight that the estimates in Dammeyer et al. (2019) are based on cross-sectional data, limiting any further interpretation on whether the employment effects differ for those who acquired sign language in the early years or later in life. Nevertheless, like D'Rosario & Dawson (2022), in the absence of more directly applicable data, these estimates provide the best available evidence with regards to employment rates associated with sign-language capabilities within a deaf population and are therefore applied assuming that the US estimates can be transferred to the UK context.

With regards to establishing baseline employment rates, existing UK figures from 2017 suggest that people with hearing loss are less likely to be employed (65 per cent) compared to those without disabilities or long-term health conditions (79 per cent) (Hill et al. 2017). More recent data suggest that people with hearing difficulties have employment rates ranging from 45 per cent to 75 per cent, depending on whether hearing loss is reported as a primary and/or secondary disability (Committees.parliament.uk 2024). Other figures suggest that 37 per cent of adults who use BSL as their primary language are currently in work, compared to 77 per cent of non-disabled working-age adults, according to 2021 Census Data for England and Wales (RNID 2024). None of these employment rates provide exactly the employment rate for deaf individuals whose preferred and predominant communication modality is or is not BSL, nor does the 37 per cent estimate for BSL as primary language suggest that BSL users do much worse in terms of employment outcomes than deaf individuals without BSL. For instance, the 37 per cent may include retired individuals, or people voluntarily not working, independent of their hearing status or BSL use. Based on some of these figures, the analysis assumes that the employment rate of the NBSL group is 60 per cent.[10] To calculate the expected employment rate for the BSL group, the odds ratio estimates from Dammeyer et al. (2019) are applied. To be conservative, the lower bound of the 95 per cent confidence interval of 1.36 is used for the base-case analysis, and a 25 per cent lower and higher value for it under the lower- and higher-input value assumptions respectively. The estimated employment rate for the BSL group is reported in Table 3.5, based on a three-step calculation that is outlined in Annex C. For an applied 60 per cent employment rate for the NBSL group, the employment rate increases by 8 percentage points for the BSL group, ranging by 4 to 12 percentage points for the lower- and higher-value input assumptions. This means that out of a modelled cohort of 250 individuals, 150 individuals in the NBSL group would be entering the workforce, whereas approximately 170 in the BSL group are in employment under the base case. All else equal, the model thus maintains a higher steady-state employment rate among the BSL group.[11]

Table 3.5. Applied employment rates for non-sign-language users (NBSL) and sign-language users (BSL)

Group	Base	Low	High
NBSL	0.60	0.60	0.60
BSL	0.68	0.64	0.72

Note: Baseline employment rate of 0.6 for NBSL group assumed with BSL employment rates calculated applying estimates from Dammeyer et al (2019). See calculations in Annex C.1.

10 It is important to note that the assumed baseline employment rate of 60 per cent for the NBSL group may represent an upper-bound estimate for individuals who are deaf and lack access to both sign language and hearing technologies. The absolute value of this assumption has limited influence on the findings, as the analysis focuses on the relative differences in cumulative outcomes between scenarios. Because the counterfactual scenario applies a constant proportional increase in the odds of employment for individuals with access to sign language, the estimated relative gains remain largely invariant to the specific baseline employment rate chosen for the reference group.

11 It is essential to note that the change in employment rates between the BSL and the NBSL group is equally applied in all scenario analyses, regardless of whether it is assumed that BSL is the sole intervention (Scenario 1) or that BSL is provided universally alongside hearing technologies (Scenario 2), since the estimates by Dammeyer et al. (2019) are adjusted for the use of hearing technologies.

Beyond the probability of being employed or not, there is potentially an additional effect in terms of improving the productivity of those employed, which is commonly measured through differences in earnings. From a human-capital perspective in the economics literature, factors such as education and health contribute to higher levels of productivity. A previous economic analysis of the value of auditory-verbal therapy (Auditory Verbal UK 2016) assumed that the intervention would lead to one year more of education, corresponding to a 15 per cent annual increase in productivity over the individual's lifetime. The loss in employment or productivity is then typically valued based on the average salary of a person in the UK. For example, the economic analysis of the auditory-verbal intervention assumed a salary of £27,000 for the full employment loss if the person is not working and 15 per cent of that for the productivity loss if a person is working but did not receive the auditory-verbal therapy. As the evidence for BSL in schools and potential effects on education and subsequent productivity outcomes is scarce, to value the employment and productivity benefits of BSL, rather than using a loss in educational attainment as a productivity proxy, we follow the health-related approach taken in Chen et al. (2018), which uses the health-related DWs from the GBD (2021) to value productivity loss associated with ill-health. The underlying assumption is that employed individuals with health impairments are contributing to the workforce, but depending on whether they are in the NBSL or BSL group, different levels of productivity impairment may be associated with the hearing loss and other potential health conditions. That is, to calculate the productivity impairment in the modelled cohort for those in the workforce, we use the DWs from the GBD reported in Table 3.4. As for the qualify-of-life effects, if the DW is applied as productivity impairment instead, then the productivity gap for those in employment between the NBSL and the BSL groups for the base case is 4.3 percentage points, which is almost a third lower than the productivity effect assumed in Auditory Verbal UK (2016) based on an estimate of additional years in education. While the valuation of potential productivity effects associated with interventions addressing hearing loss, such as early acquisition of sign language, relies on relatively conservative assumptions compared to other studies, an important methodological caveat concerns the aggregation of quality-of-life and productivity benefits. Specifically, both sets of benefits are calibrated using DWs from the GBD study. As these DWs already reflect losses in functional capacity that may partly capture productivity-related effects, combining monetised estimates of quality-of-life gains and productivity gains risks partial double-counting of benefits. This issue would primarily influence the reported BCRs. To account for this, BCRs including only quality-of-life improvements and healthcare costs savings associated with reducing the risk of early language deprivation are discussed in addition to BCRs accounting for the full range of benefits comprising employment and productivity effects.

Within the model, the productivity effects are measured in terms of the total number of working days lost each year among the working-age population (age 20 to 65). For example, assuming 250 working days per year, a relative productivity impairment of 4.3 percentage points would correspond to an excessive 10.75 days lost per year for the NBSL group relative to the BSL group. In essence, as applied in Chen et al. (2018) for other health conditions, the productivity effect across different modelled scenarios arises from differences in the applied DWs with regards to the hearing-loss status and modelled health conditions associated with early language deprivation. In addition, for those who die prematurely while still of working age, a 100 per cent productivity loss is assumed from the age of death to age 65, when the individual would enter retirement age. It is important to highlight that for Scenario 2, it is assumed that the productivity gains are only applied to the proportion of children using BSL as their preferred mode of communication (BSL group) or those that are at risk of language deprivation despite having access to hearing technologies (BSLT group), implicitly assuming that the productivity effects for the latter are attributable to the ability to communicate in BSL rather than the inadequate use of the technology. This approach to measuring the labour-supply impacts in terms of productivity costs aligns with existing methods in the health economics literature for estimating the costs associated with foregone employment. Instead of valuing the number of working days lost per year across the two groups using the standard approach of multiplying them by the average UK salary, we estimate the productivity implications using an economic model of the UK economy, a so-called computable general equilibrium (CGE) model. In essence, the model aims to estimate the economic effects of increasing human capital within the modelled cohort of 250 deaf children over their life course, using the human-capital approach (Mennini & Gitto 2022). CGE models are well-established tools for evaluating the economy-wide effects of policy interventions, external shocks and structural changes (Dixon & Jorgenson 2013). In the health economics literature, CGE models have been increasingly employed to evaluate the systemic effects of diseases, such as pandemic influenza and antimicrobial resistance (Smith, Keogh-Brown & Barnett 2011; Taylor et al. 2014). Recently, it has been demonstrated that CGE models provide a better modelling framework to assess indirect health-related productivity effects than the traditional partial equilibrium approaches in health economics evaluations (Hafner et al. 2023). Technical details on the model are reported in Annex A.

If a deaf individual in the modelled cohort enters the workforce, it is assumed that there are costs associated with employment support, including, for instance, the need for interpreters or workplace adaptations. According to Access to Work statistics, the total expenditure by primary condition for deaf or hard-of-hearing recipients in 2023/2024 was £77.9 million per year (Wilkinson 2024), which was driven by 6,090 hard-of-hearing people that received a payment, corresponding to an average payment per person of about £12,800 per year. The challenge with using this average expenditure per person is that the population of deaf or hard-of-hearing and their support needs are heterogeneous. A deaf person in a job that requires extensive daily BSL-interpreter support may need more financial support than someone in a job that requires less interpreting support. Indeed, the total Access to Work expenditure spent on deaf people who use BSL as their first or preferred language – and therefore those who more frequently book BSL interpreters – was £25.2 million in 2013/2014 (Department for Work and Pensions 2014), which corresponds to about 56 per cent of the total spend of £46 million for the deaf or hard-of-hearing population in that year (Wilkinson 2024). To account for the potentially disproportionate expenditure share for deaf BSL users, an upweighting multiplier for the £12,800 per year employment support unit cost estimate, based on the relative shares of the recipients of Access to Work within the deaf or hard-of-hearing group, is applied. The full description of how the adjustment multiplier is calculated can be found in Annex C.2. This yields an annual employment support unit cost of about £22,800 per BSL user in employment for the base case, with a sensitivity range of about £16,000 to £36,000 per user. These figures are specified as resource costs suitable for multiplying by additional BSL-using employees in the model. Given the potential uncertainty and potential individual variation in the magnitude of the annual employment support costs, the analysis estimates not only the BCR for the base case, high-cost/low-benefit and low-cost/high-benefit input parameter combinations, but also BCRs across a range of alternative annual employment support cost value inputs (ranging from £20,000 to £110,000).

3.4. Limitations

The analysis outlined in this chapter has important limitations in data inputs, model structure, assumptions and transferability of findings that must be considered when interpreting the results.

1. First, many of the key model inputs are drawn from cross-sectional or retrospective studies that rely on self-reported data and do not allow for causal identification of effects (e.g. relative risks for adverse health outcomes associated with early language deprivation or employment odds linked to sign-language proficiency). The absence of longitudinal evidence directly linking early sign-language exposure to long-term socio-economic outcomes substantially constrains the causal interpretation of these estimates. Furthermore, because of limited UK-specific data, health risk estimates and employment effects were drawn from US-based samples and mapped onto the UK context. Differences in healthcare access, education systems, labour-market structures and disability legislation between the US and the UK may influence both the direction and magnitude of observed effects. For instance, if structural barriers are more severe in UK workplaces than US workplaces, applying US employment odds ratios could overstate the benefits of sign proficiency in the UK; conversely, if UK workplace accommodations and legal protections are stronger, the US estimates may understate the true effect. These contextual uncertainties are partly addressed through the sensitivity analyses.

2. Second, the applied economic model follows a homogeneous cohort of deaf children over time. The model is substantially abstracting from reality, as individuals move to states over time (e.g. being employed or not from age 20 onwards) and then remain there without dynamic movements across other states (e.g. moving in and out of employment between time periods) unless they die. For example, developing a health condition reduces overall productivity and increases the mortality risk, but does not determine whether someone falls out of employment because of the health condition. Disease co-occurrence and competing risks are simplified as the three health conditions are modelled independently, meaning that in a case where an individual develops all three modelled health conditions independently the healthcare costs associated with each of the conditions are applied unadjusted for the existence of other health conditions within the same individual. This creates a risk of modest misestimation of co-morbidity effects, and therefore the model potentially overestimates the healthcare cost savings associated with reducing the incidence of the three modelled health conditions. Moreover, the applied model cannot take into account interactions between hearing technologies and BSL in terms of their complementarity or substitutability due to the lack of existing evidence on how these dynamics affect individual outcomes.

3. Third, results are sensitive to the discount rate and modelling horizon, and although results are also reported for a 50-year time horizon and future benefits receive less weight due to discounting, very long horizons beyond 50 years are uncertain. Specifically with regards to parameter inputs for costs and benefits, wage growth,

inflationary pressures, new medical innovations, the availability of interpreters as well as technological change are all held constant in the modelling framework over a very long time horizon, but such dynamics could reduce future resource use or increase realised benefits, or vice versa. For example, employment support costs in the model are averaged based on existing government expenditure data and kept constant, but the emergence of new technologies could decrease some of these costs over time. Moreover, the analysis assumes that once acquired, sign-language proficiency remains constant over the individual's lifetime and does not depreciate over time. In other words, the analysis abstracts from potential declines in language fluency or usage that could arise from reduced exposure, changing social environments or cognitive ageing. This simplifying assumption implies that the benefits associated with early sign-language acquisition are maintained throughout the life course without decay. While this assumption facilitates tractable modelling of long-term outcomes, it may lead to a modest overestimation of cumulative lifetime benefits if, in practice, language skills are not fully sustained or reinforced over time.

4 Fourth, a further limitation concerns the valuation of quality of life benefits. Following the approach taken in other studies, the analysis employs DALYs to quantify improvements in health-related quality of life, while cost-effectiveness thresholds used for interpretation are predominantly derived from QALY value assessments. Although DALYs and QALYs are both widely used health-related quality of life measures, they are not conceptually equivalent, and applying QALY-based thresholds to DALY outcomes should therefore be interpreted as an approximation rather than a precise benchmark. Moreover, the analysis was not able to employ a broader well-being valuation framework, such as the WELLBY, which captures changes in subjective life satisfaction beyond health status. In principle, a WELLBY-based approach may be more appropriate for interventions addressing hearing loss or the acquisition of language (spoken or signed) given their potential influence on identity, inclusion, and social participation of deaf individuals. However, implementing such an approach was not feasible because existing UK population surveys currently do not allow deaf BSL users to be reliably identified, limiting the ability to estimate well-being differentials. Future work incorporating richer data on BSL users could therefore yield more comprehensive estimates of the social value of early sign language access.

5 Fifth, as discussed, the modelling framework excludes some benefits that might be associated with early access to BSL but for which the current quantitative evidence wasn't robust enough to include in the model, such as improvements in healthcare access, social participation, educational attainment or family spillovers (e.g. improved parental well-being, caregiver stress). The influence on cultural capital and potential community-enabling effects are also qualitatively discussed but not monetised. The omission of these likely results in an underestimate of the cumulative lifetime benefits of early-years BSL acquisition. The exclusion of these potential benefits may also, however, safeguard to some extent from double-counting. For example, the model considers health-related productivity gains but not education-induced earnings effects, which would be difficult to disentangle in the current modelling framework. This conservative approach lowers the risk of double-counting but may understate aggregate

labour-market gains if early-years BSL acquisition causally improves educational attainment. At the same time, informing the productivity effects using a health-related approach risks double-counting some of the quantified quality-of-life and employment benefits. Therefore, BCRs with and without the employment benefits are discussed. Furthermore, with regards to cost inputs, parental opportunity time, travel and intermittent childcare are excluded from BSL acquisition costs.

Given these limitations, the reported BCRs and ACERs should be read as estimates under stated assumptions and not considered as precise forecasts. The true social return from early access to BSL could be higher than reported in this study, given that factors in favour of early-years BSL acquisition for which evidence is not yet available (e.g. improvements in educational attainment, better access to healthcare services) are omitted. Equally, limited evidence on the effectiveness of interventions besides sign-language acquisition or the adoption of hearing technologies on some of the modelled long-term individual outcomes and their exclusion from the analysis mean that the estimated benefits are likely overestimated.

Chapter 4. **The economic returns associated with early access to BSL: results**

This chapter presents the results of the economic analysis of early access to BSL for deaf children. As discussed, the analysis is structured around different scenarios that are compared against each other.

Scenario 1 assesses the economic returns of early-years BSL acquisition for deaf children in the absence of other interventions such as hearing aids or CIs. This scenario captures the incremental value of BSL in cases where it is the primary mode of language acquisition, with results expressed by comparing the cumulative lifetime cost and benefits against each other (BCR) or comparing the relative costs of achieving a year lived with good quality of life (ACER).

Scenario 2 models a policy experiment where all deaf children in the modelled cohort acquire BSL in early childhood based on the 'precautionary principle', but most also receive hearing technologies and pursue a predominantly spoken-language pathway. In this scenario, only a subset of children – those who either rely on BSL as their primary language or who remain at risk of language deprivation despite technology use – are assumed to derive measurable benefits from acquiring BSL between birth and the age of five. The analysis in this scenario therefore varies the size of this 'at-risk' subgroup to reflect uncertainty in the evidence base with regards to the inadequate use of hearing technologies. In essence, in Scenario 2, BSL functions as both a primary language for some deaf children and a potential safeguard against language deprivation for others.

The following sections present detailed results for both scenarios, including sensitivity analyses, alternative cost assumptions and variation in modelled time horizons.

4.1. Economic returns of investing in early-years BSL acquisition relative to no other interventions

Table 4.1 reports the estimated net present value (NPV) of lifetime cumulative benefits and costs associated with early-years BSL acquisition for a modelled cohort of 250 deaf children. The reported BCRs represent the economic return of BSL for children who acquire it BSL in the early years but do not have adequate access to other interventions, such as hearing technologies.

Table 4.1. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 1 versus Scenario 0

	(1)		(2)		(3)	
Cost inputs	**Base**		**High**		**Low**	
Benefit inputs	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,887,067	19,548	11,563,463	46,254	1,787,849	7,151
Total costs	**10,390,128**	**41,560**	**20,320,927**	**81,284**	**4,357,156**	**17,428**
Benefits						
Healthcare cost savings (ACE)	529,517	2,118	146,513	586	1,250,583	5,002
Employment gains	10,416,141	41,665	5,879,304	23,517	14,817,752	59,271
Quality-of-life gains	13,331,912	53,328	4,309,730	17,239	55,920,399	223,682
Total benefits	**24,277,570**	**97,111**	**10,335,547**	**41,342**	**71,988,734**	**287,955**
Benefit–Cost Ratio (BCR)						
	2.34		**0.51**		**16.52**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. Benefit–Cost Ratios are calculated by dividing the present value of total benefits by the present value of total costs. NPV= Net Present Value. All monetary values are reported in £2024 prices.

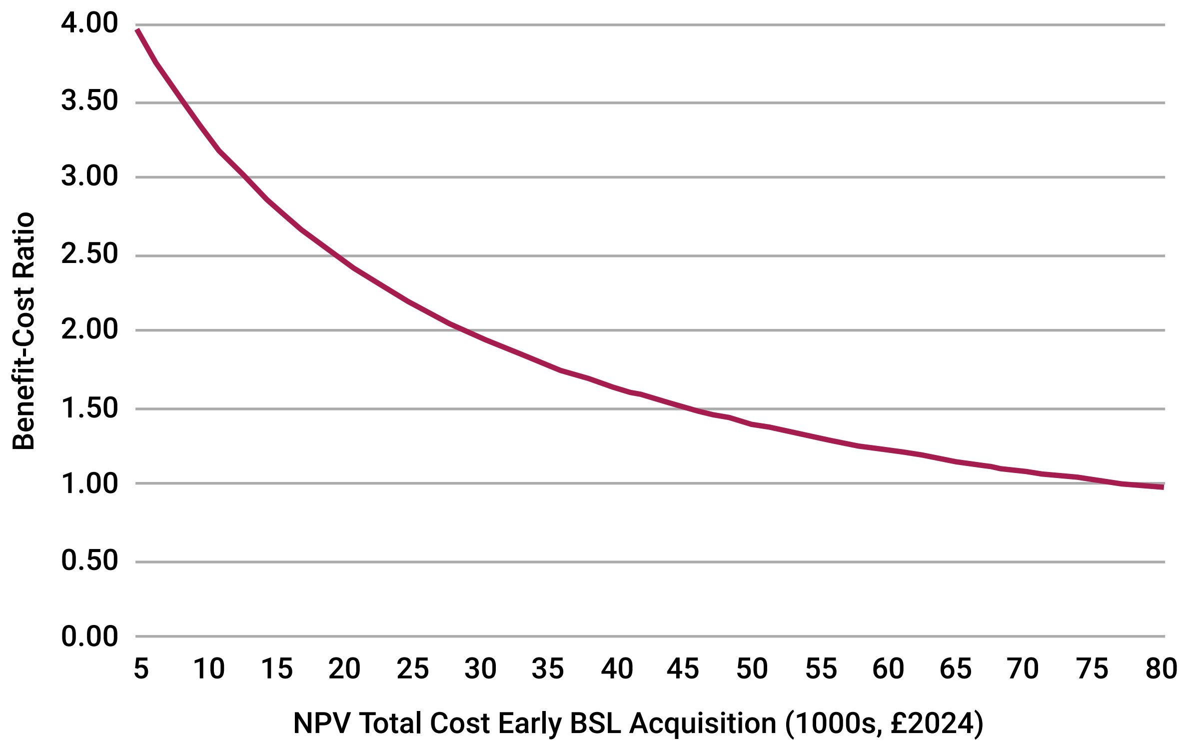
For the base-case input value assumptions, Table 4.1 suggests an estimated cumulative benefits amount of approximately £24.3 million for the cohort, equivalent to £97,111 per child. These gains are driven predominantly by improved employment outcomes and quality-of-life improvements, with healthcare cost savings from avoiding adverse outcomes linked to language deprivation contributing an additional £0.53 million (£2,118 per child). Lifetime costs are estimated at £10.4 million (£41,560 per child), of which £5.5 million (£22,012 per child) reflects BSL acquisition up to age five, and £4.9 million (£19,548 per child) reflects additional employment support costs. Taken together, the estimated BCR for the base case is 2.34, implying that every £1 invested in early-years BSL provision yields approximately £2.34 in benefits, relative to a situation in which the child would not have acquired BSL nor had access to other interventions such as hearing technologies.

For the high-cost/low-benefit input value assumptions, the estimated BCR is 0.51. Thus, even under highly pessimistic and conservative input combinations, roughly half of the investment is returned over the lifetime horizon. It is likely that including the many potential benefits of BSL that were not quantified (e.g. cultural capital, social inclusion, improved healthcare service access) would move the BCR estimates closer to the break-even point of 1. Conversely, the estimated BCR for the low-cost/high-benefit input value assumptions is 16.52, or a £16.52 return for every £1 invested. The wide range between BCRs calculated in the pessimistic and optimistic parameter combinations reported in Columns (2) and (3) of Table 4.1 highlights the inherent uncertainty in modelling. Notably, the midpoint of this BCR range (between 0.51 and 16.52) is about 8.5, suggesting that each £1 invested returns £8.50, which is substantially more favourable than the BCR reported for the base-case analysis and suggests that the central results may understate the true economic return in contexts where early-years BSL provision is delivered efficiently or where its benefits are more fully realised. Furthermore, if only the quantified quality-of-life benefits and direct healthcare cost savings are considered, to avoid the risk of double-counting the productivity and quality-of-life effects, a BCR of 2.52[12] is estimated for the base case, ranging between 0.51 and 22.25.

Given the uncertainty surrounding the costs of early-years BSL acquisition, Figure 4.1 explores the sensitivity of the base-case BCR estimates to a wide range of values for the total discounted cost inputs assumed to adequately acquire BSL in the early years, holding all other cost and benefit inputs (employment support cost, healthcare cost savings, employment gains, quality-of-life gains) constant. For example, for a total BSL acquisition cost of £5,000 per child, the estimated BCR is approximately 4. Even at a total cost of £45,000 per child, the BCR remains well above 1, suggesting a return of £1.50 for each £1 invested. The BCR falls below 1, suggesting that the investment would not fully break even, only for relatively high total cost values, at around £80,000. These results indicate that, within plausible cost ranges, the investment in early-years BSL provision is highly likely to deliver net positive social returns. Full details of sensitivity estimates are reported in Annex D.

12 Calculated as (53,328 + 2,118)/22,012.

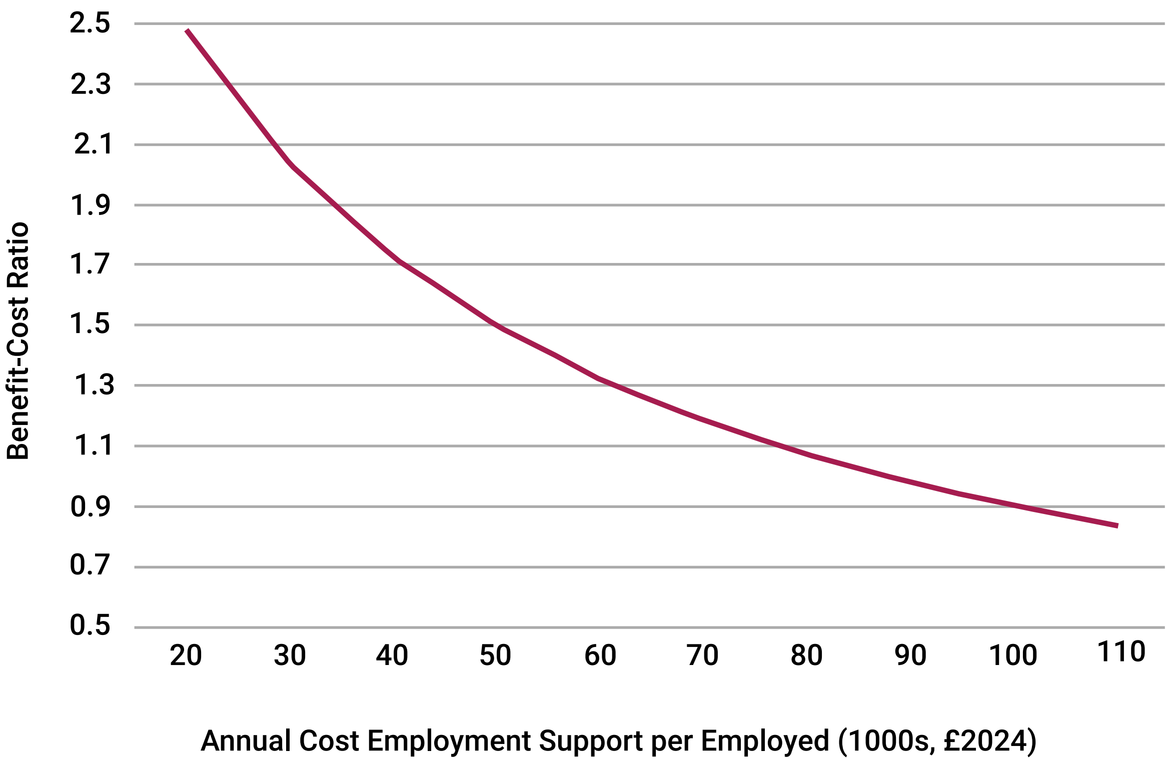
Figure 4.1. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) for a range of BSL acquisition costs – Scenario 1 versus Scenario 0



Note: Entries represent the BCR for a range of assumed total cost estimates for early-years BSL acquisition for the modelled cohort, holding all other costs (employment support) and benefits (quality of life, healthcare cost savings, employment) per person inputs (as reported for the base-case analysis in Column (1) of Table 4.1) constant.

Uncertainty also applies to the costs of long-term employment support. The base-case analysis assumes an average employment support cost of about £22,000 per year, ranging between £16,000 and £32,000. As discussed, depending on the job type, these costs could be higher or lower, depending on the need for interpreters and other support in daily work life. Figure 4.2 illustrates the base-case BCR estimates across alternative annual employment support cost ranges, again holding all other cost and benefit inputs (BSL acquisition cost, healthcare cost savings, employment gains, quality-of-life gains) constant.

Figure 4.2. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) for a range of employment support costs – Scenario 1 versus Scenario 0



Note: Entries represent the BCR for a range of assumed average annual employment support costs in the modelled cohort, holding all other costs (BSL acquisition) and benefits (quality of life, healthcare cost savings, employment) per person inputs (as reported for the base-case analysis in Column (1) of Table 4.1) constant.

For the base case, the BCR is still about 1.5 at annual employment support costs of £50,000 and falls below 1 at an annual average cost of roughly £85,000. This suggests that the economic case for BSL acquisition is not particularly sensitive to employment support costs unless these rise to relatively high levels for the average person in the modelled cohort. Full details of sensitivity estimates are reported in Annex D.

As discussed, while the cohort simulation adopts an 80-year lifetime horizon, consistent with health economics evaluation practice, HM Treasury's Green Book (HM Treasury 2024) advises against horizons beyond 50 years where possible. To test sensitivity with regards to the modelled time horizon, Table 4.2 replicates the analysis with a 50-year time horizon.

Table 4.2. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 1 versus Scenario 0

	(1)		(2)		(3)	
Cost inputs	**Base**		**High**		**Low**	
Benefit inputs	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,231,915	16,928	10,014,669	40,059	1,543,822	6,175
Total costs	**9,734,976**	**38,940**	**18,772,133**	**75,089**	**4,113,129**	**16,452**
Benefits						
Healthcare cost savings (ACE)	396,070	1,584	105,247	421	944,836	3,779
Employment gains	7,979,704	31,919	4,504,077	18,016	11,351,735	45,407
Quality-of-life gains	11,500,909	46,004	3,694,331	14,777	48,740,078	194,960
Total benefits	**19,876,683**	**79,507**	**8,303,655**	**33,214**	**61,036,649**	**244,146**
Benefit–Cost Ratio (BCR)						
	2.04		**0.44**		**14.84**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. Benefit–Cost Ratios are calculated by dividing the present value of total benefits by the present value of total costs. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Overall, the length of the time horizon does not substantially affect the magnitude of the BCR estimates. Under the base case, the BCR falls modestly from 2.34 (80-year horizon) to 2.04, implying that after 50 years each £1 invested still returns approximately £2. Results reported across the more pessimistic and optimistic input parameter combinations – Columns (2) and (3) of Table 4.2 – are similar to the 80-year time horizon, with BCRs reducing modestly in magnitude, ranging from 0.44 to 14.84, respectively. Considering only the quality-of-life and healthcare cost savings and comparing them against the cost of early-years BSL acquisition using a 50-year time horizon suggests a BCR for the base case of 2.16,[13] ranging between 0.43 and 19.34 for the other cost and benefit input value combinations.

Table 4.3 presents the estimated ACERs , comparing Scenario 1 against the baseline Scenario 0. The ACERs are calculated by dividing the NPV of the BSL acquisition costs by the cumulative discounted DALYs averted over the modelled time horizon. As for the BCR estimates presented above, results are reported under alternative input assumptions for costs and benefits, and for both 80-year and 50-year time horizons.

13 Calculated as (46,004 + 1,584)/22,012.

Table 4.3. ACERs associated with early-years BSL acquisition – Scenario 1 versus Scenario 0

	(1)		(2)		(3)	
Cost inputs	**Base**		**High**		**Low**	
Benefit inputs	**Base**		**Low**		**High**	
Horizon	**80y**	**50y**	**80y**	**50y**	**80y**	**50y**
DALYs averted	533.3	460.0	331.5	284.2	798.9	696.3
BSL acquisition (£2024)	5,503,061	5,503,061	8,757,464	8,757,464	2,569,307	2,569,307
ACER (£2024)	**10,319**	**11,962**	**26,416**	**30,817**	**3,216**	**3,690**

Note: ACERs are calculated by dividing the present value of total early-years BSL acquisition costs by the total discounted DALYs averted. All monetary values are reported in £2024 prices. 80y = 80-year time horizon; 50y = 50-year time horizon.

In the base-case analysis, early-years BSL acquisition is estimated to avert approximately 533 DALYs over an 80-year horizon (460 DALYs over 50 years) at a cumulative discounted cost of £5.5 million, yielding an ACER of £10,319 per DALY averted (rising modestly to £11,962 under a 50-year horizon). Under less favourable assumptions, where costs are higher and benefits lower, the number of DALYs averted falls to 332 (284 over 50 years) while total costs rise to £8.8 million, producing an ACER of £26,416–£30,817 per DALY averted. Conversely, under optimistic assumptions, early-years BSL averts approximately 799 DALYs, with acquisition costs falling to £2.6 million, resulting in a highly favourable ACER of £3,216 –£3,690 per DALY averted across both time horizons.

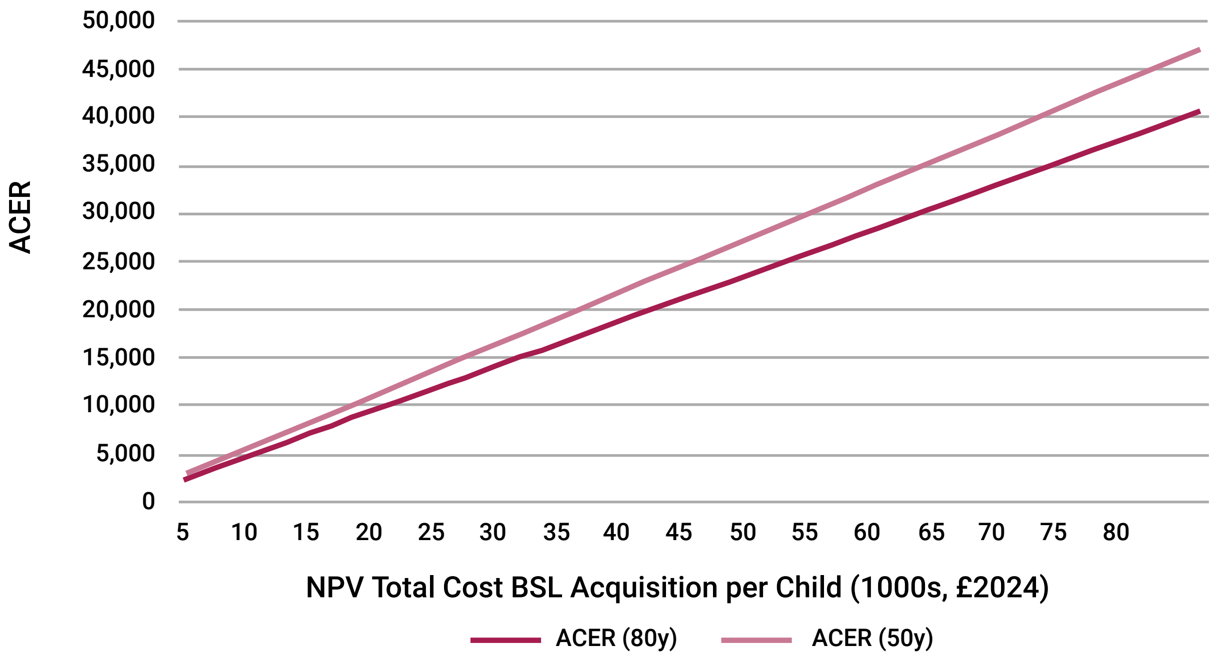
The relevance of these results is twofold. First, across all parameterisations the ACERs fall well below the implicit cost-effectiveness thresholds commonly applied, whether based on NICE guidance (£20,000–£30,000 per QALY) or HM Treasury's Green Book benchmark (£70,000 per QALY/DALY), as well as international thresholds for DALYs, assumed at 1.5 times a country's GDP per capita (Tordrup et al. 2022).[14] Even under pessimistic assumptions, the ACERs remain within the range that would generally be regarded as cost-effective, while in base and optimistic cases the ratios are substantially more favourable. Second, the comparison of 80-year and 50-year horizons demonstrates that shortening the horizon reduces the DALYs accrued, and thus raises the ACER, but the impact is modest and the acquisition of BSL in the early years remains cost-effective under both time perspectives.

Figure 4.3 illustrates how for the base-case analysis, the ACER varies with different assumptions regarding the total NPV of BSL acquisition costs per child, under both 80-year and 50-year model horizons. As expected, the ACER increases linearly with higher cost assumptions, since the denominator (DALYs averted) is held constant while the numerator (costs) rises. The results highlight two important features. First, the ACERs remain well within accepted cost-effectiveness

14 For example, if the UK GDP per capita in 2024 was £37,000, then the threshold for the valuation of a DALY is £55,500, which is well above the ACERs reported in Table 4.3.

thresholds under both horizons, even at relatively high cost levels. For example, at an acquisition cost of £45,000 per child, the ACER is approximately £25,000 for the 80-year horizon and just over £30,000 for the 50-year horizon. Second, the difference between the 80-year and 50-year horizons is consistent but modest: shortening the time horizon increases the ACER due to fewer DALYs being accrued, but the two curves remain close in magnitude across the cost range. Overall, the figure underscores the robustness of the cost-effectiveness case for early-years BSL acquisition. Even under scenarios with high acquisition costs, the intervention continues to deliver relatively favourable ACERs.

Figure 4.3. ACERs associated with early-years BSL acquisition for a range of BSL acquisition costs –Scenario 1 versus Scenario 0



Note: Entries represent for the base-case analysis the ACERs for a range of assumed total cost estimates for early-years BSL acquisition for the modelled cohort, holding DALYs averted constant.

4.2. Economic returns of investing in early-years BSL acquisition alongside hearing technologies

As discussed, Scenario 2 simulates a policy experiment in which all deaf children in the modelled cohort acquire BSL in the early years, but the majority also gain access to hearing technologies such as hearing aids or cochlear implants. Within this scenario analysis, it is assumed that only a minority of around 10 per cent of the modelled cohort will use BSL as their primary mode of communication without reliance on hearing technologies. This estimate is motivated by existing evidence on the proportion of pupils in UK schools who report BSL as their preferred mode of communication (CRIDE 2023a).[15] Nevertheless, even among those children who receive hearing technologies and follow a predominantly spoken-language pathway, existing evidence highlights that such technologies do not always provide sufficient or consistent auditory input, particularly in the critical period between birth and age five. This creates a residual risk of language deprivation and its associated adverse outcomes. In the simulation analysis, it is therefore assumed that the ability to communicate in BSL can mitigate these risks for a subset of children who, despite using hearing technologies, may not achieve adequate spoken-language development. This group is denoted as the BSLT at-risk group. To account for uncertainty regarding its size, the analysis varies the share of children in this group across a range of values: 0 per cent; 5 per cent; 10 per cent; 15 per cent; 20 per cent; 25 per cent; and 30 per cent of the cohort.

Table 4.4 reports the BCRs for early-years BSL under Scenario 2, where all deaf children acquire BSL but only a subset – those who choose BSL as their primary mode of communication and the BSLT at-risk group – derive measurable benefits, because for this group hearing technologies alone are insufficient to guarantee robust (spoken) language acquisition. The analysis varies the proportion of this at-risk group from 0 to 30 per cent, under three sets of cost and benefit assumptions (base, high-cost/low-benefit and low-cost/high-benefit), and for both an 80-year and a 50-year time horizon. The results highlight the critical role of the assumed size of the at-risk group. For example, considering an 80-year time horizon, when no children from the BSLT group are assumed to benefit directly (0 per cent), the BCR falls below 1 under both base (0.78) and high-cost/low-benefit (0.21) assumptions, although it demonstrates a positive return on investment (3.34) under low-cost/high-benefit assumptions. As the share of the at-risk group increases, the BCR improves gradually. Under base-case assumptions, the intervention becomes cost-saving once 15 per cent of children in the BSLT group are assumed to benefit directly from the ability to communicate in BSL (BCR = 1.04), rising to 1.3 if 30 per cent benefit. Under low-cost/high-benefit assumptions, BCRs are consistently high, ranging from 3.34 at 0 per cent to 7.79 at 30 per cent.

15 It is important to note that CRIDE is based mostly on measures reported by teachers on classroom language and therefore may not directly be a measure of individual language preferences of deaf children. Therefore, the 9 per cent reported in CRIDE (2023a) and applied 10 per cent could be an underestimation of the size of this group. The larger this group, all else equal, the larger the estimated BCRs and the lower the estimated ACERs.

Table 4.4. Benefits and costs associated with early-years BSL acquisition – Scenario 2 versus Scenario 0

	(1)		(2)		(3)	
Cost inputs	**Base**		**High**		**Low**	
Benefit inputs	**Base**		**Low**		**High**	
Horizon	**80y**	**50y**	**80y**	**50y**	**80y**	**50y**
At risk (BSLT): %	**Benefit–Cost Ratio (BCR)**					
0	0.78	0.64	0.21	0.17	3.34	2.84
5	0.87	0.72	0.22	0.19	4.09	3.51
10	0.95	0.80	0.24	0.20	4.83	4.18
15	1.04	0.88	0.26	0.22	5.57	4.85
20	1.13	0.96	0.27	0.23	6.31	5.52
25	1.22	1.03	0.29	0.25	7.05	6.19
30	1.30	1.11	0.31	0.26	7.79	6.86

Note: Benefit–Cost Ratios are calculated by dividing the present value of total benefits by the present value of total costs. All monetary values are reported in £2024 prices. 80y = 80-year time horizon; 50y = 50-year time horizon.

Shortening the horizon from 80 to 50 years reduces the magnitude of accrued benefits, thereby lowering BCRs across all levels of assumed at-risk children in the BSLT group. The effect is, however, modest: even under a 50-year horizon, BCRs remain positive in the base case once about 25 per cent of children are assumed to benefit. The midpoint of this BCR range (between 0.25 and 6.19) is about 3.22, suggesting that each £1 invested returns £3.22 for the 25 per cent of children with hearing technologies at risk assumption. More details for the results presented in Table 4.2. are reported in Annex D.

Table 4.5 reports the ACERs of early-years BSL acquisition under Scenario 2. As in Table 4.4, results are presented across three cost–benefit parameter combinations (base, high-cost/low-benefit, low-cost/high-benefit) and two time horizons (80-year and 50-year). The findings reveal substantial variation depending on both the assumed size of the at-risk group and the cost–benefit parameterisation. Under base-case assumptions, ACERs begin above the government threshold when no children in the BSLT group are assumed to benefit (£102,855 at the 80-year horizon; £119,534 at the 50-year horizon), but decrease steadily as the at-risk group size increases. Where 10 per cent of children are in the at-risk BSLT group, the ACER drops to £51,447 (at the 80-year horizon) and £59,771 (50-year horizon), which is below the £70,000 government threshold for the value of a QALY. From 15 per cent onwards, ACERs fall closer to the NICE threshold, with values of £41,166 (80y) and £47,818 (50y), and continue to improve, reaching £25,743 (80y) and £29,889 (50y) at 30 per cent. Thus, in the base case, early years BSL acquisition becomes cost-effective from a government perspective once at least 10 per cent of children benefit, and from a healthcare-sector perspective once at least 15 per cent of children benefit.

Table 4.5. ACERs associated with early-years BSL acquisition – Scenario 2 versus Scenario 0

At risk BSLT: %		(1)		(2)		(3)	
	Cost inputs	Base		High		Low	
	Benefit inputs	Base		Low		High	
	Horizon	80y	50y	80y	50y	80y	50y
	BSL acquisition cost (£2024)	5,503,061	5,503,061	8,757,464	8,757,464	2,569,307	2,569,307
0	DALYs averted	53.5	46.0	33.2	28.4	80.3	69.8
	ACER (£2024)	102,855	119,534	263,840	308,373	31,979	36,833
5	DALYs averted	80.2	69.1	49.8	42.6	120.5	104.6
	ACER (£2024)	68,583	79,692	175,911	205,585	21,327	24,557
10	DALYs averted	107.0	92.1	66.4	56.8	160.6	139.5
	ACER (£2024)	51,447	59,771	131,946	154,191	16,000	18,419
15	DALYs averted	133.7	115.1	83.0	71.0	200.7	174.4
	ACER (£2024)	41,166	47,818	105,567	123,354	12,804	14,736
20	DALYs averted	160.4	138.1	99.5	85.2	240.7	209.2
	ACER (£2024)	34,311	39,850	87,981	102,796	10,674	12,281
25	DALYs averted	187.1	161.1	116.1	99.4	280.7	244.1
	ACER (£2024)	29,415	34,158	75,420	88,112	9,152	10,527
30	DALYs averted	213.8	184.1	132.7	113.6	320.8	278.9
	ACER (£2024)	25,743	29,889	65,999	77,099	8,010	9,212

Note: ACERs are calculated by dividing the present value of total early-years BSL acquisition costs by the total discounted DALYs averted. All monetary values are reported in £2024 prices. 80y = 80-year time horizon; 50y = 50-year time horizon.

As discussed above, the high-cost/low-benefit input assumption represents a deliberately conservative case. Here, ACERs remain well above £70,000 across all at-risk group sizes and both horizons, ranging from £263,840 (80y) at 0 per cent to £65,999 (80y) at 30 per cent. While these values exceed conventional cost-effectiveness thresholds, they provide a useful upper bound on the uncertainty range. By contrast, under low-cost/high-benefit assumptions, early-years BSL acquisition is consistently considered to be cost-effective given existing thresholds. ACERs start at £31,979 (80y) and £36,833 (50y) even when no children in the BSLT group are assumed to benefit, both very close to the upper NICE threshold. With as few as 5 per cent of children benefitting, ACERs fall to £21,327 (80y) and £24,557 (50y), which is below £25,000. At higher at-risk proportions, cost-effectiveness strengthens further: by 30 per cent, ACERs are as low as £8,010 (80y) and £9,212 (50y). Across all analyses, shortening the horizon from 80 to 50 years marginally raises ACERs, reflecting the loss of later-life benefits. This does not, however, change the overall conclusions regarding cost-effectiveness.

4.3. Discussion

The economic analysis presented in this chapter suggests that early access to BSL for deaf children is likely a cost-effective investment that can yield a positive economic return under plausible assumptions. For instance, compared to a situation where a child born with permanent severe-to-profound deafness would not receive access to hearing technologies such as hearing aids or cochlear implants, acquiring BSL in the years between birth and the age of five is associated with a BCR of 2.34 over an 80-year time horizon, or in other words, £1 invested yields a return of £2.34 under base-case input assumptions. How does this compare to other similar programmes or interventions?

Introduced in 1999 across England, *Sure Start* was a large-scale early-years programme that aimed to improve the life chances of children under five, particularly those growing up in disadvantaged communities, through integrated early-childhood services delivered at the local level. Two key areas of focus were school readiness and children's health, and it has been suggested that the programme has returned £2.05 for each £1 invested over the long run (Carneiro et al. 2025). Furthermore, an economic assessment of the expansion of modern (spoken) language education suggests a return of about £2 for each £1 invested in promoting Arabic, Mandarin, French or Spanish education in UK secondary schools (Ayres-Bennett et al. 2022). A cost–benefit analysis with a 50-year time horizon for an auditory-verbal therapy (Auditory Verbal UK 2016) found a return of about £4 for each £1 invested. In that study, increased earnings were the most significant contributor to the benefits, followed by better quality of life and increased employment. The Auditory Verbal UK (2016) study assumes that the programme is associated with one year more of schooling, which is then translated into a 15 per cent productivity gain over the lifetime, assuming that a person earns each year 15 per cent more than in the absence of the intervention.

The analysis presented in this study does not model productivity gains through better education, but rather through health, suggesting that early access to BSL is associated later with a productivity gain of about 4 percentage points, or about a third of the productivity gains assumed in the Auditory Verbal UK (2016) analysis. If the productivity gains of the auditory-verbal-therapy analysis were omitted, the intervention would return about £2 for each £1 spent. Down-scaling their productivity gain to 26 per cent of the originally assumed value[16] would yield a return of around £2.80 per £1 invested, which is comparable to the base-case BCR of 2.04 estimated for early-years access to BSL over a 50-year time horizon.

Overall, the estimated magnitude of economic returns for early access to BSL is well within the range observed for similar types of interventions that either enhance language development or target early-years human-capital formation. Nevertheless, direct comparison across studies should be made cautiously, given differences in methodological frameworks, parameter inputs and valuation approaches that inevitably affect the magnitude of reported economic returns.

16 Calculated as dividing 4 by 15.

Chapter 5. **Conclusions and recommendations**

5.1. Conclusions

The economic analysis assesses the long-term economic value of early-years BSL acquisition for deaf children born to hearing parents under different scenarios. While the findings of this study broadly suggest that early access to a signed language such as BSL can be considered a human-capital investment that could yield favourable economic returns, several limitations merit emphasis when interpreting the results. For example, the modelling framework applied for this analysis simulates stylised and homogeneous cohort dynamics with uniform age thresholds for education, work and retirement decisions and abstracts from heterogeneity in family circumstances, educational trajectories, local provision of sign-language support and individual variation in employment-support requirements. Many of the analysis' parameter inputs, in particular the long-term health, employment and quality-of-life effects of early sign-language exposure, are constrained by cross-sectional evidence and limited UK-specific longitudinal data, requiring assumptions to link early-years BSL acquisition to lifetime outcomes. Health effects are included in the analysis through three health conditions associated with adverse childhood experiences (diabetes, cardiovascular disease and depression/anxiety disorders), but other potential areas of impact have been omitted, such as improved healthcare access for sign-language users, and the analysis does not capture broader well-being or cultural gains from Deaf identity and community participation, likely biasing estimated benefits downward. A further limitation concerns the valuation of quality-of-life benefits. The analysis quantifies outcomes using DALYs, while interpretive value thresholds are drawn from the QALY framework, meaning the cost-effectiveness benchmarks should be viewed as approximate rather than exact. In addition, a broader well-being valuation approach (e.g. WELLBY) could not be applied because existing UK data sources do not reliably identify BSL users, limiting the ability to capture wider effects on identity, inclusion, and social participation. Furthermore, the applied scenario analysis assumes that in the absence of acquiring adequate sign-language skills or access to hearing technologies, early language deprivation and its associated adverse effects on lifetime outcomes are guaranteed. In reality, however, other communication tools could also reduce the risk of language deprivation, but currently with more limited evidence to assess their relative effectiveness.

Taken together, the results of the economic analysis provide an indicative assessment that early-years BSL acquisition is likely to be cost-effective and provides positive economic returns under plausible assumptions, while also clarifying where improved evidence would improve the robustness of the findings.

First, in Scenario 1, where it is assumed that deaf children acquire BSL in the early years and are compared with a 'no-intervention' baseline, acquiring BSL is associated with a base-case BCR of 2.34 over an 80-year time horizon, or in other words, £1 invested yields a return of £2.34, which falls modestly to a return of £2.04 over a 50-year horizon. The cost for each unit of quality of life – measured as DALYs averted, the so-called ACER – is estimated at £10,300 per DALY averted over an 80-year horizon, rising to £12,000 at the 50-year horizon. Under the conservative high-cost/low-benefit input value assumptions, the BCR falls to 0.51 and the ACER rises to £26,000 for the 80-year time horizon (£30,817 for the 50-year horizon), whereas for the optimistic low-cost/high-benefit input assumptions the BCR increases to 16.5 and the ACER falls to £3,200 per DALY averted. These results indicate that without any additional consideration for further use of hearing technologies, acquisition of BSL in the early years is a cost-effective intervention within applied valuation thresholds and likely to generate net positive economic returns under a variety of plausible input assumptions. For example, the estimated 80-year-horizon BCR ranges between 0.51 and 16.5 with a midpoint of 8.5, suggesting that each £1 invested returns more than £8. This is more favourable than the BCR reported for the base-case analysis, implying that the central results may understate the true economic return in contexts where BSL provision is delivered efficiently or where its benefits are more fully realised.

By contrast, Scenario 2 considers the potential economic value of universal early access to BSL for all deaf children born to hearing parents alongside widespread uptake of hearing technologies in this population and assumes that only a subset of deaf children will realise measurable benefits from early-years BSL acquisition, including the proportion of deaf children that will follow a BSL pathway and those with uptake of a hearing technology alongside spoken language but who remain at risk for language deprivation and associated adverse outcomes due to inadequate technology use. Here, cost-effectiveness and the economic return depend on the size of the at-risk subset population. In the base case, the BCR rises from 0.78 (0 per cent at risk) to 1.30 (30 per cent at risk) calculated over an 80-year horizon, exceeding the break-even threshold of 1 once about 15 per cent of children at risk of language deprivation in the technology-use group are assumed to benefit directly from BSL. The corresponding ACER falls from £103,000 per DALY (0 per cent at risk) to £25,700 (30 per cent at risk), crossing the £70,000 government value benchmark for a QALY/DALY at 10 per cent at risk and approaching the £25,000 threshold for a QALY/DALY by 30 per cent at risk. Under high-cost/low-benefit input assumptions, BCRs remain below 1 across the range, and under low-cost/high-benefit inputs, BCRs are persistently larger than 3 even if no deaf children that use hearing technologies are assumed to be at risk, and ACERs fall well below £25,000 once about 5 per cent of this population are assumed to be at risk. Scenario 2 shows that universal early-years BSL acquisition under the ‘precautionary principle’ can be cost-effective and provide a positive economic return even when only a minority ultimately depend on BSL, with the economic case strengthening as the at-risk share of the population of deaf children with access to hearing technologies increases.

Priorities for future research include longitudinal studies that can track language exposure, educational trajectories and adult outcomes, including health and well-being, as well as more systematic evaluation of interactions between BSL and hearing technologies such as hearing aids and CIs. Such future research would allow more precise and robust estimation of economic returns than are presented in this study.

5.2. Recommendations

To realise the potential individual and societal gains outlined above, there is a need to implement several coordinated actions. Based on the evidence and findings presented in this report, three recommendations emerge.

1. **Ensure early access to BSL for deaf children.** Currently, only about 9 per cent of severely deaf pupils in Britain use BSL in education, whereas the majority use hearing technologies such as hearing aids or cochlear implants. Specifically, hearing parents of children born deaf are often steered toward oral and technology-based methods without complete information about sign-language options. Informed parental choice is crucial, as families should understand that early bilingual (sign language + spoken language) exposure can enhance cognitive development and educational success. Normalising access to BSL from infancy can potentially reduce the risk of language delays, improve school readiness and ensure that no deaf child is left behind if technology falls short or is inadequately used. This foundation likely can reduce adverse outcomes and economic costs over the lifetime of a deaf individual. And as the evidence in this report suggests, early access to BSL likely provides good value for money.

2. **Invest in research on BSL outcomes.** Dedicated research funding is necessary to address critical knowledge gaps regarding the long-term impacts of early-years BSL acquisition. Many of the benefits suggested in this report, from improved academic achievement to better mental health, rely on limited or correlational evidence. The UK, in particular, lacks robust evidence and studies that can disentangle the effects of BSL exposure from other factors. Government and academic funding bodies should support new research to rigorously evaluate BSL interventions across various domains, including child development, education, employment and health outcomes. Prioritising larger sample sizes and long-term follow-up will help address current methodological limitations and build a stronger evidence base. With better data, policymakers can more confidently assess the returns on BSL programmes and optimise services.

3. **Integrate BSL better into data-collection efforts.** There is a need to ensure that major public surveys and administrative databases capture BSL usage to enable better population-level analysis. Currently, the UK Census, conducted only once every decade, is one of the few data sources that identify sign-language users. It revealed, for example, that only 37 per cent of working-age adults who use BSL as their primary language are employed, compared to 77 per cent of non-disabled adults. Such cross-sectional data points, however, do not help identify key barriers and long-term outcomes for deaf BSL users. In most existing UK data sources, including the Labour Force Survey, do not directly enable data users to distinguish BSL users, making it impossible to track their outcomes or needs over time. Adding a simple BSL identifier in such data sources would enable further research.

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Annex A. **A dynamic cohort simulation model – technical details**

A.1. Model overview

We apply a dynamic age-structured cohort simulation with annual updating of mortality, morbidity and employment outcomes to simulate the life courses of a cohort of children born with severe-to-profound hearing loss to hearing parents. The modelling approach is closely related to the Markov state transition modelling approach frequently applied in health economic evaluation (Iskandar & Berns 2023). Unlike completely mutually exclusive states used in a Markov model, however, this cohort model tracks a population cohort from birth in annual cycles with a distribution of overlapping attributes (e.g. employment and health conditions). Thus, states are combinations of individual-level characteristics and not separate discrete states that each cohort member must fall into exclusively in every given model cycle.

In essence, the model compares two stylised populations, which vary by their sign language status, *SL:* (i) a cohort of individuals who acquire BSL in early-years, denoted the BSL group; and (ii) those who not acquire BSL but also do not have access to hearing technologies and unable to develop adequate spoken language abilities, denoted the NBSL group. Both groups are then compared across differences in employment probabilities, and age-specific risks for three chronic health conditions (diabetes, cardiovascular disease (CVD) and depression/anxiety disorders), along with associated mortality and productivity losses.

The model implicitly tracks the following states:

- *Death*, which is an absorbing state, meaning that once entered no further transitions into other states are possible. All individuals that are not in the *Death* state are in the *Alive* state.
- Between the ages of 5 and 20, individuals in the simulated cohort are in the *Education* state.
- Once they reach the age of 20, individuals can enter either the *Employed* state or the *Not Employed* state, in which they remain until the age of 65.
- Above the age of 65, assumed to be the legal retirement age, individuals exit the workforce if they have been in the *Employed* state and all *Alive* cohort members enter the *Retired* state until age 80, when the cohort automatically enters the *Death* state.
- Across the full age distribution of the modelled cohort, everyone in the *Alive* state can either be *Healthy* or *Unhealthy*, the latter determined by whether the individual has a certain health condition such as diabetes, cardiovascular disease or depression or anxiety.

The model simulates annual transitions for a cohort from birth to age 80. The transitions into the different states and the likelihood of a health condition developing depend on whether the individual is in the BSL or the NBSL group. For each year of life, individuals are exposed to:

- Age-specific baseline mortality
- Workforce participation dynamics (ages 20 to 65 only)

- Age-specific probabilities of developing health conditions, which lead to:
  - Higher morbidity (e.g. measured through disability weights)
  - Higher relative risks of mortality
  - Resulting productivity losses due to mortality and morbidity
  - Resulting quality-of-life losses due to mortality and morbidity

The cohort size for the base case is fixed at 250 individuals, and all metrics are tracked across time. The analysis runs three different scenarios: Scenario 0, in which the cohort does not receive early-years BSL provision (NBSL group); and Scenario 1, in which the cohort receives early-years BSL provision (BSL group); and Scenario 2, in which only a fraction of the cohort receives access to the benefits associated with early-years BSL acquisition. The model is implemented and run in Python.[17]

A.2. Model dynamics

The following inputs are relevant for the model:

C cohort size

$P_a^{Alive,SL}$ cohort population alive at age *a*

$P_a^{Work,SL}$ cohort population employed at age *a*

m_a age-specific baseline mortality rate

m_a^{eff} age-specific effective mortality rate

s_a age-specific survival probability

D_a cohort population dead at age *a*

d_a cohort population that died at age *a*

W_a working days

DW^{SL} disability weight associated with hearing status

DW_a^h disability weight associated with health condition *h* ∈ *(diabetes, cvd, depression)*

17 See: https://www.python.org/.

$\beta_a^{Work,SL}$ probability of being employed

$\beta_a^{h,SL}$ probability of developing a health condition *h* ∈ *(diabetes, cvd, depression)*

I_a^h age-specific baseline incidence rate (e.g. cases out of 100,000 people) associated with health condition

θ^h relative risk of developing a health condition due to adverse childhood experience associated with sign-language status

m_a^h relative mortality risk associated with health condition

E_a^h number of new cases for each health condition

γ_a relative mortality multiplier

At each age, *a*, depending on sign language status *SL*, the model computes several different outcomes, across the following model dynamics:

The population alive each year is determined by:

$$P_a{}^{Alive,SL} = C - D_a$$

The probability of developing a health condition at age *a* is determined by:

$$\beta_a^{h,BSL} = I_a^h \;\; if\, a \geq 20$$ [18]

$$\beta_a^{h,NBSL} = I_a^h \, * \, \theta^h \, if\, a \geq 20$$

where $\theta^h > 1$.

With regards to health conditions associated with early-years language deprivation, diabetes and cardiovascular disease are treated as long-term chronic conditions, whereas depression/anxiety is treated as a recurrent acute condition. Accordingly, at each annual cycle (indexed by age *a*), the number of new cases (incident events) of diabetes and cardiovascular disease is determined by applying the age-specific incidence rate to the remaining population at risk, that is, the cohort alive at age ***a*** minus those who have already developed the condition in any previous cycle. Formally, the number of new events for these chronic conditions[19] is given by:

$$E_a^{h,SL} = \left(P_a^{Alive,SL} - \sum_i^{a-1} E_a^{h,SL}\right) * \; \beta_a^{h,SL}$$

18 Note that for depression/anxiety, the starting age for onset of the condition is age 5 rather than 20.

19 *h* ∈ (*diabetes, cvd*)

Where $\sum_{i}^{a-1} E_a^{h,SL}$ represents the cumulative prevalence up to age *a*, which reduces the eligible population for onset of the two conditions. In contrast, depression/anxiety is modelled as an acute and potentially recurrent condition. Therefore, the population at risk does not decrease with past prevalence. The number of new depression/anxiety cases[20] is calculated as:

$$E_a^{h,SL} = P_a^{Alive,SL} * \beta_a^{h,SL}$$

For depression/anxiety annual healthcare costs are applied only to the new cases occurring in each year, reflecting the acute nature of the treatment costs assumed in the model, whereas the annual healthcare costs for diabetes and cardiovascular disease are applied to the cumulative prevalence at annual model cycle.

The number of deaths at a given age *a* is determined as:

$$d_a = P_a^{Alive,SL} * m_a^{eff,SL}$$

$$D_a = \sum_{i}^{a-1} d_a$$

Where $\mathrm{D_a}$ represents the cumulative dead population at age *a*. The effective mortality rate, m_a^{eff}, is determined by multiplying the baseline mortality rate with a weighted mortality multiplier, γ_a, which updates the relative mortality risks in the modelled cohort population based on the prevalent health conditions:

$$m_a^{eff,SL} = m_a * (1 + \gamma_a)$$

$$\gamma_a = \sum_{h} \frac{E_a^{h,SL}}{P_a^{Alive,SL}} * \left(m_a^h - 1\right)$$

The age-specific effective survival rate at each age is then determined by:

$$s_a^{SL} = \left(1 - m_a^{eff,SL}\right)$$

To estimate quality-of-life outcomes, DWs from the Global Burden of Disease (GBD 2021) study are applied to calculate DALYs for the modelled cohort across the life course. Two components contribute to the overall disability weight in each annual cycle. First, a baseline disability weight associated with sign language status, DW^{SL} is applied from age 5 onward, reflecting the assumption that individuals in the modelled cohort are either in the NBSL or BSL group from this point, with $DW^{NBSL} > DW^{BSL}$.[21] This component remains constant over time. Second, each of the health conditions modelled (cardiovascular disease, diabetes, depression/anxiety) carries

20 $h \in$ (*depression*)

21 Note that in scenario 2, it is assumed that only the population at-risk of language deprivation despite access to hearing technologies experiences the reduction in the DW^{SL} from the ability to communicate in BSL.

a condition-specific disability weight, DW^h such that onset of these conditions increases the overall adverse quality-of-life burden for the affected proportion of the cohort.

The adjusted disability weight at age *a* for each sign-language group is therefore calculated as:

$$DW_a^{adj} = DW^{SL} + \sum_h \left(\frac{E_a^{h,SL}}{P_a^{Alive,SL}} * DW^h \right)$$

The DALYs at each annual model cycle are calculated based on the YLL and YLD components as follows:

$$YLL_a = d_a * (80 - a)$$

$$YLD_a = P_a^{Alive,SL} * DW_a^{adj}$$

$$DALY_a = YLL_a + YLD_a$$

The working population in each year is:

$$P_a^{Work,SL} = \begin{cases} P_a^{Alive,SL} * \beta_a^{Work,SL}, \text{if } 20 \geq a \geq 65 \\ 0, \ otherwise \end{cases}$$

Where $\beta_a^{Work,BSL} > \beta_a^{Work,NBSL}$. Accordingly, the adjusted disability weight at age *a* for those in the working population to determine the productivity effects for each sign-language group is calculated as

$$DW_a^{adj,Work} = DW^{SL} + \sum_h \left(\frac{E_a^{h,SL}}{P_a^{Work,SL}} * DW^h \right)$$

The working days lost due to productivity impairment are then calculated as:

$$W_a^{SL} = \begin{cases} P_a^{Work,SL} * DW_a^{adj,Work} + \left(P_a^{Alive,SL} - P_a^{Work,SL} \right) + \left(d_a * \left(65 - a \right) \right) \Big) * 250, \text{if } 20 \geq a \geq 65 \\ 0, \ \text{otherwise} \end{cases}$$

Where the working days lost are determined through three different factors. First, those who are at work but are affected by a productivity impairment: $P_a^{Work,SL} * DW_a^{adj,Work}$. Second those in the working-age population but without employment: $P_a^{Alive,SL} * P_a^{Work,SL}$. Third, those who die prematurely due to a health condition before the retirement age: $d_a * (65 - a)$.

A.3. Model outputs

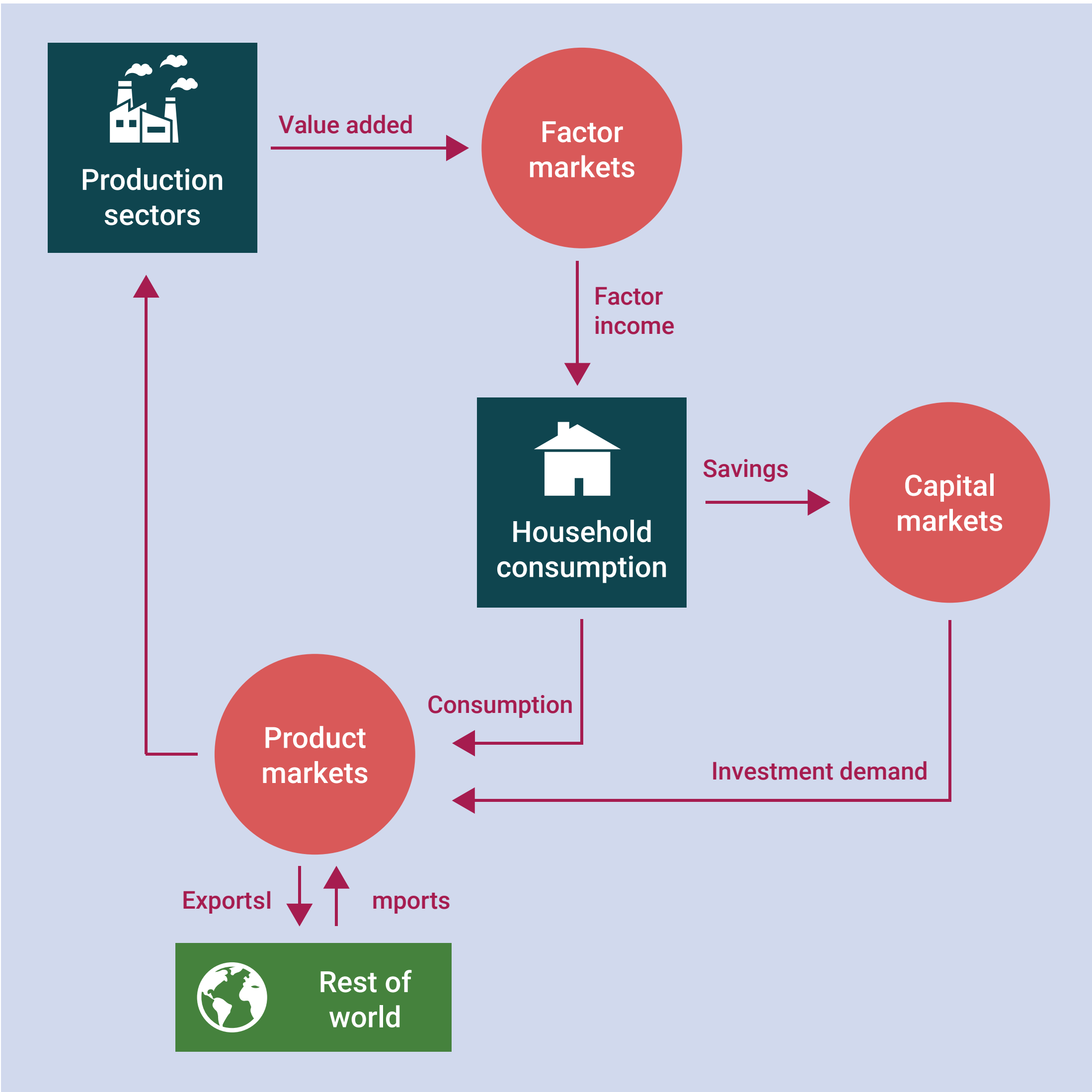
For each annual model cycle (which is equivalent to the cohort's age), the model stores the following outputs:

- Population that is alive
- Population that is dead
- Population that is in the workforce
- New cases of diabetes, CVD and depression/anxiety disorders
- Prevalence of cases of diabetes, CVD and depression/anxiety disorders
- Adjusted DW in the population
- DALYs
- Working days lost
- Healthcare costs associated with diabetes, CVD and depression/anxiety disorders

Annex B. **Assessing the employment benefits of early-years BSL acquisition in an economy-wide macroeconomic model**

To assess the value of the employment benefits associated with early-years BSL acquisition, the analysis draws on an economy-wide computable general equilibrium (CGE) model. Figure B.1 depicts some of the key interactions between the economic agents in the model. For example, just as in reality, different production sectors (e.g. agricultural, industrial and service sectors) require different capital and labour inputs, which they access through factor markets. Firms hire labour and rent capital from households, which allows households to obtain income. Goods are then sold in product markets, where households pay for them in accordance with their available income.

Figure B.1. The interactions between economic agents in the model economy



The approach depicted does not include the government, which in our model collects taxes and demands final goods. Finally, households and governments save and borrow in the capital markets. The economy also trades with the rest of the world through a complex set of international linkages. Firms in each sector produce goods and services according to specific economic production functions that require inputs such as labour, capital and intermediate inputs.

The CGE model is calibrated to a UK Social Accounting Matrix (SAM) extracted from the GTAP 11 database, which provides a consistent representation of production, consumption, trade and income flows across economic agents in the UK economy (Aguiar et al. 2022). The linkage between the cohort model and the CGE model is established via the effective labour supply channel. From the dynamic cohort simulation, cumulative working days lost between ages 20 and 65 are calculated for each scenario (e.g. NBSL and BSL), reflecting both differences in employment probabilities and productivity-adjusted labour (as proxied through disability weights). These cumulative working days lost are then used to derive an economy-wide labour efficiency parameter, $\varepsilon\varepsilon$, which scales the effective labour input in the CGE production function, such that output is represented as: $Y(K,L) = K * (L\varepsilon)$. A higher value of ε indicates greater effective labour supply for a given physical quantify of workers. Because the cohort model follows individuals over their lifetime while the CGE model is annually static, cumulative lifetime working days lost from the cohort simulation are translated into an average annual labour efficiency adjustment over the period in which the cohort is active in the labour market. Individuals are assumed to enter the labour force at age 20 and retire at age 65. Given a 2025 baseline year, this maps to the period 2045–2090. UN population projections are used to scale the cohort to the projected total UK working-age population in each year,[22] P_a^{Work} , ensuring that the productivity effects are expressed in economy-wide rather than cohort-specific terms.

The efficiency parameters for each scenario are then calculated as:

$$\varepsilon^{NBSL} = 1 - \frac{\sum_{2045}^{2090} W_a^{NBSL}}{\left(\sum_{2045}^{2090} P_a^{Work}\right) * 250}$$

$$\varepsilon^{BSL} = 1 - \frac{\sum_{2045}^{2090} W_a^{BSL}}{\left(\sum_{2045}^{2090} P_a^{Work}\right) * 250}$$

Where W_a^{NBSL} and W_a^{BSL} stem directly from the cohort model and denote annual working days lost in each scenario, and 250 represents the assumed number of working days per year. Since effective labour supply is higher under the BSL scenario due to lower long-term working day loss, it follows that $\varepsilon^{BSL} > \varepsilon^{NBSL}$. The difference between the two parameters is then introduced into the CGE model as an exogenous labour-efficiency shock, and the resulting change in gross domestic product (GDP) reflects the estimated productivity impact attributable to early BSL acquisition. The resulting annual GDP differences are then aggregated over time and discounted at 3.5 per cent to generate a net present value of productivity effects.

22 See: https://population.un.org/wpp/, using the medium variant population projections.

Using a static CGE model for this purpose is appropriate because the objective is to estimate the long-run, steady-state productivity implications of changes in effective labour supply rather than to project the full dynamic evolution of the economy over multiple decades. A dynamic CGE model would require additional inputs regarding dynamic changes technology (e.g. through total factor productivity) or capital accumulation. By contrast, the static CGE framework provides a consistent way to estimate the marginal GDP effect of labour under different scenarios if future values are discounted accordingly. Therefore, because the acquisition of BSL in a relatively small population group affects the economy primarily through an improvement in effective labour supply rather than through transitional adjustment dynamics, the long-run GDP difference estimated using a static CGE model likely closely approximates the steady-state outcome that would emerge in a dynamic CGE framework.

Annex C. **Calculating employment effects and employment support costs**

C.1. Calculating employment probabilities

To estimate differences in employment outcomes between groups, the model begins by assuming a baseline employment probability of 0.60 for the NBSL group (i.e. deaf individuals who do not acquire BSL), denoted $p_{NBSL} = 0.6$. This baseline probability is first converted into employment odds:

$$Odds_{NBSL} = \frac{p_{NBSL}}{1-p_{NBSL}} \quad (1)$$

To reflect evidence from Dammeyer et al. (2019), the odds of employment for individuals who acquire BSL are increased by the lower-bound odds ratio of 1.36. An adjustment factor . $\rho\rho$ is applied to reflect parameter uncertainty, where $\rho = 0.85$ for the base case, for the lower value input case and $\rho = 1.25$ for the higher value input case.

$$Odds_{BSL} = Odds_{NBSL} * 1.36 * \rho \quad (2)$$

These adjusted odds are then converted back into a probability to yield the employment probability for the BSL group:

$$p_{BSL} = \frac{Odds_{BSL}}{1+Odds_{BSL}} \quad (3)$$

This approach allows the model to incorporate differential employment prospects associated with early BSL acquisition while enabling systematic variation of the magnitude of the effect in sensitivity analyses. The applied employment rates are reported in Table C.1.

Table C.1. Applied employment rates for non-sign-language (NBSL) and sign-language (BSL cohort groups)

Group	Base	Low	High
NBSL	0.60	0.60	0.60
BSL	0.68	0.64	0.72

C.2. Estimating costs for additional employment support

To adjust the average Access to Work (AtW) expenditure per deaf or hard-of-hearing (DHH) person, denoted as $\bar{E}$, for a deaf BSL user ($\bar{E}_{BSL}$), we perform a set of different calculations.

Let T denote the AtW expenditure in a given year and N the corresponding number of AtW recipients of the DHH population group as reported in AtW statistics. The share of AtW recipients among the DHH population that use BSL as their preferred mode of communication is denoted as p and the share of deaf individuals with BSL as their preferred mode of communication among the DHH population group is denoted as s. The BSL specific unit cost estimate for annual employment support can then be proxied as:

$$\overline{E}_{BSL} = \frac{sT}{pN} = \frac{s}{p}\,\overline{E}$$

With the multiplier $\frac{s}{p}$ to adjust for different costs for the BSL-specific unit cost based on the publicly available $\bar{E}$ of about £12,800 in 2023/2024 (Wilkinson 2024).

The published AtW data does not provide the share of deaf BSL users within the DHH population and therefore p has to be inferred from other sources. According to AtW caseload data from 2015, out of 5,750 DHH customers, 3,084 had support awarded for BSL interpretation, suggesting a value of p of about 0.54.[23] As the estimate is older, a base-case value of 0.5 is assumed; a value of 0.6 to calculate the lower value employment support costs; and a value of 0.35 to calculate the higher value employment support costs.

According to published information, the total AtW spent on deaf people who use BSL as their first or preferred language in 2013/2014 was £25.2 million,[24] which corresponds to about 56 per cent of the total spend of £46 million for the deaf or hard-of-hearing population in that year (Wilkinson 2024). If all of that 56 per cent were to go to deaf individuals with BSL as preferred mode of communication and they would receive none of the remaining 44 per cent of expenditure on other items, such as equipment or travel, then the lower bound of s would be 0.56. If we assume, however, that the other 44 per cent of expenditure is also allocated to deaf individuals with BSL as preferred mode of communication, then s is likely to be larger. Assuming that the 44 per cent of remaining expenditure is allocated according to the value of p, we derive a base-case value for s of 0.775, ranging from 0.7075 for the lower value input assumption and 0.82 for the higher value input assumption.

Lastly, as AtW may not cover all the potential costs for employment support and employers may have to add additional resources, we multiply $\bar{E}$ (£12,800) by a factor of 1.15 for the base case (£14,720), 1.1 for the lower input value assumption (£14,080) and 1.2 for the higher value input assumption (£15,360).

It is important to highlight that the inputs for the employment support are assumed to stay constant over time within the model, therefore $\frac{s}{p}$ will fixed over time.

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23 Calculated as 3,084 divided by 5,750.

24 As of 3 November 2025: https://assets.publishing.service.gov.uk/media/5a7e352840f0b62305b817e2/foi-4093-british-sign-language-spend.pdf

Table C.2. Estimated employment support unit costs

	Base	Low	High
$\bar{E}$	14,720	14,080	15,360
p	0.5	0.6	0.35
s	0.775	0.7075	0.82
s/p	1.55	1.18	2.34
$\bar{E}_{BSL}$	22,816	16,602	35,986

Annex D. **Supplementary results**

This annex provides supplementary tables for results presented in Chapter 4.

Table D.1 reports the underlying data of Figure 4.1.

Table D.2 reports the underlying data of Figure 4.2.

Tables D.3 – D.16 report the underlying data for Table 4.4.

Table D.1. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) for a range of BSL acquisition costs – Scenario 1 versus Scenario 0

	(1)	(2)	(3)
Cost input:	**Base**	**High**	**Low**
Benefit input:	**Base**	**Low**	**High**
	Benefit–Cost Ratio (BCR)		
NPV Total Cost Early Years BSL Acquisition (£2004)			
5,000	3.96	0.81	23.70
6,000	3.80	0.79	21.90
7,000	3.66	0.78	20.35
8,000	3.53	0.76	19.01
9,000	3.40	0.75	17.83
10,000	3.29	0.73	16.79
11,000	3.18	0.72	15.86
12,000	3.08	0.71	15.04
13,000	2.98	0.70	14.29
14,000	2.89	0.69	13.61
15,000	2.81	0.67	13.00
16,000	2.73	0.66	12.44
17,000	2.66	0.65	11.92
18,000	2.59	0.64	11.45
19,000	2.52	0.63	11.01
20,000	2.46	0.62	10.61
21,000	2.39	0.61	10.23
22,000	2.34	0.61	9.88
23,000	2.28	0.60	9.55
24,000	2.23	0.59	9.24
25,000	2.18	0.58	8.96
26,000	2.13	0.57	8.69
27,000	2.09	0.56	8.43
28,000	2.04	0.56	8.19

	(1)	(2)	(3)
Cost input:	**Base**	**High**	**Low**
Benefit input:	**Base**	**Low**	**High**
	Benefit–Cost Ratio (BCR)		
NPV Total Cost Early Years BSL Acquisition (£2004)			
29,000	2.00	0.55	7.97
30,000	1.96	0.54	7.75
31,000	1.92	0.54	7.55
32,000	1.88	0.53	7.35
33,000	1.85	0.52	7.17
34,000	1.81	0.52	7.00
35,000	1.78	0.51	6.83
36,000	1.75	0.50	6.67
37,000	1.72	0.50	6.52
38,000	1.69	0.49	6.38
39,000	1.66	0.48	6.24
40,000	1.63	0.48	6.11
41,000	1.60	0.47	5.98
42,000	1.58	0.47	5.86
43,000	1.55	0.46	5.74
44,000	1.53	0.46	5.63
45,000	1.50	0.45	5.52
46,000	1.48	0.45	5.42
47,000	1.46	0.44	5.32
48,000	1.44	0.44	5.22
49,000	1.42	0.43	5.13
50,000	1.40	0.43	5.04
51,000	1.38	0.43	4.95
52,000	1.36	0.42	4.87
53,000	1.34	0.42	4.79
54,000	1.32	0.41	4.71

	(1)	(2)	(3)
Cost input:	**Base**	**High**	**Low**
Benefit input:	**Base**	**Low**	**High**
	Benefit–Cost Ratio (BCR)		
NPV Total Cost Early Years BSL Acquisition (£2004)			
55,000	1.30	0.41	4.63
56,000	1.29	0.40	4.56
57,000	1.27	0.40	4.49
58,000	1.25	0.40	4.42
59,000	1.24	0.39	4.35
60,000	1.22	0.39	4.29
61,000	1.21	0.39	4.23
62,000	1.19	0.38	4.16
63,000	1.18	0.38	4.10
64,000	1.16	0.37	4.05
65,000	1.15	0.37	3.99
66,000	1.14	0.37	3.94
67,000	1.12	0.37	3.88
68,000	1.11	0.36	3.83
69,000	1.10	0.36	3.78
70,000	1.08	0.36	3.73
71,000	1.07	0.35	3.68
72,000	1.06	0.35	3.64
73,000	1.05	0.35	3.59
74,000	1.04	0.34	3.55
75,000	1.03	0.34	3.51
76,000	1.02	0.34	3.46
77,000	1.01	0.34	3.42
78,000	1.00	0.33	3.38
79,000	0.99	0.33	3.34
80,000	0.98	0.33	3.30

Note: Entries represent the BCR for a range of assumed total cost estimates for early-years BSL acquisition for the modelled cohort, holding all other costs (employment support) and benefits (quality of life, healthcare cost savings, employment) per person inputs (as reported for the base-case analysis in Column (1) of Table 4.1) constant. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.2. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) for a range of employment support costs – Scenario 1 versus Scenario 0

	(1)	(2)	(3)
Cost input:	**Base**	**High**	**Low**
Benefit input:	**Base**	**Low**	**High**
	Benefit–Cost Ratio (BCR)		
Annual Cost Employment Support per Employed (1000s, £2024)			
20,000	2.48	0.95	8.00
30,000	2.04	0.86	5.90
40,000	1.73	0.79	4.67
50,000	1.50	0.73	3.86
60,000	1.32	0.68	3.29
70,000	1.18	0.63	2.87
80,000	1.07	0.59	2.55
90,000	0.98	0.56	2.29
100,000	0.90	0.53	2.07

Note: Entries represent the BCR for a range of assumed average annual employment support costs in the modelled cohort, holding all other costs (BSL acquisition) and benefits (quality of life, healthcare cost savings, employment) per person inputs (as reported for the base-case analysis in Column (1) of Table 4.1) constant. All monetary values are reported in £2024 prices.

Table D.3. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 0 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,770,635	19,083	11,252,145	45,009	1,740,635	6,963
Total costs	**10,273,697**	**41,095**	**20,009,609**	**80,038**	**4,309,943**	**17,240**

Benefits						
Healthcare cost savings (ACE)	54,189	217	14,305	57	133,942	536
Employment gains	6,594,744	26,379	3,693,043	14,772	8,646,735	34,587
Quality of life gains	1,337,575	5,350	431,500	1,726	5,623,985	22,496
Total benefits	**7,986,508**	**31,946**	**4,138,848**	**16,555**	**14,404,661**	**57,619**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.78**		**0.21**		**3.34**	
Employment effects: no	**0.25**		**0.05**		**2.24**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.4. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 0 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,180,185	16,721	9,874,063	40,059	1,523,080	6,175
Total costs	**9,683,246**	**38,733**	**18,631,527**	**74,526**	**4,092,387**	**16,370**
Benefits						
Healthcare cost savings (ACE)	39,643	159	10,108	421	98,097	392
Employment gains	5,052,169	20,209	2,829,204	18,016	6,624,179	26,497
Quality of life gains	1,150,940	4,604	369,186	14,777	4,882,889	19,532
Total benefits	**6,242,752**	**24,971**	**3,208,498**	**12,834**	**11,605,165**	**46,421**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.64**		**0.17**		**2.84**	
Employment effects: no	**0.22**		**0.04**		**1.94**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.5. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 5 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,777,183	19,109	11,269,829	45,079	1,743,261	6,973
Total costs	**10,280,245**	**41,121**	**20,027,293**	**80,109**	**4,312,568**	**17,250**
Benefits						
Healthcare cost savings (ACE)	81,145	325	21,435	86	200,402	802
Employment gains	6,807,625	27,230	3,814,509	15,258	8,991,556	35,966
Quality of life gains	2,005,978	8,024	647,187	2,589	8,433,178	33,733
Total benefits	**8,894,748**	**35,579**	**4,483,131**	**17,933**	**17,625,137**	**70,501**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.87**		**0.22**		**4.09**	
Employment effects: no	**0.38**		**0.08**		**3.36**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.6. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 5 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**

Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,183,067	16,732	9,881,947	39,528	1,524,224	6,097
Total costs	**9,686,128**	**38,745**	**18,639,410**	**74,558**	**4,093,531**	**16,374**
Benefits						
Healthcare cost savings (ACE)	59,442	238	15,160	61	147,055	588
Employment gains	5,215,255	20,861	2,922,258	11,689	6,888,343	27,553
Quality of life gains	1,726,357	6,905	553,772	2,215	7,323,846	29,295
Total benefits	**7,001,054**	**28,004**	**3,491,190**	**13,965**	**14,359,245**	**57,437**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.72**		**0.19**		**3.51**	
Employment effects: no	**0.32**		**0.06**		**2.91**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.7. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 10 per cent

	(1)		**(2)**		**(3)**	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,783,721	19,135	11,287,470	45,150	1,745,885	6,984
Total costs	**10,286,783**	**41,147**	**20,044,934**	**80,180**	**4,315,192**	**17,261**
Benefits						
Healthcare cost savings (ACE)	108,011	432	28,550	114	266,530	1,066
Employment gains	7,020,434	28,082	3,935,957	15,744	9,336,160	37,345
Quality of life gains	2,674,130	10,697	862,831	3,451	11,240,557	44,962

Total benefits	**9,802,576**	**39,210**	**4,827,338**	**19,309**	**20,843,247**	**83,373**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.95**		**0.24**		**4.83**	
Employment effects: no	**0.51**		**0.10**		**4.48**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.8. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 10 per cent

	(1)		**(2)**		**(3)**	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,185,949	16,744	9,889,825	39,559	1,525,367	6,101
Total costs	**9,689,010**	**38,756**	**18,647,289**	**74,589**	**4,094,674**	**16,379**
Benefits						
Healthcare cost savings (ACE)	79,227	317	20,209	81	195,952	784
Employment gains	5,378,286	21,513	3,015,298	12,061	7,152,341	28,609
Quality of life gains	2,301,737	9,207	738,353	2,953	9,764,480	39,058
Total benefits	**7,759,250**	**31,037**	**3,773,860**	**15,095**	**17,112,773**	**68,451**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.80**		**0.20**		**4.18**	
Employment effects: no	**0.43**		**0.09**		**3.88**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.9. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 15 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,790,250	19,161	11,305,069	45,220	1,748,506	6,994
Total costs	**10,293,311**	**41,173**	**20,062,533**	**80,250**	**4,317,813**	**17,271**
Benefits						
Healthcare cost savings (ACE)	134,788	539	35,650	143	332,332	1,329
Employment gains	7,233,172	28,933	4,057,386	16,230	9,680,548	38,722
Quality of life gains	3,342,034	13,368	1,078,433	4,314	14,046,160	56,185
Total benefits	**10,709,994**	**42,840**	**5,171,469**	**20,686**	**24,059,040**	**96,236**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**1.04**		**0.26**		**5.57**	
Employment effects: no	**0.63**		**0.13**		**5.60**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.10. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 15 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,188,829	16,755	9,897,699	39,591	1,526,511	6,106
Total costs	**9,691,890**	**38,768**	**18,655,163**	**74,621**	**4,095,818**	**16,383**
Benefits						
Healthcare cost savings (ACE)	98,996	396	25,256	101	244,789	979
Employment gains	5,541,262	22,165	3,108,323	12,433	7,416,173	29,665
Quality of life gains	2,877,082	11,508	922,929	3,692	12,204,791	48,819
Total benefits	**8,517,340**	**34,069**	**4,056,509**	**16,226**	**19,865,754**	**79,463**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**0.88**		**0.22**		**4.85**	
Employment effects: no	**0.54**		**0.11**		**4.85**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.11. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 20 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**

Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,796,768	19,187	11,322,626	45,291	1,751,125	7,005
Total costs	**10,299,830**	**41,199**	**20,080,089**	**80,320**	**4,320,432**	**17,282**
Benefits						
Healthcare cost savings (ACE)	161,476	646	42,735	171	397,814	1,591
Employment gains	7,445,839	29,783	4,178,795	16,715	10,024,722	40,099
Quality of life gains	4,009,694	16,039	1,293,994	5,176	16,850,022	67,400
Total benefits	**11,617,010**	**46,468**	**5,515,524**	**22,062**	**27,272,558**	**109,090**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**1.13**		**0.27**		**6.31**	
Employment effects: no	**0.76**		**0.15**		**6.71**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.12. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 20 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	NPV per person, £2024	NPV, £2024	NPV per person, £2024	NPV, £2024	NPV per person, £2024
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support (adult)	4,191,709	16,767	9,905,568	39,622	1,527,654	6,111
Total costs	**9,694,770**	**38,779**	**18,663,032**	**74,652**	**4,096,961**	**16,388**
Benefits						
Healthcare cost savings (ACE)	118,750	475	30,302	121	293,566	1,174
Employment gains	5,704,185	22,817	3,201,334	12,805	7,679,842	30,719

Quality of life gains	3,452,391	13,810	1,107,500	4,430	14,644,780	58,579
Total benefits	**9,275,325**	**37,101**	**4,339,136**	**17,357**	**22,618,188**	**90,473**
			Benefit–Cost Ratio (BCR)			
Employment effects: yes	**0.96**		**0.23**		**5.52**	
Employment effects: no	**0.65**		**0.13**		**5.81**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.13. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 25 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
			Costs			
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,803,277	19,213	11,340,141	45,361	1,753,742	7,015
Total costs	10,306,339	41,225	20,097,605	80,390	4,323,049	17,292
			Benefits			
Healthcare cost savings (ACE)	188,078	752	49,805	199	462,982	1,852
Employment gains	7,658,436	30,634	4,300,185	17,201	10,368,686	41,475
Quality of life gains	4,677,113	18,708	1,509,514	6,038	19,652,178	78,609
Total benefits	12,523,627	50,095	5,859,504	23,438	30,483,845	121,935
			Benefit–Cost Ratio (BCR)			
Employment effects: yes	**1.22**		**0.29**		**7.05**	
Employment effects: no	**0.88**		**0.18**		**7.83**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.14. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 25 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,194,588	16,778	9,913,433	39,654	1,528,797	6,115
Total costs	**9,697,649**	**38,791**	**18,670,897**	**74,684**	**4,098,104**	**16,392**
Benefits						
Healthcare cost savings (ACE)	138,490	554	35,346	141	342,283	1,369
Employment gains	5,867,053	23,468	3,294,330	13,177	7,943,348	31,773
Quality of life gains	4,027,664	16,111	1,292,066	5,168	17,084,447	68,338
Total benefits	**10,033,206**	**40,133**	**4,621,742**	**18,487**	**25,370,079**	**101,480**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**1.03**		**0.25**		**6.19**	
Employment effects: no	**0.76**		**0.15**		**6.78**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.15. Benefits and costs associated with early-years BSL acquisition (80-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 30 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**

Costs						
BSL acquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,809,777	19,239	11,357,615	45,430	1,756,357	7,025
Total costs	**10,312,838**	**41,251**	**20,115,079**	**80,460**	**4,325,664**	**17,303**
Benefits						
Healthcare cost savings (ACE)	214,593	858	56,860	227	527,841	2,111
Employment gains	7,870,963	31,484	4,421,557	17,686	10,712,440	42,850
Quality of life gains	5,344,294	21,377	1,724,994	6,900	22,452,663	89,811
Total benefits	**13,429,850**	**53,719**	**6,203,411**	**24,814**	**33,692,944**	**134,772**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**1.30**		**0.31**		**7.79**	
Employment effects: no	**1.01**		**0.20**		**8.94**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.

Table D.16. Benefits and costs associated with early-years BSL acquisition (50-year time horizon) – Scenario 2 versus Scenario 0 – At risk: 30 per cent

	(1)		(2)		(3)	
Cost:	**Base**		**High**		**Low**	
Benefit:	**Base**		**Low**		**High**	
	NPV, £2024	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**	**NPV, £2024**	**NPV per person, £2024**
Costs						
BSLacquisition	5,503,061	22,012	8,757,464	35,030	2,569,307	10,277
Employment support	4,197,465	16,790	9,921,294	39,685	1,529,940	6,120
Total costs	**9,700,527**	**38,802**	**18,678,758**	**74,715**	**4,099,247**	**16,397**
Benefits						
Healthcare cost savings (ACE)	158,214	633	40,387	162	390,940	1,564
Employment gains	6,029,868	24,119	3,387,311	13,549	8,206,695	32,827

Quality of life gains	4,602,901	18,412	1,476,628	5,907	19,523,794	78,095
Total benefits	**10,790,983**	**43,164**	**4,904,326**	**19,617**	**28,121,429**	**112,486**
Benefit–Cost Ratio (BCR)						
Employment effects: yes	**1.11**		**0.26**		**6.86**	
Employment effects: no	**0.87**		**0.17**		**7.75**	

Note: Entries represent the estimated cumulative lifetime cost and benefits associated with early-years BSL acquisition. BCRs are calculated by dividing the present value of total benefits by the present value of total costs and reported for both, with and without including the employment gains and costs for employment support. NPV= Net Present Value. All monetary values are reported in £2024 prices.