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Alzheimer's Disease & Music Engagement: Quality of Life Economic Impact Analysis

Prepared for the NeuroArts Blueprint Initiative

With support from AARP and the A. Barry Rand Fund of the AARP Foundation

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Note to Reader

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Table of Contents

Glossary

Term	Definition
Active Music Engagement	An intervention for which a participant takes an active role in making music with a facilitator. Such interventions include singing, playing an instrument, songwriting, dancing, and physical exercise with music (Cleveland Clinic, n.d.).
Activities of Daily Living (ADLs)	A term used in healthcare to refer to the basic and everyday skills that are essential to living independently such as eating, bathing, dressing, and mobility (Edemekong, Bomgaars, Sukumaran, & Schoo, 2023).
Adoption Rate	The proportion of individuals with Alzheimer's Disease who participate in music engagement.
Agitation	An unpleasant state of extreme arousal (MedilinePlus, n.d.).
Alzheimer's Disease (AD)	A progressive disease beginning with mild memory loss and possibly leading to loss of the ability to carry on a conversation and respond to the environment (Alzheimer's Disease and Related Dementias, n.d.).
Barthel Index	An ordinal scale which measures a person's ability to complete activities of daily living (American Psychological Association, n.d.).
Beck Depression Inventory (BDI)	A self-report rating inventory that measures characteristic attitudes and symptoms of depression (American Psychological Association, n.d.).
Caregiver Burden	The level of multifaceted strain experienced by professional and nonprofessional caregivers responsible for the care of individuals over time (Liu, Heffernan, & Tan, 2020).
Caregiver Burden Inventory (CBI)	A scale that measures the impact of burden on caregivers (American Psychological Association, n.d.).
Caregiver Stress/Distress	The state of mental or emotional strain or tension experienced by individuals who provide care for others, particularly those with chronic illnesses or disabilities (Lou, Xin, & Cheung, 2021).
Cognitive Function	A measure of memory, attention, and problem-solving abilities (American Psychological Association, n.d.).
Cohen-Mansfield Agitation Inventory (CMAI)	A 29-item scale to systematically assess agitation (American Psychological Association, n.d.).
Depression	The persistent feeling of sadness and loss of interest (Greenberg, 2012).

Diagnosed vs Undiagnosed Individuals with AD	Diagnosed Individuals with AD refer to individuals who have received a formal diagnosis of Alzheimer's Disease through medical evaluation, while Undiagnosed Individuals with AD refer to individuals who exhibit symptoms or risk factors for Alzheimer's Disease but lack a formal diagnosis of the disease (Johns Hopkins University, 2016).
Downstream Economic Impacts	The secondary financial impacts that result from improvements in Quality of Life metrics. Examples include reduced ER visits, hospitalization costs, risk of hospitalization, medical office visits, length of hospital stay, nursing home costs, institutional costs, etc.
Elderly Population	People aged 65 and older.
Emotional Well-being	Reflects the balance of mood and the general contentment crucial for assessing a person's overall happiness and satisfaction with life (Michalos, 2017).
Geriatric Depression Scale (GDS)	A self-report measure of depression in the elderly population (American Psychological Association, n.d.).
Healthcare Costs	The costs associated with medical care and services for individuals with Alzheimer's Disease, as generally understood in broader healthcare contexts. Examples include, but are not limited to, ER visits, home healthcare costs, inpatient hospitalization, institutional costs, medical provider costs, nursing home costs, outpatient services, and prescription medication costs.
Long-Term Care Services	Include home and community-based services and services delivered in assisted living residences and nursing homes (Alzheimer's Association, 2024).
Mini-Mental State Examination (MMSE)	A scale used to measure cognitive impairment in the elderly population (American Psychological Association, n.d.).
Montreal Cognitive Assessment (MoCA)	A screening tool for early detection of mild cognitive impairment (MoCACognition, n.d.).
Music Engagement	Interventions using music as a tool to improve mood, evoke memoires, and engage individuals (Soufineyestani, Khan, & Sufineyestani, 2021). Interventions may be "active" or "passive". Music therapy is a specific approach to music engagement.
Music Therapy	Clinical and evidence-based use of music engagements to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program (American Music Therapy Association, n.d.).
Neuropsychiatric Inventory (NPI)	A caregiver-based tool that measures the presence and severity of 12 symptoms in dementia cases including delusions, hallucinations, agitation/aggression, dysphoria/depression, anxiety, euphoria/elation, apathy/indifference, disinhibition, irritability/lability, aberrant motor behaviors, night-time behavioral disturbances, and appetite/eating disturbances (Musa, et al., 2017).

Nursing Home	Specialized facilities that offer extended care for individuals who require assistance with essential daily activities such as meal preparation and personal hygiene. These establishments ensure round-the-clock support from licensed professionals to address to the needs of their residents (Florida Medical Clinic Orlando Health, 2021).
Passive Music Engagement	An intervention for which a participant mostly listens to music rather than performs. Such interventions include music relaxation therapies, mindful music meditation, or the like (Chowdhury, 2019).
Personalized Music Engagement	Music selection is tailored to an individual's preferences, experiences, or needs.
Quality-Adjusted Life Years (QALYs)	The academic standard for measuring how well different kinds of medical treatments lengthen and/or improve an individual's life (ICER, n.d.).
Quality of Life (QOL)	The extent to which a person obtains satisfaction from life. Factors that are important for a positive quality of life include emotional, material, and physical well-being; engagement in interpersonal relations; opportunities for personal (e.g., skill) development; exercising rights and making self-determining lifestyle choices; and participation in society. (American Psychological Association, n.d.).
Response Rate	The proportion of individuals with Alzheimer's Disease who respond positively to music engagement.
Skilled Nursing Facility (SNF)	A type of nursing facility with the necessary staff and equipment to treat, manage, and observe an individual's condition and evaluate their care. A SNF can be part of nursing homes or hospitals, and provide a wide range of care, including physical therapy and intravenous injections given by a registered nurse or doctor (Medicare, 2024).
Total Healthcare Costs	The overall costs associated with medical and healthcare services for individuals with AD. These include ER visits, home healthcare costs, inpatient hospitalization, institutional costs, medical provider costs, nursing home costs, outpatient services, and prescription medication costs. This definition is used specifically within the context of the Quality of Life impact model to capture the full spectrum of healthcare expenditures.
Warwick-Edinburgh Mental Well-being Scale (WEMWBS)	A measure of mental well-being focusing entirely on positive aspects of mental health (American Psychological Association, n.d.).
Zarit Burden Interview (ZBI)	A caregiver self-report scale measuring caregiver burden (American Psychological Association, n.d.).

Executive Summary

Supported by AARP and the A. Barry Rand Fund of the AARP Foundation, this study is the second in a series of economic analyses produced within the NeuroArts Blueprint Initiative, a partnership between the Johns Hopkins University's International Arts + Lab, Center for Applied Neuroaesthetics and the Aspen Institute's Health, Medicine & Society Program. Neuroarts is an interdisciplinary field, rooted in the science of neuroaesthetics, which explores how the arts and aesthetic experiences change the brain, body, and behavior and how this knowledge can be applied to advance health and well-being. The goal of the NeuroArts Blueprint Initiative is to establish neuroarts as a recognized field and ultimately, to have neuroarts become part of mainstream medicine and public health (*NeuroArts Blueprint: Advancing the Science of Arts, Health, and Wellbeing*, 2021).

Alzheimer's Disease ("AD") and related dementias present a significant challenge globally, with over 55 million individuals affected. In the United States alone, approximately 6.9 million Americans aged 65 and older currently live with AD, a number expected to increase as the Elderly Population grows (Alzheimer's Association, 2024). The lack of proven prevention methods or a cure underscores the need for extensive research in this field. Although non-pharmacological interventions such as Music Engagement show promise in improving the Quality of Life ("QOL") for individuals with AD and their caregivers, additional comprehensive research is required to establish their effectiveness.

Deloitte was retained by the NeuroArts Blueprint Initiative to assess metrics that focus on changes in QOL of individuals with AD and their caregivers from an emotional, social, and physical perspective resulting from involvement with Music Engagement. Examples of such metrics for individuals with AD include improvements in ability to carry out Activities of Daily Living, interpersonal skills, and mood; and decreased interactions with caregivers. For caregivers, these metrics include reduced stress, burden alleviation, and enhanced emotional health. Over the course of a year, with continuous treatment, the economic impact of Music Engagement on the QOL of individuals with AD and their caregivers was estimated in terms of Healthcare Cost savings.

This study consists of three sections: 1. Discovery Phase, 2. QOL Impact Model Framework, and 3. Results.

Section 1 provides an assessment of the impact of Music Engagement on various dimensions of QOL. An initial preliminary Discovery Phase was undertaken to explore the impact of Music Engagement on the well-being of individuals with AD and their caregivers. During this step, approximately 90 peer-reviewed articles focusing on Music Engagement and its influence on QOL dimensions were reviewed. Following this step, the QOL metrics impacted by Music Engagement for individuals with AD and their caregivers were identified. A literature review was conducted to explore the quantitative impact of both Active and Passive Music Engagement on QOL metrics for individuals with AD and their caregivers. Once the QOL metrics impacted by Music Engagement for both individuals with AD and their caregivers had been identified and quantified, a further literature review was conducted to explore the influence of improvements in these QOL metrics on downstream economic costs and benefits for individuals with AD and their caregivers.

Section 1 also highlights some of the feedback and insights gathered from interviews conducted with experts in healthcare and research (including aging and neurogenerative disorders) and from various commercial sectors, AD advocates, music therapists, as well as experienced caregivers, with the objective of validating various assumptions and findings developed during the Discovery Phase. Consultations with AD advocates and caregivers focused on the unique experiences of individuals with AD and emphasized the emotional and mood management benefits of Music Engagement, which can reduce Healthcare Costs, but are currently underutilized in AD care programs. The consultations with music therapists revealed that Music Engagement alleviates physical symptoms, enhances communication and interaction, and reduces caregiver stress. However, they emphasized the importance of personalized approaches and agreed that personalized interventions conducted by professional therapists consistently yield positive impacts on individuals with AD, regardless of disease stage. In addition, they acknowledged that music interventions administered by non-professionals can also positively contribute to the overall well-being and emotional state of individuals with AD. They also noted the limited integration of these interventions into care programs. Conversations with healthcare professionals and researchers indicated that Music Engagement mainly has short- to medium-term impacts and highlighted the importance of large sample sizes and isolating specific music benefits from secondary factors.

The impacts from Music Engagement on QOL may be valued between $5.1 billion and $11.9 billion annually, depending upon the extent to which Music Engagement is utilized among individuals with AD.

Every dollar invested in Music Engagement for individuals with AD and their caregivers yields $2.40 or 2.4 times return on that investment, annually.

Section 2 describes the model framework used to estimate the impacts of Music Engagement on QOL. The starting point for the model framework was the prevalence of AD and its distribution by disease stage in the U.S. The QOL metrics related to Music Engagement for both individuals with AD and their caregivers were then identified and their impacts quantified, after which impacts of these QOL metrics on downstream economic variables were identified and quantified, with adjustments made for overlapping benefits.

Section 3 presents the final estimation of impacts from improving QOL for individuals with AD and their caregivers through Music Engagement. The findings indicate that the impacts from Music Engagement on QOL may be valued between $5.1 billion and $11.9 billion annually, which translates into a return of $2.40 for each dollar invested, or a return of 2.4 times the investment, dependent upon the rate of music utilization among individuals with AD. In addition, Music Engagement may improve the QOL of individuals with AD, which is equivalent to gaining between 13,550 and 31,610 Quality-Adjusted Life Years, annually[1]. These impacts demonstrate the substantial positive impact that Music Engagement can have on the lives of individuals with AD and their caregivers, in terms of both economic value and Quality of Life.

Total net impacts of Music Engagement on QOL

	30% Adoption Rate	50% Adoption Rate	70% Adoption Rate
Total net impacts ($Billions)	5.1	8.5	11.9
QOL Improvement (measured in QALYs)	13,550	22,580	31,610

The QOL of individuals with AD may improve with their gaining between 13,550 and 31,610 Quality of Life years annually, depending upon the extent to which Music Engagement is utilized.

[1] QALYs gained are dependent upon music Adoption Rates.

Introduction

About this Study

Supported by AARP and the A. Barry Rand Fund of the AARP Foundation, this study has been prepared for the NeuroArts Blueprint Initiative, a partnership between the Aspen Institute's Health, Medicine & Society Program and Johns Hopkins University's International Arts + Lab, Center for Applied Neuroaesthetics. Neuroarts is defined as an interdisciplinary field, rooted in the science of neuroaesthetics, which explores how the arts and aesthetic experiences change the brain, body, and behavior and how this knowledge can be applied to advance health and well-being. The goal of the NeuroArts Blueprint Initiative is to establish neuroarts as a recognized field and ultimately, to have neuroarts become part of mainstream medicine and public health (*NeuroArts Blueprint: Advancing the Science of Arts, Health, and Wellbeing*, 2021).

The study is the second in a series of economic analyses produced within the NeuroArts Blueprint Initiative. It encompasses a broader scope of analysis compared to the first study conducted in 2021 (*Alzheimer's Disease and Music Engagement Economic Impact Analysis, 2021*), which was an independent assessment evaluating the potential economic impact of engaging individuals with Alzheimer's Disease with music in various formats across the US[2]. In contrast, this study focuses on assessing the economic impact associated with improvements in the Quality of Life of individuals with AD through Music Engagement and their caregivers. However, it should be noted that the results of the two studies are not additive and must be viewed independently[3].

Deloitte was retained by the NeuroArts Blueprint Initiative to assess metrics that focus on changes in QOL of individuals with AD and their caregivers from an emotional, social, and physical perspective resulting from involvement with Music Engagement. Examples of such metrics for individuals with AD include improvements in ability to carry out Activities of Daily Living, interpersonal skills, and mood; and decreased interactions with caregivers. For caregivers, examples of these metrics include reduced stress, burden alleviation, and enhanced emotional health. Over the course of a year, with continuous treatment, the economic impact of Music Engagement on the QOL of individuals with AD and their caregivers was estimated in terms of Healthcare Cost savings.

Context

AD and related dementias pose one of the greatest challenges of our time, given that the risk of AD increases with age. Currently, there are over 55 million individuals with AD and related dementias worldwide, yet there is neither any proven method to prevent AD, nor a cure for the disease (Alzheimer's Association, 2024)

For 2024, there are approximately 6.9 million Americans aged 65 and older with AD. This number is expected to rise as the U.S. population aged 65 and older is projected to grow from 58 million in 2022 to 82 million by 2050. The prevalence of AD increases with age: 5% of people aged 65 to 74, 13% of people aged 75 to 84, and 33% of people aged 85 and older have AD. In addition, approximately 200,000 Americans under the age of 65 are estimated to have younger-onset AD (Alzheimer's Association, 2024).

Consequently, the quest to prevent, slow, better manage, and ultimately cure AD and related dementias stands as a top priority for research centers globally. The understanding of alternative treatments for AD remains limited due to a lack of comprehensive research. While non-pharmacological therapies hold promise for reducing stress and managing symptoms without the side effects of medications (Alzheimer Society of Canada, n.d.), this gap in research means the benefits of alternative interventions are neither well-recognized nor well-established, impeding their integration into mainstream medicine and public health.

Given the significant and growing prevalence of AD and its devastating impact on both individuals with the disease and their caregivers, as well as the limited understanding of alternative AD interventions, there is an urgent need to explore possibilities that can improve the QOL for both groups of people. This study is

[2] The potential economic impact of the first study was estimated in terms of output (measure of the total value of goods or services produced within a sector), Gross Domestic Product (GDP), job creation, labor income, and tax revenues.

[3] The results of the two studies are not additive because they may include overlapping benefits and involved different sets of literature reviewed over different time periods.

motivated by the potential of Music Engagement to address this need by offering meaningful benefits to the QOL of individuals with AD and their caregivers, and improve the overall well-being of those affected by the disease.

Alzheimer's Disease, Caregivers, and Music Engagement

AD is a progressive neurodegenerative disorder that affects the brain, leading to memory loss, cognitive decline, and behavioral changes. It is the most common form of dementia, accounting for approximately 60 to 80% of cases (Alzheimer's Association, 2024). The disease progresses through different stages, including mild, moderate, and severe, each characterized by specific symptoms and levels of impairment. The initial or mild stage may involve subtle memory lapses and difficulty with concentration. As the disease advances to the moderate stage, individuals may experience more noticeable memory loss, confusion, and difficulty with problem-solving. Finally, in the severe stage, individuals may require assistance with daily activities such as eating, bathing, and dressing, as their cognitive and physical abilities continue to decline (Alzheimer's Association, 2024).

It is important to highlight the significant impact that AD has on mortality rates. Among individuals aged 70, research indicates that 61% of those with AD are expected to die before reaching the age of 80, compared to only 30% of people without the disease (Alzheimer's Association, 2024). This statistic underscores the severity and life-altering nature of this condition. Furthermore, the economic burden associated with AD is substantial. For 2024, it is projected that health and long-term care costs for individuals with AD and related dementias will reach a staggering $360 billion (Alzheimer's Association, 2024). This financial burden affects not only individuals with the disease but also their families and society as a whole.

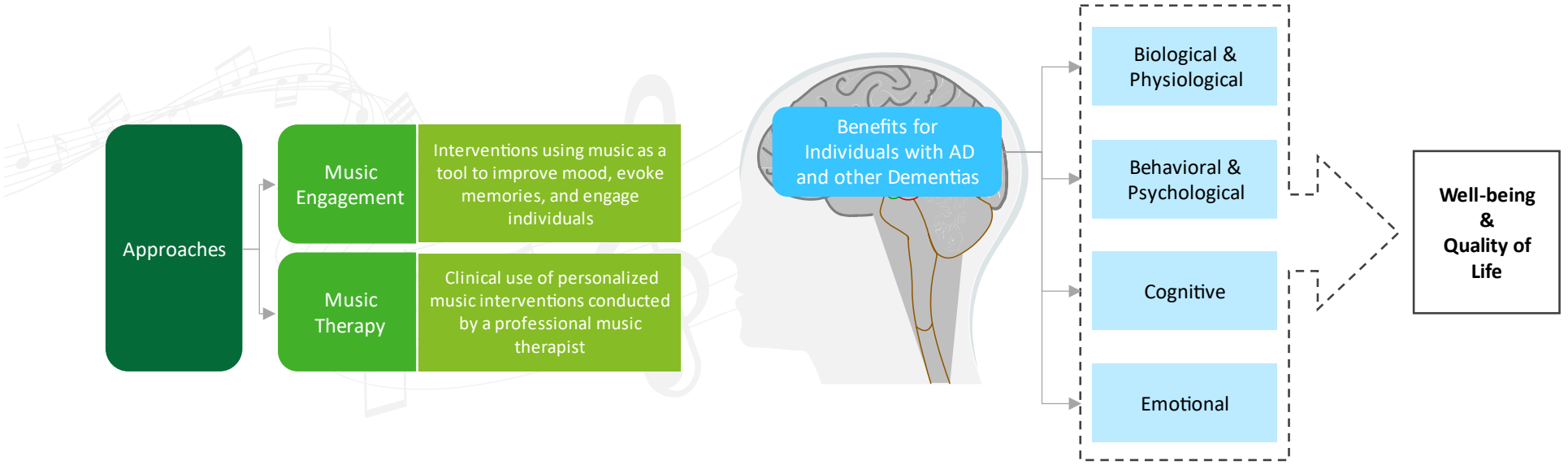
There are both pharmacological and non-pharmacological approaches available for managing AD. Pharmacological treatments, including donepezil and lecanemab, seek to alleviate symptoms and slow down the cognitive decline associated with the disease (Alzheimer's Association, 2024). These medications do not cure or reverse the underlying disease process and may not be suitable for all individuals with AD. Non-pharmacological treatments focus on enhancing QOL and managing behavioral symptoms. These interventions encompass a range of activities, including cognitive stimulation, physical exercise, and psychosocial experiences such as art and Music Engagement (Alzheimer's Association, 2024).

Music Engagement utilizes music as a tool to enhance mood, evoke memories, and engage individuals in various activities. This can involve playing familiar songs or providing musical instruments for individuals to participate and interact with, thereby stimulating cognitive processes and improving different aspects of QOL. Music Engagement has shown to provide a wide range of benefits for individuals with AD and related dementias. These benefits are wide ranging and include biological/physiological, behavioral, and psychological, cognitive, and emotional, all of which can lead to improvements in QOL and overall well-being for individuals with AD:

- Biologically and physiologically, Music Engagement can reduce heart rate, blood pressure, and stress hormone levels, fostering relaxation and physical comfort.
- Behaviorally, Music Engagement can enhance social interaction, reduce Agitation, and promote positive behaviors.
- Psychologically, it can alleviate symptoms of Depression and anxiety.
- Cognitively, Music Engagement can stimulate memory recall, enhance communication abilities, and improve attention and executive functions.
- Emotionally, it can evoke positive emotions, foster a sense of identity and belonging, and provide a comforting and familiar presence.

Collectively, these multifaceted benefits underscore the therapeutic potential of Music Engagement in enhancing the overall well-being and QOL for individuals with AD and related dementias (Soufineyestani, Khan, & Sufineyestani, 2021; Ceccato, 2012). The report delves into the benefits that arise from Music Engagement with a particular focus on the following aspects: behavioral and psychological benefits, cognitive benefits, and emotional benefits.

Benefits of Music Engagement approaches for individuals with AD and other dementias



This image is an adapted version from the original image in Soufineyestani, Khan, & Sufineyestani (2021).

The impact of AD extends beyond the individuals with the disease to include their caregivers who play a critical role in providing support. Over 11 million Americans dedicate their time and effort to providing unpaid care for a family member or friend with dementia. This caregiving contribution is estimated to be worth almost $350 billion to the nation (Alzheimer's Association, 2024). Caregivers assume multiple responsibilities, including managing medications, assisting with Activities of Daily Living, and ensuring safety for individuals with AD. This commitment to service often takes a toll on the well-being of caregivers, leading to high levels of stress, burnout, and emotional exhaustion. Caregivers also frequently face financial burdens and may be forced to make adjustments to their own personal and professional lives. As the aging population continues to rise in the U.S., the demand for caregivers will increase. The Alzheimer's Association reports that between 2021 and 2031, the U.S. will require over one million additional direct care workers, making it the occupation with the highest demand for new workers in the country (Alzheimer's Association, 2024).

Report Structure

This report is divided into three sections. Section 1, the Discovery Phase, describes the comprehensive literature review that was conducted and the relevant QOL metrics, Music Engagement impacts, and Downstream Economic Impacts that were identified. Feedback and insights gathered from interviews conducted with experts in relevant fields are weaved into this Section. The development of the tool used to measure impacts of continuous Music Engagement on QOL over the course of a year is explained in Section 2, QOL Impact Model Framework. Section 3, Results, presents the outcomes of the analysis. Selected quotes from the conversations with various experts in the field are incorporated throughout the report.

1. Discovery Phase

To identify the variables related to Quality of Life for individuals with Alzheimer's Disease and their caregivers that are influenced by Music Engagement, an extensive literature review was conducted. This review consisted of identifying the relevant variables and the impacts that Music Engagement may have on both groups of people, and focused on interactions with caregivers, the neuropsychiatric symptoms of individuals with AD, self-reported well-being, and associated costs and benefits. The objective of the Discovery Phase was to gather relevant information to guide the development of a model framework. The Discovery Phase comprised two steps: 1. Selection of QOL metrics and identification of Music Engagement impacts, and 2. Identification of Downstream Economic Impacts from QOL metrics.

Step 1: Selection of Quality of Life (QOL) Metrics and Identification of Music Engagement Impacts

The primary objective of Step 1 was to discern the implications of Music Engagement on QOL metrics by reviewing studies that explore its efficacy on the Elderly Population with AD and other dementias, as well as their caregivers.

Initially, an analysis of a broad spectrum of some 90 peer-reviewed studies designed to examine QOL metrics in relation to AD was performed. The studies were conducted over a period of 23 years (1999-2022) and included both men and women, aged 65 and older, living across the globe, with various stages of AD ranging from those diagnosed with early-stage AD to individuals with late-stage AD, as well as their caregivers. Utilizing traditional research methodologies such as randomized control trials, systematic reviews, and observational studies, the purpose of each study was to assess the impacts of diverse Active and Passive Music Engagement on individuals with AD. The goal of this exploratory phase was to identify the QOL metrics that were most frequently evaluated and highlighted in existing research. An iterative process was employed to categorize and quantify the prevalence of various QOL metrics across the studies. For each study, this involved cataloging every instance a specific metric was noted, thereby creating a data-driven hierarchy of QOL metrics based on their recurrence in the literature.

While this analysis demonstrated the existence of a body of work on the effectiveness of Music Engagement for individuals with AD and their caregivers, it also revealed the necessity for further research to better understand the extent of its benefits and to establish standardized guidelines for its full implementation. Limitations on studies currently available primarily stem from inconsistencies in the methodology employed across studies, including variations in participant numbers, age range, disease severity, cognitive levels, outcome measures, types of Music Engagement, duration of interventions, small sample sizes, and non-randomized controlled trials.

Once the metrics impacting QOL for both individuals with AD and their caregivers had been identified, an additional literature review was conducted to explore the quantitative impact of Music Engagement on the selected metrics.

QOL Metrics for Individuals with AD and Corresponding Impacts

Following the iterative process described above, a selection of QOL metrics was identified as having positive impacts resulting from Music Engagement for individuals with AD:[4]

> "MUSIC ENGAGEMENT ENHANCES MOOD AND ASSISTS INDIVIDUALS WITH AD WITH ACTIVITIES LIKE WALKING AND DAILY TASKS. IT'S A WAY TO CONNECT WITHOUT WORDS."
>
> *— Music Therapist*

Activities of Daily Living: Music Engagement has been found to improve independence scores relating to Activities of Daily Living by 5%, on average (Dayuan, et al., 2022; Satoh, et al., 2017; Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021).

Agitation, characterized by states of extreme arousal, was identified as a metric because of its alignment with measuring levels of restlessness and irritability (American Psychological Association, n.d.). On average, Music Engagement has been found to decrease Agitation scores for individuals with AD by 4% (Ridder, Stige, Qvale, & Gold, 2013; Tuet & Lam, 2006; Hill-Wilkes, Renales, Seibenhener, & Jefferson, 2023; Tuet & Lam, 2006).

Cognitive Function was identified as a metric due to its ability to measure memory, attention, and problem-solving abilities (American Psychological Association, n.d.). Music Engagement has been found to lead, on average, to a 7% improvement in Cognitive Function scores for individuals with AD (Lyu, et al., 2018; Bliebel, Cheikh, Saider, & Abou-Abbas, 2023; Cramer, 2015; Wang Z., et al., 2018; Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021).

Depression was specified as a distinct metric because of its frequency and significance in affecting the QOL of individuals with AD, often resulting in a persistent feeling of sadness and loss of interest (Greenberg, 2012)**.** Music Engagement has been found to decrease Depression scores by 48%, on average, for individuals with AD (de la Rubia Ortí, et al., 2018; Gulliver, et al., 2021; Cooke, Moyle, Shum, & Harrison, 2010; Greenberg, 2012; Park & Cho, 2022).

Emotional Well-being: Music Engagement has been found to lead, on average, to a 30% improvement in Emotional Well-being for individuals with AD (Särkämö, et al., 2014; Reschke-Hernandez, Gfeller, Oleson, & Tranel, 2023; Narme, et al., 2014; Ting, et al., 2023; Lam, Li, Laher, & Wong, 2020; Solé, Mercadal-Brotons, Galati, & De Castro, 2014; Guétin, et al., 2009; de la Rubia Ortí, et al., 2018; Massaia, et al., 2018).

Loneliness and Isolation were included as metrics to capture the factors of social interactions and feelings of loneliness (American Psychological Association, n.d.). On average, Music Engagement has been found to result in an 18% improvement in feelings of loneliness and isolation for individuals with AD (Cheetu, et al., 2022; O'Rourke, et al., 2021; Kurt & Alpar, 2021; Schafer, et al., 2022).

> "I WOULD USE MUSIC AT NIGHT TO HELP MANAGE HIS SYMPTOMS AND CALM HIM."
>
> *— AD Caregiver*

[4] For a more detailed description of the findings from the literature review conducted to identify the impacts of Music Engagement on the selected QOL metrics for individuals with AD see Appendix.

Neuropsychiatric Symptoms were chosen for their impact on behavior and mental health, encompassing a range of conditions from delusions and hallucinations to Depression and anxiety, which are prevalent in individuals with AD (American Psychological Association, n.d.). Music Engagement has been found to lead, on average, to a 22% decrease in neuropsychiatric symptoms scores for individuals with AD (Gulliver, et al., 2021; Garcia-Navarro, Buzon-Perez, & Cabillas-Romero, 2022; Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021; Brotons & Marti, 2003).

Quality-Adjusted Life Years is the metric for measuring how well different kinds of medical treatments lengthen and/or improve individuals' lives (ICER, n.d.). On average, Music Engagement has been associated with a gain of 0.018 QALYs relative to the individuals in the control groups of various studies that did not participate in Music Engagement (National Institute for Health and Care Excellence, 2018).

> "SHE WOULD SING TO THE MUSIC EVEN THOUGH SHE WAS NOT COMMUNICATIVE."
>
> *— AD Caregiver*

Sleep Quality was included as a metric because it is a vital component of overall good health. This metric focuses on measuring sleep patterns among individuals with AD. Music Engagement has been reported to improve sleep quality scores for individuals with AD and other dementias by 30%, on average (Mu, Lee, Boddupalli, & Meng, 2022; Kumar, et al., 1999; Wang C., et al., 2021).

Tools and scales used to measure the selected QOL metrics were thoroughly analyzed to ensure only those with proven robustness, validity and reliability were included. Among these tools/scales are the Barthel Index and the functional independence measure to assess Activities of Daily Living; the Neuropsychiatric Inventory to evaluate a spectrum of neuropsychiatric symptoms; the Geriatric Depression Scale and the cornell scale for Depression in dementia to measure Depression; the Cohen-Mansfield Agitation Inventory to assess the frequency of manifestations of agitated behaviors; and QALYs gained to measure the quality and quantity of life years gained.

Other metrics reviewed in the literature but ultimately not included were aggression, apathy, and appetite. These variables, despite their relevance to QOL, were not included in other phases of the analysis because they lacked sufficiently strong evidence within the literature to validate the scales used to measure them effectively. Only the most reliably assessed aspects of QOL were included to ensure the integrity and applicability of the study's findings.

Individuals with AD QOL metrics and corresponding impacts from Music Engagement

5% Activities of Daily Living	4% Agitation	7% Cognitive Function
48% Depression	30% Emotional Well-being	18% Loneliness and Isolation
22% Neuropsychiatric Symptoms	0.018 QALYs QALYs Gained	30% Sleep Quality

QOL Metrics for Caregivers and Corresponding Impacts

Caregivers navigate the challenges and complexities of providing care to individuals with AD. Music Engagement has been found to serve as a tool for improving their QOL as well as those they serve. Following the same iterative review process used for individuals with AD, a set of key metrics impacting the QOL for their caregivers was identified:[5]

Caregiver Burden refers to the physical, emotional, and psychological strain experienced by nonprofessional and professional caregivers responsible for the care of individuals with AD (American Psychological Association, n.d.). On average, it has been found that Music Engagement is associated with a decrease of 30% in Caregiver Burden scores (D'Aniello, et al., 2021; Guétin, et al., 2009; Massaia, et al., 2018; Särkämö, et al., 2014).

Caregiver Stress/Distress emerged as a prominent metric, recognizing the significant physiological and psychological responses caregivers experience due to their demanding roles (Narme, et al., 2014; Quinn-Lee & Mowry, 2019; Schafer, et al., 2022; Kim, Engström, Theorell, & Emami, 2021). Stress is a natural response to stressors, whether they are internal or external, while distress specifically refers to the feeling of being overwhelmed by demands, losses, or perceived threats (American Psychological Association, n.d.). On average, Music Engagement has been reported to improve Caregiver's Stress/Distress scores by more than 25% (Narme, et al., 2014; Quinn-Lee & Mowry, 2019; Schafer, et al., 2022; Kim, Engström, Theorell, & Emami, 2021).

Emotional Well-being which encompasses factors such as anxiety, Depression, mood, and overall satisfaction in life was identified as a crucial metric because of its profound influence on caregivers' emotional state and ability to provide effective care. Music Engagement has been found to improve caregiver Emotional Well-being scores by 25%, on average (García-Valverde, Badia, Orgaz, & Gónzalez-Ingelmo, 2019; Brotons & Marti, 2003; Rio, 2018; Osman, Tischler, & Schneider, 2016; Lee, O'Neill, & Moss, 2022; Hanser, Butterfield-Whitcomb, Kawata, & Collins, 2011; Davidson & Almeida, 2014).

Caregiver QOL metrics and corresponding impacts from Music Engagement

30%	Caregiver Burden
25%	Caregiver Stress/Distress
25%	Emotional Well-being

As with the selection of QOL metrics for individuals with AD, tools and scales used to measure caregiver metrics were thoroughly examined. Among these tools/scales are the Neuropsychiatric Inventory to provide a holistic understanding of the condition of an individual with AD while also assessing caregiver distress; the caregiving distress scale to measure the degree of distress experienced by caregivers, including emotional, physical, and psychological effects; the Caregiver Burden Inventory and the Zarit Burden Interview to evaluate the impact of burden on caregivers; the Beck Depression Inventory to assess attitudes and symptoms of Depression; and the state-trait Anxiety inventory to diagnose anxiety and distinguish it from depressive syndromes, and also serving as an indicator of caregiver Emotional Well-being. In addition, qualitative approaches such as semi-structured interviews were used within the literature to gain a deeper understanding of caregivers' experiences, revealing the challenges and impact of caregiving on their Emotional Well-being.

The variables of social relationships, loneliness, and sleep quality for caregivers was initially explored but ultimately excluded from the model due to insufficient evidence in the literature to affirm their impact. The focus again remained solely on those metrics that are well-established and measurable, ensuring that the study's conclusions are grounded in reliable and actionable data.

[5] For a more detailed description of the findings from the literature review conducted to identify the impacts of Music Engagement on the selected QOL metrics for caregivers see Appendix.

The consultations with AD advocates and caregivers included participants with high levels of experience in supporting individuals with AD. These participants are actively involved in various advocacy organizations and awareness activities, driven by their personal experiences with AD and other dementias. They emphasized that the disease affects individuals in distinct ways and noted that the impact of music is often related to a deeper personal connection, where early-life music can unlock memories and evoke powerful emotional responses. Music Engagement was recognized as a strategy for managing the moods of individuals with AD and providing emotional relief to caregivers. However, participants underscored the fact that the current integration of Music Engagement into AD care programs is limited.

> "When I played music, we would dance and she'd be motivated to do more things, like go to the bathroom."
>
> — *AD Caregiver*

> "The music engagement would relax him, and I would be relaxed if he was more relaxed. There was a moment of hope."
>
> — *AD Caregiver*

The consultations with music therapists provided insights that reinforced the benefits of Music Engagement for individuals with AD. Participants included founders of institutes specializing in music and neurologic function, recognized for their research on the clinical applications of Music Engagement for neurological rehabilitation, as well as music therapists with expertise in clinical practice, program development, and research. They emphasized that Music Engagement alleviates physical symptoms such as Agitation, pain, and discomfort, while also enhancing attention, communication, and interaction skills. They also highlighted the significant reduction in stress and burden experienced by caregivers as a direct result of Music Engagement. Moreover, Personalized Music Engagement was credited as fostering a sense of safety and mood improvement in individuals with AD, thereby benefiting the Emotional Well-being of caregivers. Consistent with the views of AD advocates and caregivers, however, music therapist participants noted that the integration of Music Engagement into care programs is inadequate and often lacks personalization and professional guidance, diminishing its effectiveness.

Step 2: Identification of Downstream Economic Impacts from Selected QOL Metrics

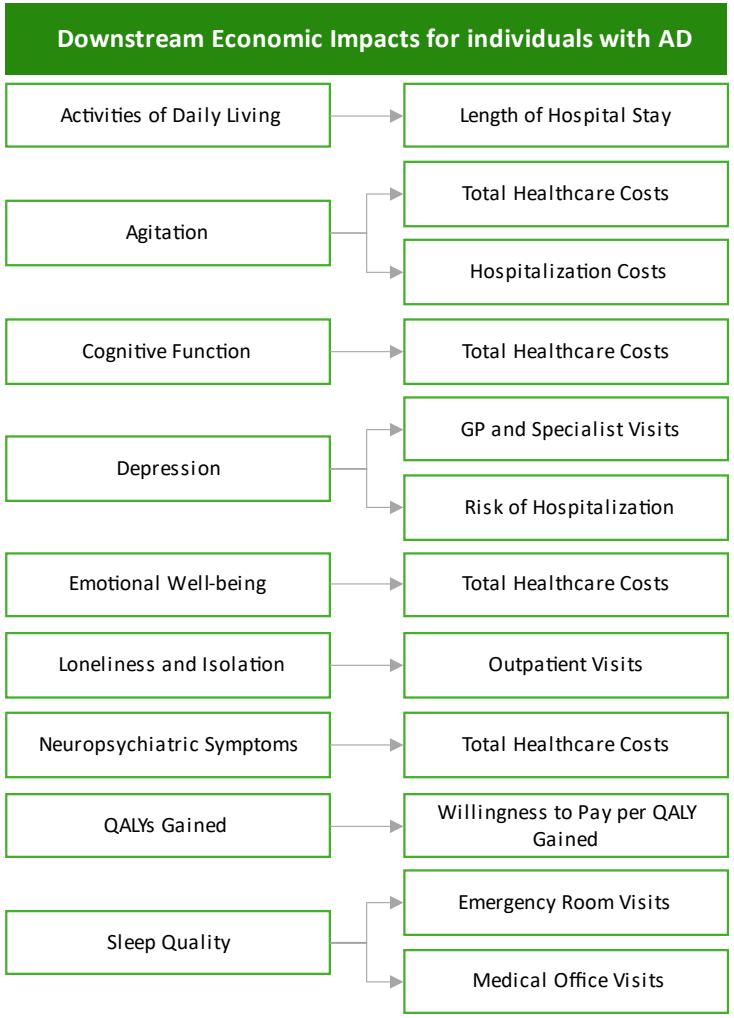
After identifying the QOL metrics and the impacts of Music Engagement on individuals with AD and their caregivers, an additional comprehensive literature review was conducted. The purpose of this review was to explore how improvements in these QOL metrics could affect Downstream Economic Impacts. This linkage is key to quantifying the overall impact of Music Engagement on the QOL of individuals with AD and their caregivers, as discussed later in Section 2.

Downstream Economic Impacts from Improvements in QOL Metrics for Individuals with AD

QOL metrics impacted by Music Engagement for individuals with AD were found to have a positive effect on the following downstream economic variables:

- **Activities of Daily Living:** Research results show that improvements in functional independence, measured by independence scores reduced lengths of hospital stays. A 1.9% increase in independence scores is associated with a 9% reduction in the length of hospital stays (Peiris, Shields, Brusco, Watts, & Taylor, 2013).
- **Agitation:** Research shows that increased Agitation, measured by the Cohen-Mansfield Agitation Inventory ("CMAI"), results in higher Healthcare Costs, with a one-point increase in CMAI score resulting in an increase of 0.5% in Total Healthcare Costs (Panca, et al., 2018). Diminishing Agitation leads to a 7.7% reduction in hospitalization costs (Cots, Chiarello, Perez, Gracia, & Becerra, 2015).

- **Cognitive Function:** Declines in Cognitive Function, measured by a decrease in Mini-Mental State Examination ("MMSE") scores, are found to significantly raise Healthcare Costs, with an improvement of 2.2 points in MMSE scores resulting in 8% increase in Total Healthcare Costs (Schousboe, et al., 2019).
- **Depression:** Study results indicate that reductions in depressive symptoms, as measured by the Geriatric Depression Scale ("GDS"), lead to savings in Healthcare Costs. A decrease in GDS scores from mild to little/no symptoms is found to decrease Healthcare Costs by 19%, with each unit increase growing general practitioner and specialist visits by 3%, resulting in an 8% risk of hospital admission (Schousboe, et al., 2019; Buczak-Stec, et al., 2022).
- **Emotional Well-being:** Studies demonstrate that improvements in a person's Emotional Well-being, as indicated by increased scores on the Warwick-Edinburgh Mental Well-being Scale ("WEMWBS"), decreases Healthcare Costs and sickness benefit transfers. Each point increase on the WEMWBS scale decreases Total Healthcare Costs by 7.4% and sickness benefit transfers by 0.8% per person annually (Santini, et al., 2021).
- **Loneliness and Isolation:** Study results reveal that high perceived social isolation among the Elderly Population significantly increases the risk of hospitalization and emergency department visits. Compared to individuals with low perceived social isolation, individuals with moderate isolation saw a 16% increase in outpatient visits, while those with high social isolation experienced a 26% increase (Manemann, et al., 2018).
- **Neuropsychiatric Symptoms:** Research has found that deterioration in neuropsychiatric symptoms increases direct Healthcare Costs. A one-point increase in the Neuropsychiatric Inventory scale, which measures the presence and severity of neuropsychiatric symptoms, is associated with a 2% increase in annual direct Total Healthcare Costs (Murman & Colenda, 2012).
- **Quality-Adjusted Life Years (QALYs) Gained:** Researchers have conducted various studies to determine the amount of money individuals are willing to pay for each QALY gained. This willingness to pay is measured in terms of a country's Gross Domestic Product ("GDP") per person. Findings from studies indicate that individuals are willing to pay between 0.5 and 0.8 times the GDP per person for each QALY gained (Gloria, et al., 2021; Kouakou & Poder, 2022). By applying this finding to the GDP per person for the U.S. in 2023, it can be estimated how much an American is willing to pay for each QALY gained. Combining this with the findings from QALYs gained from Music Engagement in Step 1, a monetary value for the QALYs gained through Music Engagement can also be estimated.

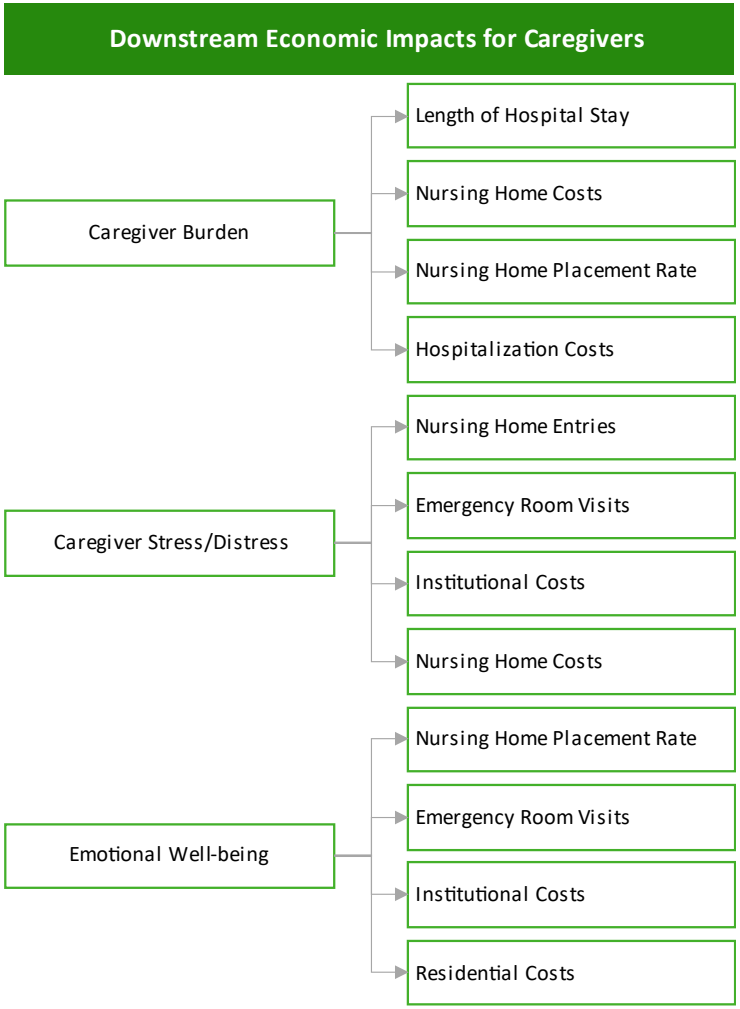


- **Sleep Quality:** Studies show that sleep disorders (which are indicators of poor sleep quality) are linked to higher healthcare utilization, where adults with sleep disorders were found to have 7.6 more medical office visits and 0.15 more emergency room visits, when compared to those adults without sleep disorders (Huyett & Bhattacharrya, 2021). In addition, untreated insomnia is found to increase outpatient costs by 20% (Wickwire, et al., 2019).

Downstream Economic Impacts from Improvements in QOL Metrics for Caregivers

QOL metrics impacted by Music Engagement for caregivers of individuals with AD were found to have a positive impact on the following downstream economic variables:

- **Caregiver Burden:** Studies show that an increase in Caregiver Burden can lead to greater health-related costs. A one-point increase in the Zarit Burden Interview scale, which measures Caregiver Burden, is associated with a 3% increase in the number of days individuals with AD spend in the hospital and a 0.2% increase in Nursing Home costs (Lau, Abdin, Jeyagurunathan, & Seow, 2021; Miller, Rosenheck, & Schneider, 2010). Reductions in Caregiver Burden are also found to decrease Nursing Home placement rates by 9% and hospitalization costs by 5% (Mittelman, Haley, Clay, & Roth, 2006; Kuzuya, et al., 2011; Bartsch, et al., 2020).
- **Caregiver Stress/Distress:** Research indicates that eliminating high caregiver stress reduces Nursing Home entries by 2% (Spillman, Long, & Institute, 2007). A one-point increase on the Neuropsychiatric Inventory scale, which measures caregiver distress, increases the number of emergency room visits by 7%, and total institutional and Nursing Home costs by 0.9% and 0.4%, respectively (Lau, Abdin, Jeyagurunathan, & Seow, 2021; Miller, Rosenheck, & Schneider, 2010).
- **Emotional Well-being:** Improvements in caregivers' Emotional Well-being are linked to significant reductions in Healthcare Costs and improved outcomes for individuals with AD. Improvements in Emotional Well-being, measured through enhanced caregiver support, reduces the rate of Nursing Home placements by 28% (Mittelman, Haley, Clay, & Roth, 2006). The presence of caregiver Depression is found to be associated with a 73% increase in the rates of emergency room use among individuals with AD (Guterman, Allen, & Josephson, 2019). Each unit increase in the Beck Depression Inventory score, which measures caregiver Depression, increases total institutional costs and residential costs by 1% and 0.5%, respectively (Miller, Rosenheck, & Schneider, 2010).



Consultations with AD advocates and caregivers confirmed the findings that Music Engagement reduces Healthcare Costs by decreasing doctor visits, ER visits, and lowering medication use for individuals with AD and their caregivers. However, the Downstream Economic Impacts for individuals with AD and for their caregivers may overlap, since certain QOL metrics can influence the same downstream variable, interconnect between individuals with AD and their caregivers, or both. This overlap of impacts is addressed in the model framework development stage, informed by the expert consultations and additional research, as described in Section 2.

2. Quality of Life Impact Model Framework

Model Framework

The model framework quantifies the impacts of Music Engagement on the QOL of individuals with AD and their caregivers assuming continuous engagement.

The model framework for this analysis is grounded on evidenced-based conclusions derived from the literature review and consultations conducted (as described in Section 1) which support the view that Music Engagement has a positive impact on the QOL metrics for individuals with AD and their caregivers. The sequential process of the framework is as follows:

1) **Impact of Music Engagement on QOL Metrics:** The analysis begins by examining studies on the impact of Music Engagement on QOL metrics for individuals with AD. Specific QOL metrics influenced by Music Engagement for individuals with AD and their caregivers were thereafter identified, as described in Section 1, Step 1. For individuals with AD, these metrics include ADLs, Agitation, Cognitive Function, Depression, Emotional Well-being, loneliness and isolation, neuropsychiatric symptoms, QALYs Gained, and sleep quality. For caregivers, they include Caregiver Burden, Caregiver Stress/Distress, and Emotional Well-being.

2) **Link Between QOL Improvements and Healthcare Cost Savings:** Next, the analysis reviews studies that demonstrate how improvements in these QOL metrics can lead to decreased Healthcare Costs. This step involves identifying the Downstream Economic Impacts of improved QOL metrics on Healthcare Costs, as described in Section 1, Step 2. These studies focus on the general relationship between QOL improvements and Healthcare Cost savings, rather than being specific to individuals with AD. By understanding how enhancements in QOL metrics such as ADLs, Cognitive Function, Emotional Well-being, and sleep quality can reduce healthcare utilization and associated costs, a clear link between the benefits of Music Engagement and Healthcare Cost savings can be established.

3) **Quantifying Total Healthcare Cost Savings:** Finally, the analysis combines the robust evidence gathered from steps 1 and 2 to quantify the Healthcare Cost savings. This involves integrating data from the Alzheimer's Association and other relevant sources to estimate the Healthcare Cost savings of Music Engagement on the QOL of individuals with AD and their caregivers over the course of a year. The assumptions listed below are also incorporated into this quantification process. A more detailed example outlining the quantification process can be found in the Appendix here.

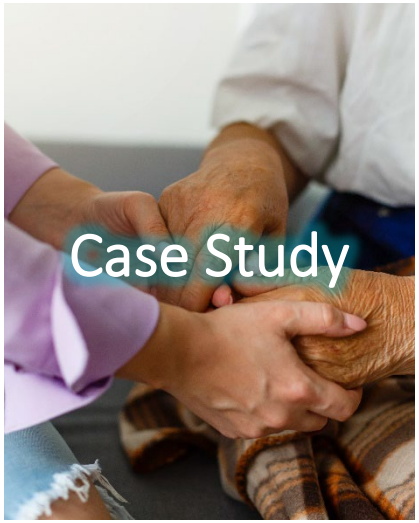
Conservative estimates for Music Engagement Adoption Rates and Response Rates have been employed, recognizing that the intervention may not be effective for every individual with AD. This cautious approach ensures that the projections remain conservative and reasonable. Informed by research findings and expert insights, the following set of assumptions, including Adoption Rates and Response Rates were developed for the model framework:

ASSUMPTIONS FOR POPULATION OF INDIVIDUALS WITH AD AND ASSOCIATED COSTS	
Assumption	**Description**
Population of individuals with AD	Individuals with AD in the U.S. is estimated at 6.9 million, which includes both Diagnosed and Undiagnosed Individuals with AD (Alzheimer's Association, 2024).
Distribution by disease stage	The AD population can be segmented into three groups based on their disease stage: mild (50.4%), moderate (30.3%), and severe (19.3%) (Yuan, et al., 2021).

ASSUMPTIONS FOR POPULATION OF INDIVIDUALS WITH AD AND ASSOCIATED COSTS	
Assumption	**Description**
Music Engagement adoption scenarios	Since a specific Music Engagement Adoption Rate is unknown, three different music adoption scenarios are considered, with Adoption Rates set at 30%, 50%, and 70%.
Increase in cost by disease stage	Healthcare Costs increase by 40% from a mild to moderate AD diagnosis, and by 57% from a moderate to severe AD diagnosis (Quentin, Riedel-Heller, Luppa, Rudolph, & König, 2010).
Institutional costs	Costs related to inpatient hospitalization, outpatient services, Skilled Nursing Facility care, Nursing Home services, and hospice care.
ER visits	Costs per ER visit are similar to those paid by Medicare for such services.
Individuals with AD living in the community by disease stage	The distribution by disease stage for individuals with AD living in the community is consistent with that of the entire AD population: 50.4% are classified as mild; 30.3% are classified as moderate, and 19.3% are classified as severe (Yuan, et al., 2021).
Individuals with AD living in Nursing Homes by disease stage	Individuals with AD not living in the community are presumed to be Nursing Home residents. Among individuals with AD living in Nursing Homes, 38.7% are classified as mild; 24.8% are classified as moderate; and 36.6% are classified as severe (Centers For Medicare and Medicaid Services, 2015).

ASSUMPTIONS FOR MUSIC ENGAGEMENT PARTICIPATION AND COSTS	
Assumption	**Description**
Positive response to Music Engagement	Positive Response Rates differ by disease stage of AD, with 52% of mild cases responding positively, 28% of moderate cases responding positively, and 14% of severe cases responding positively (KPMG, 2021).
Music Engagement delivery	20% of individuals with AD participating in Music Engagement receive individual music sessions, while 80% of such individuals receive group music sessions with five individuals participating in each group session (KPMG, 2021).
Length and frequency of Music Engagement	Two 30-minute sessions per week for one year (National Music Therapy Institute, n.d.).
Median cost of individual music session	$79 per hour (2021 dollars) (American Music Therapy Association, 2021).
Median cost of group music session	$90 per hour (2021 dollars) (American Music Therapy Association, 2021).

ASSUMPTIONS FOR MUSIC ENGAGEMENT AND DOWNSTREAM ECONOMIC IMPACTS ON QOL	
Assumption	**Description**
Music Engagement impact time	Most impacts on individuals are estimated as the average of the impacts identified in the literature over the short- to medium-term, reflecting a time frame of 2-6 months (confirmed with healthcare researchers).
Continuous Music Engagement	The continuous engagement with music over the course of a year.
QALYs gained	Impacts on QALYs gained are similar for all disease stages of AD (confirmed with health economic experts).
Downstream Economic Impacts	The opposite effect on downstream variables found in the Discovery Phase holds true. For instance, if a 1 unit increase in the NPI scale increases emergency room visits by 7%, assumption is that a 1 unit decrease in the NPI scale decreases emergency room visits by 7%.



Fran, a participant in the Music and Memory program at the Alzheimer's Outreach program, is a former elementary school teacher with a vibrant personality. Despite living with dementia, Fran maintains a positive outlook and uses music as a valuable tool to navigate her challenging days. She finds comfort in revisiting the songs that have shaped her life, such as her favorite church hymns and country artists. Fran's headphones have become her constant companion, allowing her to escape into melodies that bring her solace. Her husband frequently joins her in these musical moments, creating opportunities for connection and reminiscing. Music has provided Fran with a means of expression and connection that transcends the limitations of her condition. It acts as an anchor, helping her navigate daily complexities and reconnecting her with cherished memories.

– (Music and Memory, 2023)

Interviews with experts in healthcare, research, AD advocacy, Music Engagement, and with commercial sectors were conducted for the purpose of validating several of these assumptions and findings generated through the Discovery Phase. The majority of the experts either endorsed the assumptions as logical or acknowledged the absence of opposing data or evidence to refute them.

During the consultations, healthcare professionals and researchers, who are experts in various aspects of neurodegenerative conditions (encompassing cognitive aspects of movement disorders, biomarkers and genetics, and the epidemiology and treatment of neuropsychiatric disorders in AD) provided valuable input. These experts corroborated the Discovery Phase findings, which indicated that the impacts of Music Engagement are more likely to manifest as short- to medium-term impacts rather than long-term impacts.

Based upon the data presented and using the assumptions described above, the total impacts of Music Engagement on QOL for individuals with AD and their caregivers under each of the three music adoption scenarios were estimated. The following diagram presents the logical progression employed in developing the model framework and measuring the impacts attributed to the improvement of QOL through Music Engagement.

Model Framework for Quantifying Impacts from Music Engagement on QOL

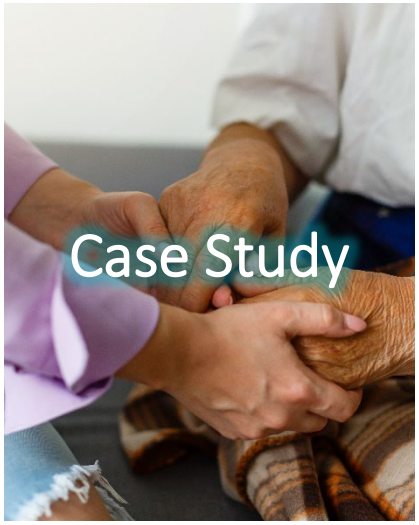
Monetization Pathways

The model framework produced several anticipated downstream monetization pathways that result from the improvement in QOL metrics through Music Engagement.

As described in Step 2 of the Discovery Phase, a set of anticipated Downstream Economic Impacts resulting from improvements in QOL metrics were identified. These effects aim to quantify the impacts of Music Engagement on the QOL of both individuals with AD and their caregivers. With the incorporation of these impacts into the model framework, the following monetization pathways based on data from the Alzheimer's Association and other sources were established:

- **ER visits:** The number of emergency room visits that individuals with AD may experience. This pathway captures the anticipated reduction in ER visits costs.
- **Home Healthcare Costs:** The costs associated with home healthcare services provided to individuals with AD. This pathway represents the anticipated reduction in home Healthcare Costs.
- **Inpatient hospitalization:** The utilization of inpatient hospital services by individuals with AD. This pathway reflects the anticipated decrease in hospital stays and hospital stay length.
- **Institutional costs:** The costs related to hospice, inpatient hospitalization, Nursing Home, outpatient services, and Skilled Nursing Facilities. This pathway captures the anticipated decrease in institutional costs.
- **Medical provider costs:** The costs incurred by individuals with AD and their caregivers for physician visits, other provider and laboratory services, and medical equipment and supplies. This pathway captures the anticipated decrease in medical provider costs.
- **Nursing Home costs:** The expenses related to the number of individuals with AD who require placement in Nursing Homes for Long-Term Care Services. It reflects the anticipated decrease in Nursing Home costs.
- **Outpatient services:** The utilization of services delivered outside of a hospital setting by individuals with AD. This pathway indicates the anticipated reduction in the need for outpatient services.
- **Total Healthcare Costs**[6]**:** The overall costs associated with healthcare services for individuals with AD. This pathway encompasses various healthcare expenses, including those described above and others such as prescription medication costs. It captures the anticipated reduction in Total Healthcare Costs for individuals with AD and their caregivers.
- **Quality-Adjusted Life Years (QALYs):** The willingness of a person to pay for each QALY gained through the participation of individuals with AD in Music Engagement.

[6] Total Healthcare Costs are treated as a separate monetization pathway and are not distributed among other pathways. This decision is based on the nature of the Downstream Economic Impacts (analyzed in Section 1, Step 2), which generally report findings on Total Healthcare Costs without providing a detailed breakdown. For example, an increase of one point on the WEMWBS scale (which measures Emotional Well-being) is associated with a 7.4% reduction in Total Healthcare Costs without specifying the individual components of those costs. Consequently, Total Healthcare Costs are included as a distinct pathway to enable accurate quantification in the model framework. In the next section, overlapping benefits resulting from this approach are accounted for.



Brett is an active participant in the Music & Memory program offered by the Dementia Alliance of North Carolina. Living with dementia and frequent anxiety, Brett faces challenges in staying calm and connecting with others. However, personalized music playlists have proven transformative for him. Listening to his favorite songs brings remarkable changes: anxiety subsides, and he can fully engage in activities like watching football with his sister and caregiver, Debee. Music profoundly enhances Brett's quality of life, restoring his identity, connection to others, and providing comfort, pleasure, and meaning.

– (Music and Memory, 2023)

Incorporating these Downstream Economic Impacts as a whole into the model framework may intuitively introduce a potential risk of double counting impacts. This is due to the interconnected nature of QOL metrics for both individuals with AD and their caregivers, as well as the influence of these metrics on the monetization pathways. Specific adjustments were made in the model framework to address the concern of overlapping impacts.

Overlapping Impacts

Three crucial cost-related adjustments were built into the model framework to address the challenge of potential double counting of overlapping impacts.

Overlapping impacts in the model framework could occur in three different ways. First, certain monetization pathways may already take into account and include other monetization pathways. Second, there can be overlapping impacts between the QOL metrics of individuals with AD and the QOL metrics of their caregivers, which can influence the same monetization pathway. Third, overlapping impacts can be observed within the QOL metrics of individuals with AD themselves. These interconnected impacts between individuals with AD and their caregivers were confirmed through consultations with experts in the field where appropriate. In each instance, the result may be the unintentional double counting of the overall impact of Music Engagement. To address this challenge of overlapping impacts, three cost-related adjustments were built into the model framework:

Adjustment 1: Addressing double counting from monetization pathways already included in other monetization pathways

Individuals with AD: Music Engagement is found to positively impact QOL for individuals with AD, leading to a reduction in Total Healthcare Costs. These costs include various expenses that have already been considered in other monetization pathways. To avoid double counting, estimates have been discounted based on potential overlapping benefits. For example, the impact of Music Engagement on individuals with AD not only reduces Total Healthcare Costs, but also affects medical provider costs, outpatient services, and inpatient hospitalization costs. Since medical provider, outpatient services, and hospitalization costs are components of Total Healthcare Costs, Total Healthcare Costs have been discounted to account for the impacts already included in these areas.

AD Caregivers: Music Engagement is found to positively impact QOL for caregivers, leading to a reduction in institutional costs for individuals with AD. These costs include various expenses that have already been taken into account in other monetization pathways. To avoid double counting, estimates have been discounted based on potential overlapping benefits. For example, the impact of Music Engagement on caregivers not only reduces institutional costs, but also affects inpatient hospitalization and Nursing Home costs. Since inpatient hospitalization and Nursing Home costs are components of institutional costs, institutional costs have been discounted to account for the impacts already included in these areas.

Adjustment 2: Addressing overlapping impacts from interrelated impacts between individuals with AD and their caregivers on the same monetization pathway

The impacts of Music Engagement on individuals with AD are closely linked to the impacts on their caregivers, and both are found to have impacts on the same monetization pathway. For instance, when individuals with AD experience Music Engagement, an improvement in their independence may result, which, in turn, may reduce the burden experienced by their caregivers. Both these QOL metrics -- independence of the individual with AD and Caregiver Burden -- have been found to contribute to a reduction in inpatient hospitalization costs.

To account for the potential challenge of double counting resulting from these overlapping impacts, the model factors 50% of the impacts across each inter-related caregiver metric. This adjustment is based on the assumption that 50% of the impact on the monetization for caregivers is already included in the monetization pathways for individuals with AD. The caregiver metrics that have been adjusted for overlapping impacts include Caregiver Burden, Emotional Well-being, Caregiver Stress/Distress as follows:

- **Depression of individual with AD and Caregiver Burden:** Improvements in both these QOL metrics resulting from Music Engagement have impacts on inpatient hospitalization costs.
- **Independence of individual with AD (measured by ADL) and Caregiver Burden:** Improvements in both these QOL metrics resulting from Music Engagement have impacts on inpatient hospitalization costs.
- **Sleep Quality of individual with AD and Caregiver Emotional Well-being:** Improvements in both these QOL metrics resulting from Music Engagement have impacts on ER visits.
- **Sleep Quality of individual with AD and Caregiver Stress/Distress:** Improvements in both these QOL metrics resulting from Music Engagement have impacts on ER visits.

Adjustment 3: Addressing overlapping impacts from interrelated impacts within individuals with AD on the same monetization pathway

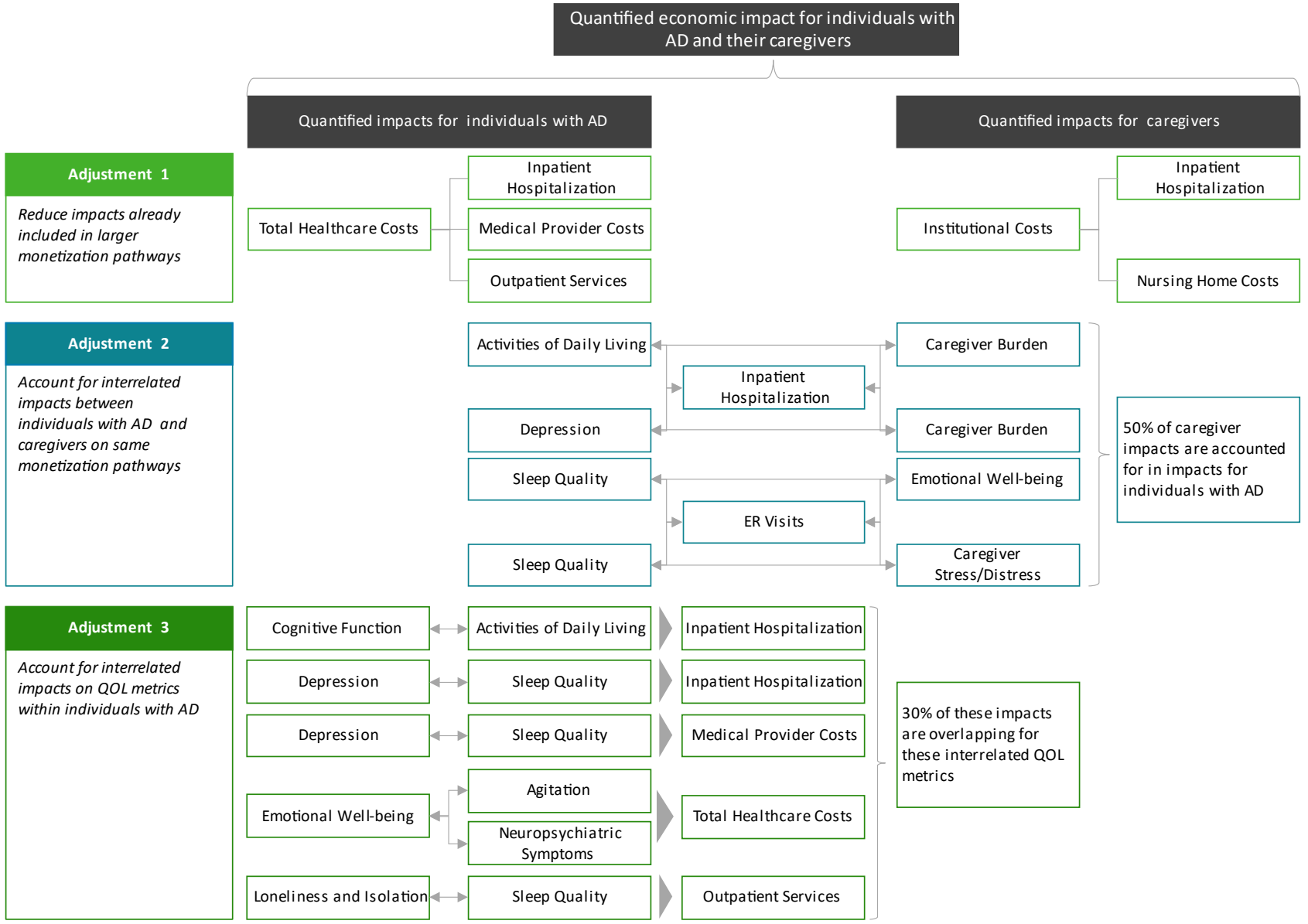
There are multiple QOL metrics for individuals with AD that are impacted by Music Engagement. These metrics are often interconnected, indicating the possibility of overlapping impacts. In addition, it has been found that these QOL metrics have impacts on the same monetization pathway. For instance, the sleep quality and Depression impacts for individuals with AD are closely linked and both are found to affect medical provider costs.

To account for the potential challenge of double counting resulting from these overlapping impacts within individuals with AD, the model factors 70% of the impact across each of the interrelated metrics. This adjustment is based on the assumption that 30% of the impact is already accounted for in another QOL metric. The interrelated QOL metrics for individuals with AD that have been adjusted for overlapping impacts include:

- **Cognitive Function and ADLs:** These metrics are interconnected, as cognitive decline can affect an individual's ability to perform ADLs (de Paula, et al., 2015). Both metrics have been found to impact the same monetization pathway, inpatient hospitalization costs.
- **Depression and Sleep Quality:** These metrics are closely related, as poor sleep can contribute to the deterioration or experience of Depression, and Depression can contribute to poor sleep quality. Research has found that among people with Depression, 75% experience difficulties falling asleep or staying asleep (Johns Hopkins Medicine, n.d.). Both metrics have been found to impact the same monetization pathway, medical provider costs and inpatient hospitalization costs.

- **Emotional Well-being, Agitation, and Neuropsychiatric Symptoms:** These metrics are closely connected in terms of mental health, and their impacts can overlap. They have all been found to impact the same monetization pathway, Total Healthcare Costs.
- **Loneliness and Isolation and Sleep Quality:** These metrics are closely related, since sleep quality can have a significant impact on social skills and social interactions, while poor social well-being can also affect sleep quality (Ghose, Reid, Dautovich, & Dzierzewski, 2022). Both metrics have been found to impact the same monetization pathway, outpatient services.

Model Framework for Addressing Potential Overlapping Impacts from Music Engagement



3. Results

Incorporating Music Engagement in the care of individuals with AD improves the QOL for such individuals and their caregivers, which translates into a total economic value between $5.1 billion and $11.9 billion annually, including a gain of between 13,550 and 31,610 QALYs per year, dependent on Music Engagement Adoption Rates. These estimates are for a one year period, assuming continuous Music Engagement by individuals with AD over that timeframe.

This section presents the resulting estimated economic impacts that can result from improvements in the QOL for individuals with AD and their caregivers through Music Engagement. These results encompass the findings obtained during the Discovery Phase, the data inputs and assumptions outlined in Section 2, and the model framework developed to estimate these impacts, all of which was further informed by the consultations conducted with experts in the field.

Nearly 65% of the economic impact from Music Engagement for individuals with AD is attributed to mental and emotional well-being Quality of Life measures.

As detailed in Section 2, the anticipated impacts for three different scenarios of Music Engagement Adoption Rates have been estimated: 30%, 50%, and 70%.[7] In terms of savings in Healthcare Costs and gains resulting from improvements in QOL, the analysis indicates that the total economic impact for individuals with AD ranges from $6.4 billion to $14.8 billion per year. Nearly 65% of this impact is attributed to improvements in QOL metrics related to the mental and Emotional Well-being of individuals with AD; more than 20% of the impact is associated with improvements in QOL metrics related to their functional independence; 11% of the impact is related to QALYs gained, and 3% accounts for loneliness and isolation. The analysis also finds that the number of Quality-Adjusted Life Years gained from Music Engagement for individuals with AD ranges from 13,550 to 31,610, annually.

Impacts from Music Engagement on individuals with AD ($Billions)

	QOL metrics included	30% Adoption Rate	50% Adoption Rate	70% Adoption Rate
Functional Independence	Activities of Daily Living, Cognitive Function	1.4	2.3	3.2
Loneliness and Isolation	Loneliness and Isolation	0.2	0.3	0.4
Mental and Emotional Well-Being	Agitation, Depression, Emotional Well-being, Neuropsychiatric Symptoms, Sleep Quality	4.1	6.8	9.5
QALYs Gained		0.7	1.2	1.7
Total impact for individuals with AD		**6.4**	**10.6**	**14.8**
Cost of Music Engagement		3.7	6.1	8.5

[7] Estimates provided throughout this Section are rounded to the nearest $10 million and 10 QALYs. Totals may not add up due to rounding.

Net impact for individuals with AD	**2.7**	**4.5**	**6.3**

Upon subtracting the costs associated with providing Music Engagement, the estimated range of impact is reduced to a range of $2.7 billion to $6.3 billion. Thus, for every dollar invested in Music Engagement, the improvement in QOL for individuals with AD as translated into dollars and cents is $1.70, or 1.7 times the investment in Music Engagement[8]. These figures validate the anticipated economic benefits and positive impact on overall well-being and QOL that can be achieved through the incorporation of Music Engagement in the treatment and care of individuals with AD.

Gains in QALYs from Music Engagement for individuals with AD

	30% Adoption Rate	50% Adoption Rate	70% Adoption Rate
QALYs Gained ($billions)	0.7	1.2	1.7
QOL Improvement (measured in QALYs)	13,550	22,580	31,610

Every dollar invested in Music Engagement for individuals with AD yields $1.70 or 1.7 times return on that investment, annually.

In terms of cost savings resulting from improvements in QOL, the analysis indicates that the total economic impact for caregivers of individuals with AD ranges from $2.4 billion to $5.6 billion per year. Most of this impact is linked to the burden experienced by caregivers, accounting for 51% of the overall impact. Caregiver Stress/Distress contribute to 35% of the impact, while Emotional Well-being accounts for 14%. Thus, for every dollar invested in Music Engagement, the improvement in QOL for caregivers of individuals with AD as translated into dollars and cents is $0.70, or 0.7 times the investment in Music Engagement[9].

Impacts from Music Engagement on caregivers ($Billions)

	30% Adoption Rate	50% Adoption Rate	70% Adoption Rate
Caregiver Burden	1.2	2.0	2.8
Caregiver Stress/Distress	0.8	1.4	1.9
Emotional Well-being	0.3	0.6	0.8
Total impact for caregivers	**2.4**	**4.0**	**5.6**

Every dollar invested in Music Engagement for caregivers of individuals with AD yields $0.70 or 0.7 times return on that investment, annually.

[8] For every dollar invested in Music Engagement, the improvements in QOL for individuals with AD valued at $1.70 is derived by dividing the total impact for individuals with AD by the cost of Music Engagement. This gains ratio is the same for all three adoption scenarios at 30%, 50%, and 70% as potential efficiencies associated with increasing the scale of adoption are not considered in the analysis.

[9] For every dollar invested in Music Engagement, the improvements in QOL for caregivers of individuals with AD valued at $0.70 is derived by dividing the total impact for caregivers by the cost of Music Engagement. This gains ratio is the same for all three adoption scenarios at 30%, 50%, and 70% as potential efficiencies associated with increasing the scale of adoption are not considered in the analysis.

When the net impact of Music Engagement on the QOL of individuals with AD is combined with such impact on their caregivers, the total potential impact of Music Engagement ranges from $5.1 billion to $11.9 billion per year. Thus, for every dollar invested in Music Engagement, the total improvements in QOL for individuals with AD and their caregivers, as measured in dollars and cents is $2.40, or 2.4 times the investment in Music Engagement [10].

Total net impacts of Music Engagement on QOL

	30% Adoption Rate	50% Adoption Rate	70% Adoption Rate
Total net impacts ($Billions)	5.1	8.5	11.9
QOL Improvement (measured in QALYs)	13,550	22,580	31,610

The impacts from Music Engagement on QOL may be valued between $5.1 billion and $11.9 billion annually, depending upon the extent to which Music Engagement is utilized among individuals with AD.

It is important to note that a significant proportion, up to 50%, of individuals in the U.S. who meet the diagnostic criteria for AD and other dementias may remain undiagnosed or uninformed about their condition. (Savva & Arthur, 2015; Alzheimer's Disease International, 2015; Amjad, et al., 2018; Lin, et al., 2021; Alzheimer's Association, 2024). This lack of awareness may impact the utilization of Music Engagement programs if individuals are unaware of their diagnosis, or unaware of the QOL benefits they could realize from Music Engagement. By increasing the awareness of the benefits of Music Engagement and ensuring accurate information dissemination, it is more likely that higher Adoption Rates, and ultimately greater QOL impacts can be achieved.

The QOL of individuals with AD may improve with their gaining between 13,550 and 31,610 Quality of Life years annually, depending upon the extent to which Music Engagement is utilized.

Every dollar invested in Music Engagement for individuals with AD and their caregivers yields $2.40 or 2.4 times return on that investment, annually.

[10] For every dollar invested in Music Engagement, the total improvements in QOL for individuals with AD and their caregivers valued at $2.40 is derived by dividing the total impact for individuals with AD and their caregivers by the cost of Music Engagement. This gains ratio is the same for all three adoption scenarios at 30%, 50%, and 70% as potential efficiencies associated with increasing the scale of adoption are not considered in the analysis.

Recommendations and Next Steps

Integrating Music Engagement within health insurance plans, utilizing the report's analytical framework for future economic and QOL analysis of arts-based interventions across other diseases and conditions, and building upon the existing body of research are key recommendations for next steps.

Based upon the extensive body of research reviewed, consultations conducted, and results from the analysis within this report, several key recommendations and potential next steps have been identified:

Incorporate Music Engagement into health insurance plans. Conducting research that demonstrates the effectiveness and cost-effectiveness of Music Engagement for individuals with AD and their caregivers can contribute to the evidence base for their inclusion in health insurance plans, making the engagement more accessible and affordable for those in need, and ultimately generating greater adoption and Healthcare Cost savings at a national level. Initiatives such as Medicare's Supplemental Benefits for the Chronically Ill could potentially allow individuals with AD to benefit from Music Engagement if supported by robust evidence (Department of Health and Human Services - CMS, 2019; Department of Health and Human Services - CMS, 2024).

Utilize the report's framework as a template to assess the QOL impacts of different art forms on diverse health conditions. The analytical framework developed for this report can be utilized as a template to evaluate the economic impacts of different art forms on QOL across various health conditions. Applying this model to assess the benefits of other arts-based interventions offers valuable insights into the economic value and impact of diverse art forms on populations with varying mental and physical health conditions, expanding the understanding of QOL impacts beyond Music Engagement and providing a comprehensive framework for decision-making regarding coverage and implementation of Music Engagement in various settings.

Continue and refine research. Although there is an extensive body of research on the impacts of Music Engagement on individuals with AD, there is an opportunity to address select limitations with some of these studies in future research, such as the use of small sample sizes, non-randomized controlled trials, and a lack of robust research on the long-term effects of Music Engagement. Specific research is also recommended regarding aspects such as loneliness, sleep quality, and social relationships to explore the effects of Music Engagement on caregivers of individuals with AD. By conducting more comprehensive studies and gathering robust data across these areas, deeper insights can be gained into the specific benefits associated with Music Engagement, ultimately leading to more effective interventions and support for individuals with AD and their caregivers.

Appendix

Discovery Phase Supplemental Information

The findings from the literature review conducted to identify the impacts of Music Engagement on the selected QOL metrics for individuals with AD and their caregivers are described in greater detail in this Appendix.

Impacts of Music Engagement for Individuals with AD

Music Engagement was found to have a positive impact on the QOL of individuals with AD, as follows:

- **Activities of Daily Living:** Music Engagement has been found to significantly impact the ability of individuals with AD to complete ADL tasks and other related activities, including visuospatial and Cognitive Function (Dayuan, et al., 2022; Satoh, et al., 2017; Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021). Specifically, Music Engagement has been found to significantly improve measurements on the Barthel Index, a well-known scale assessing ADL competence. On average, individuals with AD who participate in Music Engagement experience a 5% improvement in independence.
- **Agitation:** Research has consistently demonstrated that Music Engagement has a significant impact in reducing Agitation among individuals with AD (Ridder, Stige, Qvale, & Gold, 2013; Tuet & Lam, 2006; Hill-Wilkes, Renales, Seibenhener, & Jefferson, 2023). To measure Agitation behaviors, the Cohen-Mansfield Agitation Inventory ("CMAI") was utilized as a reliable and validated scale (American Psychological Association, n.d.). The structured approach of the CMAI ensures accurate assessment of the effectiveness of Music Engagement in managing Agitation. Results from studies using the CMAI show that Music Engagement has a positive impact on Agitation levels in individuals with AD (Tuet & Lam, 2006). On average, it was found that Music Engagement led to a 4% decrease in Agitation scores for individuals with AD.
- **Cognitive Function:** Music Engagement has been found to enhance Cognitive Functions in individuals with AD, with improvements in areas such as verbal fluency, memory, and overall cognitive abilities (Lyu, et al., 2018; Bliebel, Cheikh, Saider, & Abou-Abbas, 2023; Cramer, 2015). Evaluations using tools such as the Mini-Mental State Examination and the Montreal Cognitive Assessment have highlighted the benefits of Music Engagement over standard care (Wang Z., et al., 2018). Active Music Engagement has demonstrated sizes of greater effect on cognitive and behavioral symptoms compared to passive interventions (Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021). On average, it was found that Music Engagement led to a 7% improvement in Cognitive Function scores for individuals with AD.
- **Depression:** Music Engagement has been proven to have significant benefits in alleviating the symptoms of Depression commonly suffered by individuals with AD and dementia in general. It enhances social integration, self-worth, and mood (de la Rubia Ortí, et al., 2018; Gulliver, et al., 2021; Cooke, Moyle, Shum, & Harrison, 2010). The studies included in this review utilized the Geriatric Depression Scale and the cornell scale for Depression in dementia as the primary assessment tools. These scales are widely recognized for their high validity and reliability in detecting depressive symptoms among the Elderly Population and those with AD (Greenberg, 2012; Park & Cho, 2022). On average, it was found that Music Engagement led to a 48% decrease in Depression scores for individuals with AD.
- **Emotional Well-being:** The literature review highlighted the positive impact of Music Engagement on Emotional Well-being in individuals with AD. Participating in Music Engagement, whether actively or passively, has consistently shown improvements in emotional responses, such as enhanced self-esteem, reduced anxiety, and decreased sadness (Särkämö, et al., 2014; Reschke-Hernandez, Gfeller, Oleson, & Tranel, 2023; Narme, et al., 2014; Ting, et al., 2023; Lam, Li, Laher, & Wong, 2020; Solé, Mercadal-Brotons, Galati, & De Castro, 2014; Guétin, et al., 2009; de la Rubia Ortí, et al., 2018; Massaia, et al., 2018). On average, Music Engagement led to a 30% improvement in Emotional Well-being for individuals with AD.
- **Loneliness and Isolation:** Studies have indicated that involving individuals using Long-Term Care Services in Music Engagement can have positive impacts on their social interactions, reducing feelings of isolation and loneliness (Cheetu, et al., 2022; O'Rourke, et al., 2021; Kurt & Alpar, 2021). Music Engagement has also been associated with increased nonverbal sociable interactions, suggesting that these activities can enhance the QOL and social engagement of individuals with AD

(Schafer, et al., 2022). On average, it has been found that Music Engagement leads to an 18% improvement in feelings of loneliness and isolation for individuals with AD.

- **Neuropsychiatric Symptoms:** Music Engagement has shown to effectively reduce neuropsychiatric symptoms in individuals with AD (Gulliver, et al., 2021; Garcia-Navarro, Buzon-Perez, & Cabillas-Romero, 2022). The Neuropsychiatric Inventory ("NPI"), a widely validated and reliable measure, was commonly used in the literature to assess these symptoms (American Psychological Association, n.d.). The NPI evaluates a broad range of neuropsychiatric symptoms, providing a comprehensive understanding of an individual's condition. Studies utilizing the NPI consistently reported significant improvements in neuropsychiatric symptoms among individuals with AD who participated in Music Engagement (Gomez-Gallego, M., Gomez-Gallego, J., Gallego-Mellado, & Garcia-Garcia, 2021; Brotons & Marti, 2003). On average, Music Engagement led to a 22% decrease in NPI scores for individuals with AD.
- **Quality-Adjusted Life Years (QALYs) Gained:** Research indicates that Music Engagement generates benefits in the form of QALYs gained, which measure the improvement in individuals' quantity and Quality of Life, and overall well-being. The foundation of the QALY lies in expected utility theory, which assumes that utility values can be assigned to specific health states relative to the time spent in those states (Howren, 2013). By incorporating both quantity and Quality of Life, the QALY provides a reasonable estimate of the amount of quality time an individual may experience as a result of a particular program or intervention. The number of QALYs gained are then calculated by multiplying the change in utility value resulting from a treatment or intervention, by the duration of the treatment effect (Prieto & Sacristan, 2003). On average, it has been found that Music Engagement is associated with a gain of 0.018 QALYs relative to those individuals participating in the control groups of various studies who did not participate in Music Engagement (National Institute for Health and Care Excellence, 2018).
- **Sleep Quality:** Music Engagement has been demonstrated to be effective in improving the quality of sleep in individuals with AD (Mu, Lee, Boddupalli, & Meng, 2022). Studies have also indicated an increase in melatonin levels following Music Engagement sessions, which likely contributes to enhanced sleep quality (Kumar, et al., 1999). In addition, research has shown that Music Engagement is effective in improving various aspects of sleep quality among the Elderly Population, including sleep latency (the time it takes to fall asleep), sleep duration, sleep efficiency, and daytime dysfunction (Wang C., et al., 2021). On average, it has been found that Music Engagement leads to a 30% improvement in sleep quality scores for individuals with AD and other dementias.

Impacts of Music Engagement for Caregivers

Music Engagement was found to have a positive impact on the QOL of caregivers of individuals with AD, as follows:

- **Caregiver Burden:** Studies consistently find significant decreases in Caregiver Burden scores, as measured by scales such as the Caregiver Burden Inventory and the Zarit Burden Interview (D'Aniello, et al., 2021; Guétin, et al., 2009; Massaia, et al., 2018; Särkämö, et al., 2014). On average, it has been found that Music Engagement is associated with a decrease of 30% in Caregiver Burden scores.
- **Caregiver Stress/Distress:** Numerous studies have demonstrated that caregivers involved with Music Engagement experience a notable reduction in distress scores and maintain their stress levels relative to those individuals participating in the control groups of various studies who did not participate in Music Engagement (Narme, et al., 2014; Quinn-Lee & Mowry, 2019; Schafer, et al., 2022; Kim, Engström, Theorell, & Emami, 2021). These findings suggest an improvement in overall QOL. To measure these scores, reliable scales such as the Neuropsychiatric Inventory and the Caregiver Distress Scale were utilized. On average, these findings suggest an improvement in Caregiver Stress/Distress scores of more than 25%.
- **Emotional Well-being:** Research consistently demonstrates the positive impacts of Music Engagement on reducing Depression scores, improving Emotional Well-being, and decreasing anxiety levels for caregivers (García-Valverde, Badia, Orgaz, & Gónzalez-Ingelmo, 2019; Brotons & Marti, 2003). Reliable scales such as the Beck Depression Inventory and state-trait Anxiety inventory were employed to measure scores. Community-based music programs and individual/group singing interventions have also been found to improve Emotional Well-being among caregivers (Rio, 2018; Osman, Tischler, & Schneider, 2016; Lee, O'Neill, & Moss, 2022; Hanser, Butterfield-Whitcomb, Kawata, & Collins, 2011; Davidson & Almeida, 2014). On average, these findings indicate a 25% improvement in caregiver Emotional Well-being scores.

Quantification Process in Model Framework

Based on the assumptions and framework logic described in Section 2, equations can also be used to quantify the economic impacts of Music Engagement for individuals with AD and their caregivers. The components of the equation are as follows:

Model Framework Equation for Quantifying the Impact of Music Engagement for Individuals with AD

$$\text{Quantified Economic Impact of Music Engagement for Individuals with AD} = A \times B \times C \times D \times E$$

where,

A = # of Individuals with AD by Disease Stage (Mild, Moderate, Severe)

B = % of Music Engagement Impacts × % of Downstream Economic Impacts

C = Monetization Pathway (Relevant Healthcare Cost Associated with the QOL Metric)

D = Music Engagement Adoption Rate

E = Music Engagement Response Rate

Model Framework Equation for Quantifying the Impact of Music Engagement for Caregivers of Individuals with AD

$$\text{Quantified Economic Impact of Music Engagement for AD Caregivers} = V \times W \times X \times Y \times Z$$

where,

V = # of Individuals with AD by Disease Stage (Mild, Moderate, Severe)

W = % of Music Engagement Impacts × % of Downstream Economic Impacts

X = Monetization Pathway (Relevant Healthcare Cost Associated with the QOL Metric)

Y = Music Engagement Adoption Rate

Z = Music Engagement Response Rate

Components *C* and *X* refer to the monetization pathways decsribed in Section 2. These monetization pathways are relevant Healthcare Costs (e.g., outpatient services) or benefits (e.g., QALYs) associated with a specific QOL metric. They are based on data from the Alzheimer's Association and other relevant sources. A detailed table outlining specific monetization pathways (i.e., Healthcare Costs or benefits) are listed in the table below:

QOL Metric	Monetization Pathway
Individuals with AD	
Activities of Daily Living	Inpatient hospitalization
Agitation	Total Healthcare Costs
Cognitive Function	Total Healthcare Costs
Depression	Medical provider costs Inpatient hospitalization
Emotional Well-being	Total Healthcare Costs
Loneliness and Isolation	Outpatient services
Neuropsychiatric Symptoms	Total Healthcare Costs
Quality-Adjusted Life Years (QALYs) Gained	Willingness to pay for QALYs Gained
Sleep Quality	Medical provider costs ER visits Outpatient services
Caregivers of Individuals with AD	
Caregiver Burden	Inpatient hospitalization Nursing Home costs
Caregiver Stress/Distress	Nursing Home costs ER visits Institutional costs
Emotional Well-being	ER visits Institutional costs Home Healthcare Costs

Illustrative Example of Depression Metric

To illustrate the type of equations used in the model framework for individuals with AD, consider the Depression metric found to be impacted by Music Engagement for individuals with AD in Section 1, Step 1, and its relevant Downstream Economic Impact on general practitioner (GP) and specialist visits in Section 1, Step 2. Below is a simplified example for individuals with AD at the mild stage of disease, and with a conservative 30% Music Engagement Adoption Rate:

- A = 6.9 million individuals with AD in the US multiplied by the proportion of mild cases (50.4%)
- B = Music Engagement impact at 4.43[11] multiplied by the Downstream Economic Impact of GP and special visits at 3% (per each 1 unit decrease in GDS score)
- C = Medical provider costs for mild AD at $4400, annual payment
- D = Music Engagement Adoption Rate at 30%
- E = Music Engagement Response Rate at 52%

The simplified calculation would be as follows:

(A) 6.9 million x 50.4%; x (B) 4.43 x 3%; x (C) $4400; x (D) 30%; x (E) 52% = $317,000,000[12]

Thus, the unadjusted cost savings from Music Engagement for individuals with mild AD at a conservative 30% Adoption Rate for the Depression QOL metric is approximately $317 million. This example is intended to provide a basic understanding of the quantification process. In practice, this process is repeated across all metrics for individuals across all stages of the disease (mild, moderate, severe), and the results are summed at the end. It is important to note that this simplified calculation does not account for overlapping benefits, which are addressed as described in Section 2, to adjust the results to avoid overestimation.

[11] This value represents the average decrease in the GDS score (a measure of Depression) in units. Units are used instead of the percentage result from Section 1, Step 2, as this adjustment is necessary to integrate the impacts of Music Engagement with Downstream Economic Impacts for the quantification process. Therefore, the calculations in the model are more complex than presented in this example.

[12] Totals may not add up due to rounding. In addition, the multiplication of the components in the formula may not yield exactly $317,000,000 due to rounding in the individual components.

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