Neighbour Day

Cost-Effectiveness Evaluation

1.1 Report Authors

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The authors acknowledge Aboriginal and Torres Strait Islander Australians, the traditional custodians of this Country, and pay respects to their elders past and present.

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2 Executive Summary

An evaluation of the Neighbours Every Day Campaign, and its Day of Action known as ‘Neighbour Day’, was conducted by researchers at the Australian National University (ANU) and the University of Queensland (UQ) in collaboration with Relationships Australia.

The purpose of this evaluation was to answer two main research questions:

1. What is the primary benefit of Neighbour Day for participants compared to the general population?
2. What is the return on investment (cost-effectiveness) of delivering these benefits?

The **main findings** of the evaluation were:

1. Compared to non-participants, Neighbour Day participants were more likely to have experienced reduced loneliness compared to the general population;
2. A reduction in loneliness was associated with increased quality of life;
3. We found an incremental cost effectiveness ratio of $4,667 per quality adjusted life years (QALYs) which would be considered cost effective at a $28,033 willingness-to-pay threshold.

Key **recommendations** arising from this evaluation:

1. Based on the available evidence, Neighbour Day represents a cost-effective model of building community connection and wellbeing which should be scaled nationally.
2. The cost of Neighbour Day compares favourably to other models of loneliness intervention and estimates of what Australian governments are willing to pay for interventions that benefit quality of life. The cost-effectiveness of Neighbour Day should be considered in the context of other mental health and public health interventions when deciding the return-on-investment case for government investment.
3. Additional investment in Neighbour Day could focus on people living in disadvantaged communities, or communities that are culturally and linguistically diverse, to expand the culturally appropriate adaptations to Neighbour Day that are available and to maximise population benefits.
4. This evaluation focused on Neighbour Day (a day of action in March every year) which has now been expanded into Neighbours Every Day, emphasising the continuity of forming and maintaining relationships year-round. Future work could expand estimates of cost-effectiveness to include the Neighbours Every Day approach.

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3 Introduction

3.1 Neighbour Day

Neighbour Day was an Australian initiative founded in Melbourne in March 2003. From its initial focus on checking in on elderly neighbours, Neighbours Every Day has evolved into a year-round grass roots community development campaign with a focus on inclusion and connection, making others welcome, and building respectful relationships. It seeks to increase social participation, build connection with individuals and groups, reduce loneliness, and promote social inclusion. The Day of Action, Neighbour Day, is estimated to reach almost 300,000 attendees each year (Cruwys et al., 2019) and is supported by a large number of Ambassadors, Very Neighbourly Organisations, Community Organisations, and Councils. While Neighbour Day was traditionally celebrated once a year, in October 2022 it was rebranded as a year-round campaign to promote neighbourhood connection: Neighbours Every Day (neighbourseveryday.org), which retains an annual "Day of Action" on the last Sunday in March every year. Although the Campaign is now called Neighbours Every Day, we retain the Neighbour Day terminology in this report because these analyses are based on data from before the rebranding.

3.2 Relationships Australia

Relationships Australia (relationships.org.au) works in a variety of ways across Australia. They advocate and promote the importance of respectful relationships with respect to positive individual mental health outcomes and general community outcomes. Relationships Australia is a community based, not-for-profit Australian organisation with no religious affiliations who provide services for all members of the community (e.g., regardless of religious belief, age, gender, sexual orientation, lifestyle choice, cultural background, or economic circumstances).

Relationships Australia is a leading provider of relationship support services for children, adults, couples, families, and communities. Services around the country include counselling, family dispute resolution and mediation, family violence services, mental health services, and a range of family and community support and education programs. Relationships Australia member organisations provide support services across all Australian states and territories, including in regional and remote areas, with their national office based in Canberra.

Relationships Australia took responsibility for Neighbour Day on 1 January 2014. Relationships Australia utilises Neighbour Day as a key platform of their social connection campaign to support and promote sustainable respectful relationships across communities.

3.3 Previous Neighbour Day Evaluations

In 2019, ANU and Relationships Australia evaluated Neighbour Day for over 400 hosts and found that, compared to baseline, participation was associated with an increased sense of neighbourhood identification. This, in turn, led to increased social cohesion, decreased loneliness, and improved wellbeing. These benefits were found to be sustained over time at the six-month follow-up (Cruwys et al., 2019; Fong et al., 2021).

In the following year, the 2020 Neighbour Day was impacted by the COVID-19 pandemic and unprecedented social restrictions imposed by the government. Many of the planned Neighbour Day activities were cancelled and alternative ways to connect remotely were carried out instead. Despite the mandated restrictions on social gatherings, the 2020 evaluation by the ANU and Relationships Australia again found that increased sense of neighbourhood identification was associated with better wellbeing (Cruwys et al., 2020). Those respondents who were able to celebrate Neighbour Day in some way (even online) were also more likely to report confidence that they could rely on their neighbours for support in a time of need.

The 2021 evaluation took a different sampling approach to previous years by recruiting both Neighbour Day participants and non-participants from the general population (Cruwys et al., 2022a). Neighbour Day participation (either as a host or attendee) was associated with greater neighbourhood identification, as well as higher wellbeing and reduced psychological distress despite prolonged COVID-19 lockdowns that occurred in many states during the evaluation time-period. Benefits of Neighbour Day were similar across different ages, genders, educational backgrounds, relationship status, employment status, and socioeconomic backgrounds. Neighbour Day participants were more likely to have high quality social relationships of all kinds (e.g., with their colleagues and friends), rather than only their neighbours. Furthermore, there was evidence for positive changes in both social connection and wellbeing over time among Neighbour Day participants.

4 The Neighbour Day Cost-Effectiveness Evaluation

Building on this previous research, the present evaluation sought to answer two research questions:

1. What are the potential benefits of Neighbour Day for participants compared to the general population?
2. What is the return on investment (cost-effectiveness) of delivering these benefits?

5 Evaluation methodology

5.1 Approach

The aim of this evaluation was to investigate the cost-effectiveness of Neighbour Day to improve the wellbeing of participants compared to the general population.

To do this, a secondary analysis of existing data was performed by combining three datasets: (1) de-identified survey data from the 2019 Neighbour Day evaluation, (2) operational data from Relationships Australia on costs and the 2019 Neighbour Day event register, and (3) population survey data from the Household, Income and Labour Dynamics in Australia (HILDA) survey. Ethical approval for the original 2019 Neighbour Day study was obtained through the Human Research Ethics Committee at ANU (Protocol: 2019/132).

The methodology and research questions were developed by the research team based at the Australian National University (ANU) and the University of Queensland (UQ) in consultation with Relationships Australia. Data analyses were conducted by ANU and UQ authors independently of Relationships Australia.

5.2 Methods

5.2.1 Datasets

Results utilised secondary data collected for the 2019 Neighbour Day Evaluation report (Cruwys et al., 2019), internal Relationships Australia data (event register and costings), as well as wave 19 (2019) of the Household Income Labour Dynamics of Australia (HILDA) Release 21 (Department of Social Services; Melbourne Institute of Applied Economic and Social Research, 2022), which provided a comparable general population sample.

The 2019 Neighbour Day survey was chosen for the intervention sample rather than more recent years because these datasets were collected prior to COVID-19 lockdowns. This is appropriate for two reasons. Firstly, lockdowns are likely to have negatively impacted psychological wellbeing unevenly across state jurisdictions, which could confound any benefits from Neighbour Day. ANU research found that the stringency of COVID-19 policies and state-level case numbers significantly increased reported loneliness over the COVID-19 period up to August 2022 (Biddle et al., 2022). Secondly, previous evaluations found lockdowns led to the cancellation or postponement of many in-person Neighbour Day events typical of previous years, such as barbeques and events centred around sharing food. A report on the impact of COVID-19 on Neighbour Day 2020 found that virtual actions increased, while in-person gathering sizes were reduced to observe physical distancing restrictions (Cruwys & Fong, 2020).

The 2019 Neighbour Day survey design is described in the corresponding Evaluation Report (Cruwys et al., 2019). More than six months after Neighbour Day (timepoint three or T3, collected October to November 2019), respondents were followed-up to evaluate whether neighbourhood identification was enhanced and sustained over time (Fong et al., 2021). We chose to compare this timepoint against baseline in the month prior to Neighbour Day (timepoint one or T1, collected 1-30 March 2019) for the intervention group to better correspond to the yearly interval between timepoints for the control group.

The HILDA wave 19 (collected in 2019) was used to identify a control group. The data was obtained with restricted access to postcode-level data which was used to isolate those from the HILDA survey that were unexposed to Neighbour Day events. The HILDA survey is designed to be representative of the Australian population, with the exception of people living in very remote parts of Australia and people living in institutions (e.g., nursing homes) (Summerfield et al., 2021). Access to HILDA unit record files is available via the Australian Data Archive (ADA) Dataverse at the Australian National University. Access to the data was granted on 1 March 2023 via a formal request and registration with the ADA.

A timeline for each data collection timepoint in relation to the Neighbour Day 2019 event (31 March 2019) is given in Figure 1 below. The number of observations used in analysis were **186** for the Neighbour Day (intervention) sample and **7,825** for the HILDA (control sample), with changes in loneliness status (outcome) assessed across two time-points for each dataset.

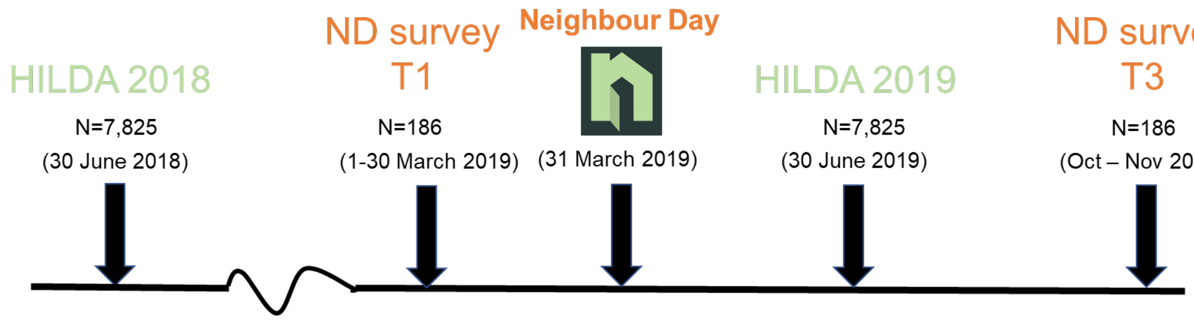

Figure 1. Timeline of data collection for Neighbour Day and HILDA surveys in relation to Neighbour Day event (31 March 2019)

HILDA=Household, Income and Labour Dynamics in Australia; T1= timepoint 1, T3 = timepoint 3

5.2.2 Identifying the control group

We defined exposure to Neighbour Day using postcodes reported by respondents to the 2019 Neighbour Day Evaluation Survey and to an Event Register. The latter is routinely collected via a website pop-up on the Relationships Australia website which hosts typically visit to obtain resources for event promotion (i.e., invitation cards, posters, social media collateral). First, combining the survey and register postcodes, we removed duplicates to compile a unique list of postcodes considered to be "exposed" to Neighbour Day. This list was merged into HILDA at the individual level and HILDA respondents from exposed postcodes were removed from the final combined dataset. In addition, we removed individuals from both the Neighbour Day survey and HILDA sample that were missing observations for key control variables (see Appendix A).

5.2.3 Key outcomes of Neighbour Day

Neighbour Day can be described as a complex intervention in that we would theoretically predict it could produce a range of outcomes for participants. Consistent with this, Cruwys et. al (2022a; 2022b) found that Neighbour Day participation was associated with increased neighbourhood identification, social cohesion, social networks and had a positive association with mental health. Thus, for this analysis, we considered a range of potentially relevant outcomes for inclusion as outcomes for the economic evaluation. We also had pragmatic constraints given that measures of the chosen outcome/s needed to be available both in the 2019 Neighbour Day survey data and in the HILDA data. Figure 2 represents the variables found to be comparable across the two datasets, with the darker green circles representing potential outcome variables and the lighter green circles identified as potentially important explanatory variables. Orange circles represent relevant data available in HILDA, but not available in the Neighbour Day survey data.

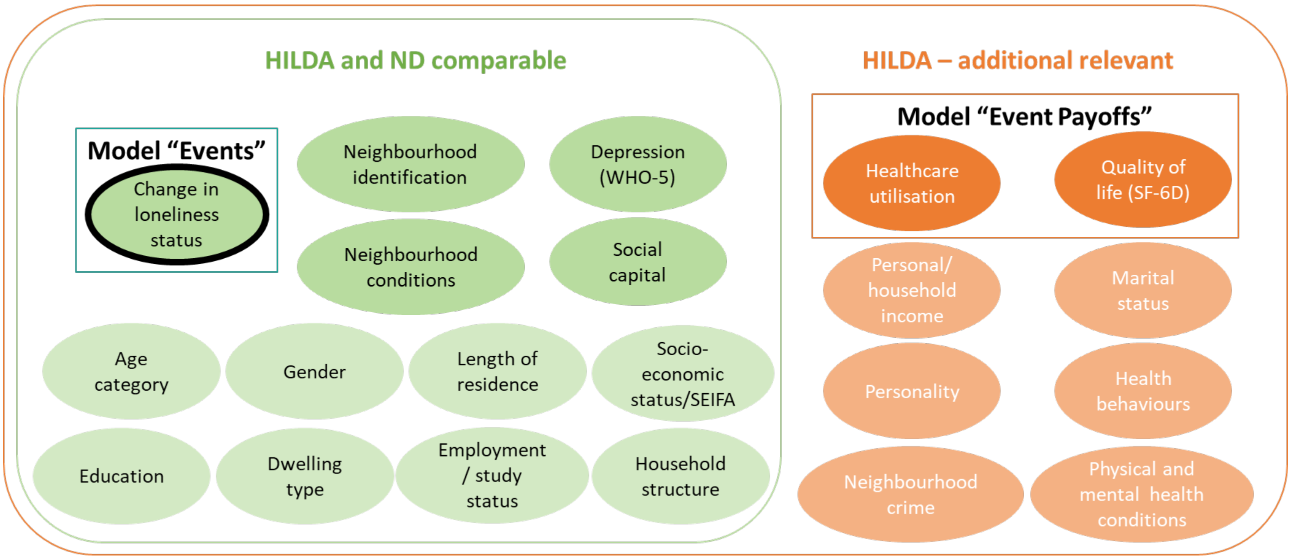

Figure 2: Data variables considered for inclusion in the analysis

HILDA=Household, Income and Labour Dynamics in Australia; ND = Neighbour Day; SF-36 = Short-Form 36-Item Instrument; SEIFA = Socio-economic Index for Areas; WHO-5 = World Health Organization – 5 item Wellbeing scale

While differences in neighbourhood identification, social capital, and mental health due to participation in Neighbour Day were all considered potentially relevant, **loneliness** was ultimately chosen as the key outcome measure. This choice was based on the growing body of evidence showing a strong association between reduced loneliness and reduced health care utilisation costs (Majmudar et al., 2023; Duncan et al., 2021), as well as positive wellbeing outcomes (Erzen & Çikrikci 2018; Sirois & Owens 2021; Valtorta et al., 2016), all of which can inform an economic evaluation. However, as noted by Fong and colleagues (2021), enhanced neighbourhood identification and social cohesion are still likely pathways through which interventions like Neighbour Day might operate to benefit health and wellbeing.

The next step in this evaluation was to estimate a robust average effect[1] of Neighbour Day participation on reducing loneliness, considering the potential confounding effects of social identity, social cohesion, and mental health status, as well as (pre-existing) differences between people who choose to participate in Neighbour Day compared to those who do not. Differences between those that participate and don't participate may also be associated with loneliness (the 'sample selection' problem) which if left unaddressed, could lead to misleading results.

For this reason, we used a treatment effects model (Chesnaye et al., 2021; Huber, 2015) to estimate the average effect of Neighbour Day on loneliness among people who choose to participate compared to the general public who did not participate. In short, we matched both cohorts on observed characteristics such as age, gender, education and employment levels so we could compare changes in levels of loneliness between the two groups, while accounting for other confounding factors that may affect comparison between these two samples. This type of modelling has been designed to be used in situations where a randomised trial is not feasible, to emulate random allocation to treatment and control groups as the most rigorous way of controlling for potential biases.

To estimate effects of Neighbour Day on loneliness that can be used in the economic evaluation, we needed to identify the probability that loneliness may change. We identified four relevant pathways: (i) move from lonely to not lonely; (ii) stay lonely; (iii) move from not lonely to lonely; and (iv) remain not lonely. To create a binary "lonely" variable, we used the following question:

"I often feel very lonely"

which was measured on a seven-point Likert scale, where 7 represents strongly agree. Thus, loneliness was defined by a binary variable constructed from this item with a cut-off of greater than or equal to 5 on the Likert scale per similar cost-consequence literature (Majmudar et al., 2023; Duncan et al., 2021).

Details of how the effect of Neighbour Day on loneliness was estimated using the treatment effects model are presented in Appendix A.

5.2.4 Included costs

Two main costs were included in the economic evaluation: (i) the cost of running Neighbour Day (both direct and indirect); and (ii) the costs of healthcare utilisation.

The cost of running Neighbour Day

Relationships Australia provided summary (direct) costs of administering Neighbour Day which included costs of the national level office as well as state affiliates, organisations, and local councils. In addition, we included an estimate for the (indirect) cost of volunteer

[1] This refers to the average effect of the intervention across all participants, estimated to be robust to misspecification of either the treatment (propensity score) equation or the outcome equation by combining inverse probability weighting and regression. Refer to Appendix A for more details.

time to organise and host events by applying shadow prices based on average earnings in Australia to capture the opportunity cost of volunteer's time (ABS, 2019). This is consistent with the standard approach to costing volunteer or other non-market work (see Volunteering Queensland, https:/volunteeringqld.org.au/calculator/). Our approach to the costs of running Neighbour Day is therefore very conservative, as many volunteers may consider their involvement in Neighbour Day a beneficial leisure activity rather than labour or an alternative to workforce participation.

Details of included costs of running Neighbour Day are presented in Appendix B.

The costs of health care utilisation

There is a growing body of literature that shows a strong association between loneliness and increased health care utilisation, particularly increased visits to a general practitioner (GP) and hospital admissions (Majmudar et al., 2023; Duncan et al., 2021). The number of GP visits and hospitalisations were not asked in the Neighbour Day evaluation survey; therefore, we used estimates from the general population (using HILDA data) grouped by different levels of loneliness (see Figure 2). Count variables for annual GP visits and hospitalisations were used, adjusted for the population sampling weights (to make population estimates more reflective of the Australian population), to which an average cost per visit was applied. Two key assumptions were made:

1. As both variables are only contained within our HILDA dataset, we assumed any differences between healthcare utilisation for those that are and are not lonely among HILDA respondents reflects the experiences for their counterparts in the ND survey; and
2. As healthcare utilisation questions are asked every fourth wave in the HILDA survey, we used wave 17 (collected in 2017) as the closest pre-COVID period available. Given average healthcare utilisation remains relatively static across each wave (analysis not shown), we assume the difference in healthcare utilisation between those who do and do not report loneliness in 2017 is similar to 2019.

Our healthcare utilisation summary inputs and a sub-group analysis (lonely versus not lonely) are detailed in Appendix C. Details of our approach to the use of sampling weights for health care costs are included in Appendix D.

5.2.5 Included benefits

In economic evaluations of health care or public health interventions, governments and other funding organisations find it helpful to have benefits expressed as outcomes that allow for comparison across different interventions to aid decision making. For this reason, we applied estimates of quality of life to different states of loneliness using a multi-attribute utility instrument, which measures overall quality-of-life on a scale from zero (death) to one (full health) (Brazier et al., 2002).

Quality-Adjusted Life Years (QALYs) are a way of numerically measuring the effectiveness of different health outcomes to help people make decisions about healthcare resources. They typically combine the quantity (extended lifespan) and quality of life (improved physical and mental health function) (Whitehead & Ali, 2010). For example, if a new treatment increases the length of life but decreases its quality, perhaps due to side effects, the QALY measure will incorporate both of these effects. We make no claims of extended life due to Neighbour Day participation for this analysis, which focuses only on one year (2019). Assessing the possibility of reduced survival due to mental and physical health sequelae from chronic loneliness would require longitudinal data from Neighbour Day participants followed over a much longer period of time (10+ years). Therefore, we focused only on the quality-of-life dimension of the QALY measure to assess differences for Neighbourhood Day participants compared to the general public. QALYs are widely used as the effectiveness component of the Incremental Cost Effectiveness Ratio (ICER, see section 5.2.8) in cost-effectiveness evaluations, to allow the costs and benefits of diverse interventions to be compared in the same units.

Much like healthcare costs, estimates of quality of life were not included in the Neighbour Day evaluation survey, but can be derived from the HILDA survey data. We used the Short-Form 6-Dimension (SF-6D) responses, taken from HILDA wave 19, to calculate quality of life. This measure has been converted from the longer 36-item questionnaire (SF-36) and weighted according to Australian population preferences for health states (Summerfield et al., 2021). The weighted SF-6D utility values reflect six dimensions of physical and mental health concepts (physical functioning, role limitations, social functioning, pain, mental health and vitality) (Brazier et al., 2002).

As for healthcare utilisation estimates, we assumed any difference in quality of life for those that are, versus those that are not, lonely among HILDA respondents reflects the experiences for their counterparts in the Neighbour Day survey. Population weights are used to account for the sampling strategy of the HILDA survey.

Summary inputs and a sub-group analysis of the quality-of-life estimates used in the model (lonely versus not lonely) are presented in Appendix E. Details of our approach to the use of sampling weights for utility estimates are included in Appendix D.

5.2.6 Benefits considered but not included in the analysis

To be comprehensive in cost estimates incurred due to loneliness, we investigated whether there are differences in sick days incurred by people reporting loneliness for the working age population, as well as variation in health behaviours across all age groups (Appendix F).

A clear pattern between number of sick days and whether a person is lonely was not identified (Figure F1). This is consistent with a recent report that also investigated the cost of loneliness using HILDA data (Duncan et al., 2021). Those authors surmised that some groups, particularly older workers, may value employment as a mitigation against loneliness. This may explain why we tend to see somewhat fewer sick days taken by lonely workers (particularly for women), despite poorer health and excess healthcare use incurred.

No consistent pattern was observed in terms of physical inactivity or alcohol consumption according to loneliness status. In terms of smoking behaviour, there was some indication that those in their forties, and men in their fifties are more likely to be current smokers if lonely (Appendix Figure F2). A strong signal was observed indicating that those reporting loneliness are more likely to be daily smokers across both genders and age groups (Appendix Figure F3). While this may be of interest to health policy makers, we decided against costing these effects in our model to remain conservative and avoid potential double-counting alongside our included measures of health care utilisation. Further, causal relationships between loneliness and health behaviours such as smoking, alcohol consumption and regular exercise are complex and not well understood. Thus, for this analysis we have not included costs or benefits of potential changes in health behaviours due to changes in loneliness status.

5.2.7 Model structure and assumptions

A decision tree model for a period of one year was used for the economic evaluation. This compares the costs and benefits for Neighbour Day participants compared to the general population in non-exposed neighbourhoods (non-participants). The structure of the model is presented in Appendix G and the model parameters are detailed in Appendix H. The model relies on estimates of the probability of changes in loneliness (section 5.2.3 Key outcomes of Neighbour Day), the costs of running Neighbour Day and healthcare costs for participants and non-participants (section 5.2.4 Included Costs), and any differences in quality of life for being lonely versus not lonely (section 5.2.5 Included Benefits). We did not consider future costs and benefits (following the convention for economic evaluations of public health interventions) as the model only runs for one year.

5.2.8 Assumed Willingness-To Pay threshold

In health care technology assessment, the incremental costs of participation in a program (such as Neighbour Day) are expressed against the incremental effects (e.g., quality-of-life benefits) to form an Incremental Cost Effectiveness Ratio (ICER). ICERs may be used to compare the relative value of policy or program options against alternatives. They can also be compared against a Willingness to Pay (WTP) threshold, which reflects that desired health benefits must be weighed against limited healthcare budgets. In other words, the WTP threshold represents an estimated upper limit on what governments and/or other healthcare investors have shown a willingness to invest in a new healthcare intervention.

Typically, cost-effectiveness evaluations will assume a WTP threshold of $50,000 United States dollars per QALY by convention for health technology assessments (Grosse, 2018). However, an empirical approach was recently used by Edney and colleagues (2018) to derive the opportunity costs from existing government health expenditure (foregone benefits of the best alternative use of the additional resources required to fund a new technology) and thereby estimate a reference ICER threshold in the Australian context. They estimated a more modest WTP of 28,033 Australian dollars ($AUD) per QALY gained (95% confidence interval $AUD 20,758–37,667). While there is no explicit WTP threshold stated by Australian governments when funding new health technologies, this threshold is useful in interpreting whether our ICER is cost-effective (benefits justify the additional costs) or cost-ineffective (costs outweigh benefits). ICER values below a given WTP threshold may indicate a greater likelihood of attracting government funding. However, cost-effectiveness metrics should be considered as a starting point when making funding decisions, and multiple other contextual factors (equity, patient preferences, rare conditions) are often relevant to funders, policymakers and society.

For this evaluation, we used the WTP threshold of $AUD 28,033 estimated by Edney and colleagues (2018) for mental health interventions to contextualise the ICER values obtained in the base case and sensitivity analyses presented in Section 6.3.

6 Results

6.1 Socio-demographic summary

The characteristics of all persons in the selected sample for each dataset are presented in Table 2. Results of independent sample *t*-tests for each measure show that, compared to unexposed individuals (HILDA sample), Neighbour Day participants were, on average:

- 31% more likely to be *female*, $t(8009)=7.4$, $p<0.001$
- ~12% more likely to be aged between *30 and 49 years of age*, $t(8009)=4.6/4.5$, both $p<0.001$
- 15% more likely to be in a *romantic couple with children*, $t(8009)=4.2$, $p<0.001$
- 15% more likely to hold a *postgraduate* degree $t(8009)=7.7$, $p<0.001$
- 9% more likely to *work part-time*, $t(8009)=2.9$, $p=0.004$

Baseline differences in perceived neighbourhood quality and social variables also strongly indicated a self-selection effect into Neighbour Day. At baseline, compared to unexposed individuals, Neighbour Day participants:

- reported 5% better *social cohesion*, $t(7930)=3.0$, $p=0.003$
- reported 5% better *neighbourhood identification*, $t(7991)=3.1$, $p=0.002$
- perceived 11% better *neighbourhood quality* (per PNQ-3), $t(8009)=6.1$, $p<0.001$

This suggests that the Neighbour Day survey respondents may have been somewhat less vulnerable in their social relationships than the general population.

Table 2. Socio-demographic summary

	ND participants	HILDA sample	*p*-value
Sample size (%)	**186 (2.3%)**	**7,825 (97.7%)**	
Gender			
Female	150 (81%)	**4,166 (50%)**	**<0.001**
Age category			
18-29	**11 (5.9%)**	**1,503 (19.2%)**	**<0.001**
30-39	**55 (29.6%)**	**1,307 (16.7%)**	**<0.001**
40-49	**51 (27.4%)**	**1,206 (15.4%)**	**<0.001**
50-59	40 (21.5%)	1,451 (18.5%)	0.305
60-69	**18 (9.7%)**	**1,236 (15.8%)**	**0.023**
70+	**11 (5.9%)**	**1,122 (14.3%)**	**<0.001**
SEIFA Quintiles			
1 Least advantaged	**21 (11.3%)**	**1,514 (19.3%)**	**0.006**
2	35 (18.8%)	1,687 (21.6%)	0.368
3	**49 (26.3%)**	**1,477 (18.9%)**	**0.010**
4	38 (20.4%)	1,539 (19.7%)	0.796
5 Most advantaged	43 (23.1%)	1,608 (20.5%)	0.392
Employment Status*			
Full-time	90 (48.4%)	3,355 (42.9%)	0.133
Part-time	**56 (30.1%)**	**1,668 (21.3%)**	**0.004**
Unemployed	8 (4.3%)	203 (2.6%)	0.151
Not in labour force	**23 (12.4%)**	**2,599 (33.2%)**	**<0.001**
Student	**4 (2.2%)**	**747 (9.5%)**	**<0.001**
Living situation			
Living alone	**17 (9.1%)**	**1,200 (15.3%)**	**0.020**
Couple no children	**56 (30.1%)**	**3,127 (40.0%)**	**0.007**
Couple with children	**87 (46.8%)**	**2,509 (32.1%)**	**<0.001**
Single parent	7 (3.8%)	566 (7.2%)	0.070
Houseshare	**17 (9.1%)**	**83 (1.1%)**	**<0.001**
Other	**2 (1.1%)**	**340 (4.3%)**	**0.029**
Education			
Less than Year 12	**16 (8.6%)**	**1,638 (20.9%)**	**<0.001**
Year 12 Cert	**10 (5.4%)**	**1,147 (14.7%)**	**<0.001**
Certificate III or IV	44 (23.7%)	1,905 (24.3%)	0.829
Diploma or Grad Diploma	**17 (9.1%)**	**1,368 (17.5%)**	**0.003**
Post-graduate	**39 (21.0%)**	**510 (6.5%)**	**<0.001**
Loneliness: "I often feel very lonely"			
Continuous outcome [a]	2.88 (1.70)	2.69 (1.73)	0.150
Binary outcome [b]	21.0% (40.8)	17.7% (38.2)	0.249
Social capital			
Feeling part of local community [c]	**5.45 (1.33)**	**5.17 (1.23)**	**0.002**
Cohesion [d]	**5.03 (1.05)**	**4.80 (1.05)**	**0.003**
Perceived neighbourhood quality [e]	**5.27 (1.13)**	**4.76 (1.14)**	**<0.001**

*participants could select multiple options

Notes: a: 7-point Likert scale where 1 = Strongly disagree (SD) and 7 = Strongly agree (SA); **b:** As per binary cut-off (≥5) **; c:** 7-point Likert scale where 1 = SD and 7 = SA; **d:** 5-item sum score for neighbourhood cohesion including: People around here are willing to help their neighbours; People in this neighbourhood can be trusted; People in this neighbourhood generally do not get along with each other (reverse coded); This is a close-knit neighbourhood; People in this neighbourhood generally do not share the same values (reverse coded); **e:** 3-item sum score for similar questions related to neighbourhood noise, rubbish and presence of unsupervised young people (see Appendix table A3)

6.2 What is the primary benefit of Neighbour Day for participants compared to non-participants?

6.2.1 Greater loneliness-free years (reduction in the proportion of people who are lonely)

As noted in section 5.2.3, the Neighbour Day survey results had to be modelled to account for self-selection into participation. Figure 3 compares the inverse-probability weighted (adjusted) outcomes for each category of loneliness status change between our samples. A significant difference was found for the proportion of people who report no longer feeling lonely, which increased by 7.3 percentage points, $t(8009)=3.4$, $p=0.001$. This can be interpreted as at least 7.3 averted cases of loneliness for each 100-person cohort who participate in Neighbour Day.

The proportion of individuals who do not report being lonely at either timepoint ("Never lonely") is statistically significant at the 10% level ($p=0.06$) but not at our assumed cut-off of 5%. The difference is about 5 percentage points lower for the Neighbour Day group, reflecting slightly higher levels of loneliness reported by Neighbour Day participants at baseline compared to the general population, which is also insignificant ($p=0.249$). Other outcomes (stay lonely and become lonely) remain the same with no statistically significant changes.

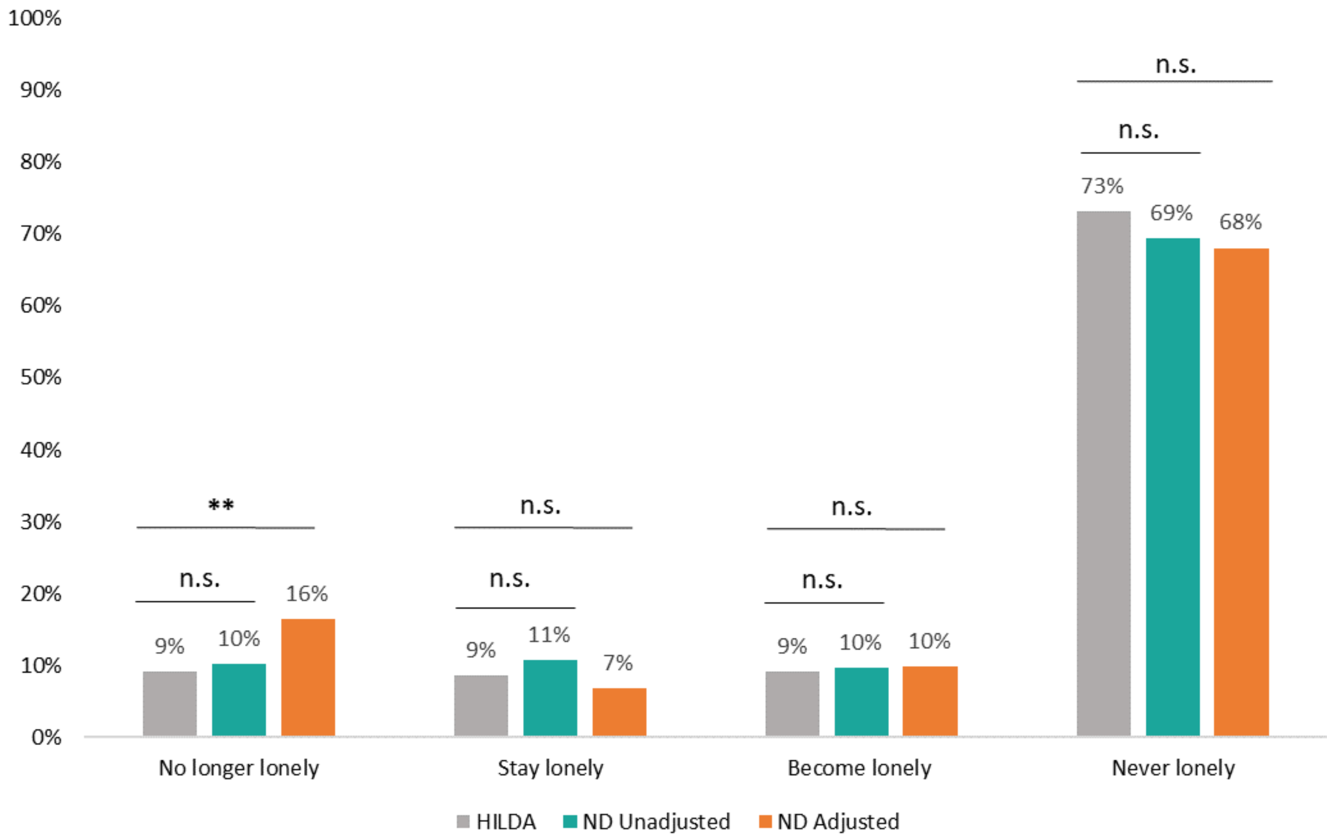

Figure 3. Changes in loneliness status for Neighbour Day compared to HILDA.

Note. ND = Neighbour Day; HILDA = Household Income and Labour Dynamics in Australia; ** = p= 0.001; n.s. = not statistically significant.

Using the estimate of approximately 7.3 averted cases of loneliness for each 100-person cohort that participate in Neighbour Day, we also calculated an incremental cost per loneliness free year (LFY) gained as a natural unit alternative to the incremental cost per QALY to compare against past and future estimates in the loneliness intervention literature.

6.2.2 Greater quality-adjusted life-years (QALYs)

Estimates for quality of life using complex survey weighting (Appendix E) show that lonely individuals have significantly lower overall quality of life compared to non-lonely individuals over all age and gender subgroups using HILDA wave 19. Point estimates used in the decision tree model reflect this difference:

- Lonely individuals on average reported 0.2 (31%) lower health-related quality of life compared to non-lonely individuals (adjusted Wald test $F(366)=582$, $p<0.001$).

6.2.3 Averted healthcare costs for the individual and society

Lonely individuals tend to report greater healthcare use across most age categories for both men and women (Appendix C). This is reflected in point estimates inputted into the decision tree model for those who report loneliness:

- 2.25 (51%) greater doctor visits (adjusted Wald test $F(366)=87.5$, $p<0.001$)
- 0.1 (59%) greater hospitalisations (adjusted Wald test $F(366)=32.5$, $p<0.001$)

Removal of healthcare costs was tested in sensitivity analysis, as overlapping confidence intervals suggested the difference does not reach statistical significance for all subgroups (see section 6.3.2).

6.3 What is the return on investment (cost-effectiveness) of delivering these benefits?

The following sections describe the results of the decision tree analysis:

- Section 6.3.1 details base case summary results
- Section 6.3.2 explores the effect of changes to the model structure or assumptions underlying model inputs to test the sensitivity of base case results
- Section 6.3.3 explores changes to the base case ICER when each model input is individually amended to its lower and upper 95% confidence interval value, also known as univariate sensitivity analysis
- Section 6.3.4 displays the results of 1,000 simulations of the base case ICER estimate, when all model inputs are allowed to vary simultaneously, also known as probabilistic sensitivity analysis.

The latter three sections describe different kinds of *sensitivity analyses*, which is where the assumptions and parameters of the models are changed to other plausible alternatives so that the effect of these on the findings can be considered. If these different models do not change the results too much, we can say that the findings are *robust* in that the conclusions we draw are not reliant on any specific assumption or parameter decision.

6.3.1 Base case results

A base case illustrates what the researchers expect to be the most realistic outcomes from a scenario, for example, the impact on health from engaging with Neighbour Day. The base case is determined using assumptions from previous research. Base case results in **Table 3** show that the intervention incurs **$10.39** per participant after program costs are offset by avoided healthcare costs. Per 100 participant cohort, the intervention averts 7.3 cases of loneliness and accrues 0.22 QALYs (or approximately one fifth of a year in perfect health). Taken together, this results in an ICER of approximately **$4,667 per QALY**, which is highly cost-effective compared to the WTP threshold of $28,033 per QALY gained proposed by Edney et al. (2018).

We also calculated an incremental cost of $141 per loneliness free year (LFY) gained, to compare against past and future estimates in the loneliness intervention literature.

Table 3. Base-case results

	Intervention (ND)	Control (HILDA)	Difference
Costs (per person)			
Program costs	$16.95	Nil	$16.95
Healthcare costs	$1,171.69	$1,178.25	-$6.56
Total costs	$1,188.64	$1,178.25	$10.39
Outcomes (per 100 participants)			
Number people no longer lonely (loneliness free year, LFY)	16.4/100	9.1/100	7.3/100
Quality adjusted life-year (QALY)	62.26	62.04	0.22
Summary measures (per participant)			
Incremental cost per QALY (ICER)	$4,667.20*		
Incremental cost per LFY	$141.43*		

*Figure subject to rounding

6.3.2 Robustness tests

A number of robustness tests were undertaken to assess the effect of a range of assumptions that have been made to calculate the base case results. Details of the robustness tests can be found in Appendix I. The resulting ICER is recalculated for each robustness test. An increase in the ICER indicates that Neighbour Day is considered less cost-effective under that particular scenario compared to the base case. The robustness tests and resulting ICERs are:

1. Removing avoided healthcare costs from the model (ICER increases to $7,615.65; cost per LFY increases to $230.78); and

2. Using only Neighbour Day survey postcodes and excluding event register postcodes to identify where Neighbour Day events occurred. This information was used to determine the control group used from HILDA (ICER increases to $5,732.08; cost per LFY increases to $152.39).
3. Using direct costs only (direct salary and project expenditure by organisations) and excluding the indirect time costs to participants. This reduced the cost per participant from $16.95 to $2.05 and causes the incremental cost for participation in Neighbour Day to be negative (-$4.51) after the averted healthcare costs of $6.56 are accounted for. The economic term for this is that the ICER is ***dominant*** over the alternative of not participating in Neighbour Day, that is, more effective and lower cost.

The increase in the ICER of +63% for test 1 and +23% for test 2 show that the ICER is sensitive to the assumptions made for estimating the base case results.

For test 3, the intervention becomes dominant as costs are negative. When an intervention is dominant, it's considered the clear choice because it offers better outcomes at lower costs. Expressing the ICER for such interventions is unnecessary because it would only confirm what is already evident from the cost and effectiveness comparison: it's the preferred choice. Dominant interventions are superior in terms of both effectiveness and cost, making the ICER calculation redundant in such cases.

6.3.3 Univariate sensitivity analysis

Figure 5 depicts the impact on the base case ICER when each model input is individually amended via univariate sensitivity analysis to its lower and upper 95% confidence interval value. This is important to test to ensure that results are not disproportionately driven by certain inputs, such as hospital admission, and to assess the impact of reasonable changes to each input, for example, what would happen to the incremental effectiveness measure if we assume the average lonely person requires fewer hospital visits? The results are shown via a Tornado diagram, where inputs are sorted in descending order according to their impact on the ICER. Red bars indicate the impact when the relevant input has been increased to its upper limit, while blue indicates the impact when it has been reduced to its lower limit.

Results show that the base case ICER is most sensitive to reductions in the probability of becoming lonely or staying lonely among the unexposed population (pBCLUnexp and pStayLUnexp, respectively). This inflates the ICER to $13,000 and $15,000 per QALY gained, respectively. While this change is substantial, these values are still considered cost-effective against the WTP threshold derived by Edney and colleagues (2018) of $AUD 28,033 per QALY gained. In fact, these values are below the lower bound (lowest feasible estimate) of the WTP threshold ($AUD 20,758), providing assurance of the cost-effectiveness of Neighbour Day.

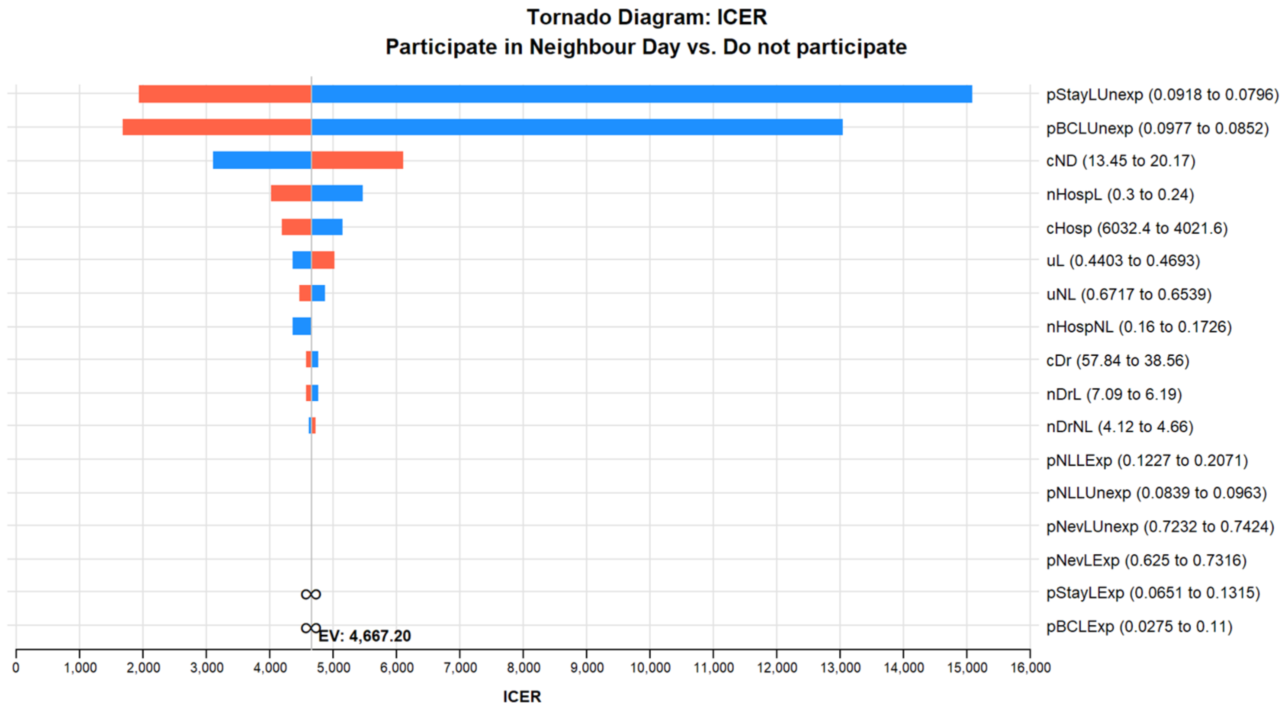

Figure 5. Univariate Sensitivity Analysis (Tornado diagram).

Note. Red bars indicate the impact when the relevant input has been increased to its upper limit, while blue indicates the impact when it has been reduced to its lower limit. EV = Expected value; ICER = Incremental Cost-Effectivess Ratio; cDr = Cost of a doctor visit; cHosp = Cost of a hospital admission; pNLL: Probability of being no longer lonely; pBCL: Probability of becoming; pStayL: Probability of staying lonely; pNevLExp: Probability of never being lonely; Exp = Exposed to Neighbour Day (ND); Unexp = Unexposed to Neighbour Day (HILDA); pDie: Background mortality based on life expectancy; nDrL/nDrNL = Number of doctor visits if lonely and not lonely, respectively; nHospL/nHospNL = Number of hospital admissions if lonely and not lonely, respectively; uL/uNL = SF-6D health utility (quality of life) if lonely and not lonely, respectively.

6.3.4 Probabilistic sensitivity analysis

Figure 6 displays probabilistic sensitivity analysis, or the results of 1,000 simulations when all model inputs are allowed to vary simultaneously across their given probability distributions. This is shown via a scatterplot on an Incremental Cost-Effectiveness plane with incremental effectiveness (SF-6D health-related quality of life utilities or QALYs) on the X axis and incremental costs (program and healthcare costs) on the Y axis. Red dot points represent iterations in which the incremental effectiveness is either negative (33% of total simulations) or too low to outweigh the costs (3%). Green points represent iterations in which Neighbour Day represents the optimal strategy, that is cost effective (37%) or cost saving (27%).

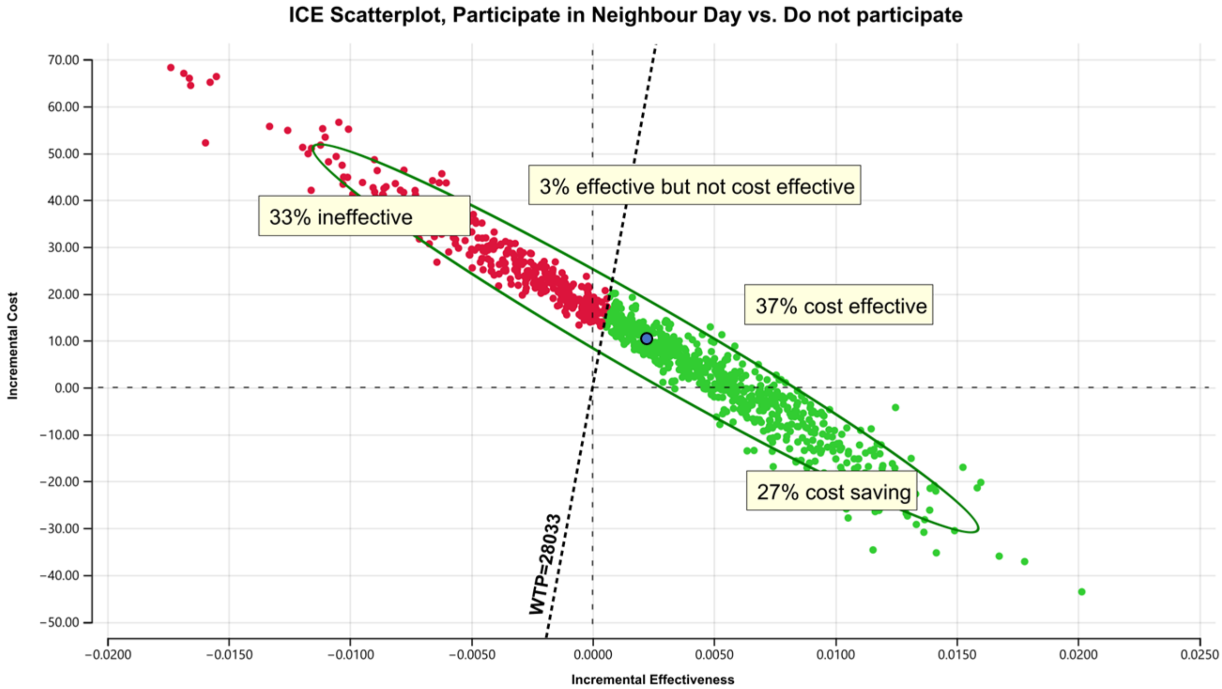

Figure 6. Incremental Cost-Effectiveness Scatterplot from 1,000 simulations (Probability Sensitivity Analysis).

Note. Red and green points collectively represent 1,000 simulations of the incremental cost and effectiveness of "Participate in Neighbour Day" against "Do not participate", allowing all inputs to vary simultaneously. The blue central point with black outline depicts the approximate mean (base case) incremental values. Dashed line represents the assumed WTP threshold of $AUD 28,033. Oval outlines the 95% confidence interval of estimates.

7 Discussion and Recommendations

7.1 Key Findings

This report combines data from previous Neighbour Day evaluations, and the nationally representative HILDA survey, to model the impact of Neighbour Day participation in terms of costs and outcomes. To undertake a fair comparison with a population that have not participated in Neighbour Day, we first had to estimate the likely effect on levels of loneliness for participants compared to the general population. The results show an increase of 7.3 percentage points for the proportion of people who were previously lonely, but who are no longer lonely after participation in Neighbour Day, increasing confidence that Neighbour Day has a causal effect on reducing loneliness. We used this estimated treatment effect, along with additional information on costs and outcomes from the HILDA dataset to model the cost-effectiveness on Neighbour Day participation on loneliness. We found Neighbour Day increases quality of life and reduces loneliness among participants at an acceptable cost, with a base case ICER of **$4,667**.

We also tested the robustness of this result to the assumptions made in the base case and precision of the model parameters. We found that the model was sensitive to assumptions made in the base case. The ICER increased to approximately $7,615 when removing healthcare costs and was most sensitive to the estimates of precision for becoming or staying lonely but remained cost-effective against our assumed WTP threshold in all instances. While probabilistic sensitivity analysis indicates some uncertainty when all inputs are varied simultaneously, our outcomes are robust to all re-specification tests and univariate sensitivity analysis. This builds confidence that our estimate of the cost-effectiveness of Neighbour Day is accurate. The probabilistic sensitivity analysis showed some uncertainty in the base case results whereby Neighbour Day is optimal in 64% of cases. This may be explained by the relatively low numbers in the population who are classified as lonely using our binary cutoff, and even smaller proportion of those for whom Neighbour Day is an effective intervention for this particular outcome. There are no known harms from participation in Neighbour Day, therefore iterations in the North-West quadrant likely reflect uncertainty in the overall quality of life utility estimate given the underlying event probabilities. This also helps to explain why event probabilities for the pathways leading to loneliness in the control group produce the largest impact on the base case ICER. Future research using larger samples of Neighbour Day participants is recommended to test the reproducibility and robustness of the results shown here, including for additional outcomes known to be linked to Neighbour Day, such as neighbourhood identification and social cohesion (Fong et al., 2021). Neighbourhood identification has been linked to enhanced wellbeing and reduced symptoms of psychological distress and may be a feasible target for interventions aiming to increase mental health resilience among disadvantaged neighbourhoods (Cruwys et al., 2022b).

Our analysis has a number of strengths. Inputs have been estimated conservatively via:

- inclusion both direct and indirect (time/volunteer) costs in estimating incremental costs, and

- inclusion of healthcare costs only (exclusion of loneliness-related lifestyle and productivity costs for which the evidence base is weaker) in estimating incremental benefits.

It is known from previous evaluations (Cruwys et al., 2022a) that Neighbour Day represents an investment in community resilience. People who were involved in Neighbour Day were protected against detriments to mental health and wellbeing that occurred nationally in the context of a global pandemic and the unpredicted and significant impact on peoples' movement, employment, and finances. We purposefully chose to model pre-pandemic data to remain as conservative as possible, therefore our cost-effectiveness values may underestimate the benefits accrued during a global crisis with enforced social distancing measures, when social needs were likely higher.

The incremental cost per QALY (ICER) and cost per LFY estimates enable a comparison across health interventions as evidence to support investment and growth of Neighbour Day as a preventative and supportive intervention to combat the health consequences of chronic loneliness. For example, our base case result of $4,667 per QALY is similar to a UK-based evaluation (Knapp et al., 2011) of a population level suicide awareness training, an intervention which yielded a cost per QALY of £1,573, £2,044, and £2,924 (equivalent to approximately $AUD 3,000, 3,900 and 5,600, 2023 prices) over 1, 5 and 10-year timeline respectively. Our results are also favourable compared to a Dutch analysis (Onrust et al., 2008) of a widow/widower visiting service which estimate a €6827 per QALY (equivalent to approximately $AUD 11,320, 2023).

In the United Kingdom (UK), the Department of Health has introduced a cost per QALY gained threshold of £15,000 ($AUD 28,614, 2023) for public health interventions, which is lower than the £20,000 per QALY gained for interventions assessed by the National Institute of Health and Care Excellence (NICE) (Owen & Fischer, 2019; Department of Health and Social Care, 2016 (s.7 para.70)). This is comparable to the threshold willingness to pay of $AUD 28,033 per QALY gained derived by Edney and colleagues for mental health interventions (2018). A recent systematic review by Owen & Fischer (2019) summarised 71 published public health intervention guidelines assessed by NICE over the time period March 2006 – March 2018. They found the median ICER was £1,986 ($AUD 3,788, 2023). Thus, the base-case ICER of $4,667 for Neighbour Day is similar to the median estimate of funded public health interventions in the UK, and well below the willingness to pay threshold for both the Department of Health UK for public health interventions and that found by Edney (2018) for mental health interventions.

We also calculated an incremental cost of $141 per loneliness free year (LFY) gained to compare against past and future estimates in the loneliness intervention literature. McDaid & Park (2021) recently conducted an evaluation of a loneliness alleviation programme for older people based in the United Kingdom. This analysis showed incremental cost of £768 per LFY gained, equivalent to approximately $AUD 1,500. This figure is approximately ten times our estimate of $141 per LFY. This difference can be explained given that the UK analysis was based on a social impact bond funded program that involved 6- to 9-months of personalised intervention by a trained volunteer, therefore necessarily incurring higher cost demands compared to the flexible community led and grassroots nature of Neighbour Day. Additionally, the costs of this intervention are likely underestimated if it were applied in the Australian context, especially in regional and remote areas. This means that Neighbour Day is a low-cost intervention that compares favourably to the accrued benefits, relative to other cost-effectiveness analyses of loneliness interventions.

7.2 Limitations

Without experimental data (e.g., a randomised controlled intervention study), it is not possible to obtain strong evidence of causality. The conclusions of this evaluation are derived from the available data and should not be extrapolated beyond this sample and context. We have based our analysis on data for one year. Longitudinal data provides more robust estimates of whether improvements in loneliness may be realised over time: this is an area of future research.

While our chosen methodology for estimating an effect of Neighbour Day on loneliness (inverse probability weighted regression analysis or IPWRA) enables us to make some causal inference, there are several data limitations that may weaken the conclusions. This is mainly as a result of not having data on all variables of interest. Thus, this method cannot account for errors in the measurement of the underlying confounders nor for missing variables. In terms of measurement error, one should acknowledge the potential for respondent bias in the Neighbour Day survey. For instance, individuals who are keen to see Neighbour Day continue may be inclined to report reductions in loneliness, even if this is not the specific benefit realised in their case. Important omitted variables for this analysis include income (proxied by socioeconomic status using SEIFA) and marital status (not available in Neighbour Day survey data). Both indicate important aspects of social capital and individual resources which may heavily influence our results. Missing physical health indicators in the Neighbour Day sample (such as presence of disability) may have also confounded estimates of healthcare utilisation.

We have conducted robustness checks including testing the specification of postcode exposure. This causes the ICER to increase only slightly, indicating the results are robust to misspecification of exposure. Nonetheless, the crudeness of postcode as measure of Neighbour Day exposure must be acknowledged. This is because the level of activity undertaken at a postcode level, as well as any neighbourhood connections formed as a result of Neighbour Day, are not well captured, increasing the uncertainty of the effect of Neighbour Day that we estimated.

Overall, this analysis provides the first comparative evidence of the cost-effectiveness of Neighbour Day, suggesting that it provides population-level benefits in terms of reduced loneliness and improved quality of life for relatively low cost. The estimated cost-per-QALY gained of **$4,667** is comparable to funded public health interventions, suggesting that a case for government subsidy of the program to be expanded could represent a worthwhile investment.

7.3 Recommendations

1. Based on the available evidence, Neighbour Day represents a cost-effective model of building community connection and wellbeing which should be scaled nationally.
2. The cost of Neighbour Day compares favourably to other models of loneliness intervention and estimates of what Australian governments are willing to pay for interventions that benefit quality of life. The cost-effectiveness of Neighbour Day should be considered in the context of other mental health and public health interventions when deciding the return-on-investment case for government investment.
3. Additional investment in Neighbour Day could focus on people living in disadvantaged communities, or communities that are culturally and linguistically diverse, to ensure culturally appropriate adaptations to Neighbour Day are available and to maximise population benefits.
4. This evaluation focused on Neighbour Day (a day of action in March every year) which is part of a larger campaign known as Neighbours Every Day, emphasising the continuity of forming and maintaining relationships year-round. Future work could expand estimates of cost-effectiveness to include the Neighbours Every Day approach.

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9 Appendices

9.1 Appendix A | Estimating the effect of Neighbour Day on loneliness

Selection bias in observational data studies

Formal randomisation in randomised clinical trials (RCTs) is conducted to increase the likelihood that intervention and control groups have similar observable characteristics. This balance implies that any remaining differences are due to chance, effectively eliminating confounding and providing assurance that differences in pre-specified outcomes between groups may reasonably be interpreted as causally attributable to the intervention.

Evaluation of Neighbour Day via a RCT is neither feasible nor preferrable. Even if a standardised intervention could be agreed among stakeholders, the imposition of a top-down structure would weaken Neighbour Day's grass-roots nature. This is a central tenet that allows participants the freedom to tailor activities to the needs of their specific community and is credited for the equality of realised benefits for hosts and attendees across all age-groups (Cruwys et al., 2022). Additionally, trialists face prohibitive costs to manage recruitment, materials, and standardised data collection via trained interviewers. Assuming these barriers could be overcome, enforcing adherence to treatment assignment would raise ethical concerns given social interaction is known to be supportive to mental health.

When we approached our research questions using the existing observational data, we also needed to control for the fact that participation in Neighbour Day is not randomly assigned. For example, individuals with greater social needs due to loneliness may be more inclined to participate in Neighbour Day, and more likely to benefit from their participation. This is referred to as self-selection into Neighbour Day and creates selection bias in estimates of the effect of participation on wellbeing. Not controlling for this effect using simple methods such as pre-post analysis may lead to misleading results.

Estimating treatment effects using weighting and regression adjustment

Imbalanced individual characteristics between treated and control groups and non-random treatment assignment need to be accounted for when attempting to infer causal relationships from non-experimental data. In addition, the 'fundamental problem' of causal inference is a missing data problem – for each treated individual we cannot observe their outcome had they not received treatment (their "counterfactual" outcome), and vice versa for control individuals. Multiple methods have been proposed in the econometric literature to overcome these issues (Huber 2015).

For this analysis, we used inverse probability weighted regression adjustment (IPWRA), which incorporates for both selection effects (treatment model) and the counterfactual issue (outcome model). This technique also has the benefit of being "doubly robust" in that estimators will approach the true population value as our sample size becomes infinitely large (or be "consistent") even if one of the models treatment or outcome is mis-specified.

There are four main steps involved in estimating treatment effects using IPWRA:

1. Define a treatment model (estimate selection into treatment given individual characteristics) and an outcome model (estimate outcome given treatment and individual characteristics).
2. Predict probability of treatment for all observations.
3. Assign the inverse probability of treatment to exposed individuals and the inverse probability of not being treated to unexposed individuals (estimate the "counterfactual" or unobserved potential outcome for each group).
4. Re-estimate the outcome model using these new weights.

Figure A1 provides an example of how inverse probability weighting affects the distribution of each variable, using an averaged three-item sum score of perceived neighbourhood quality, described in detail below. The left-hand (raw data) panel shows that Neighbour Day participants are more likely to perceive greater neighbourhood quality, making it ideal for inclusion in the treatment model. The right-hand panel shows the balance in the probability density graph is significantly improved after probability weighting.

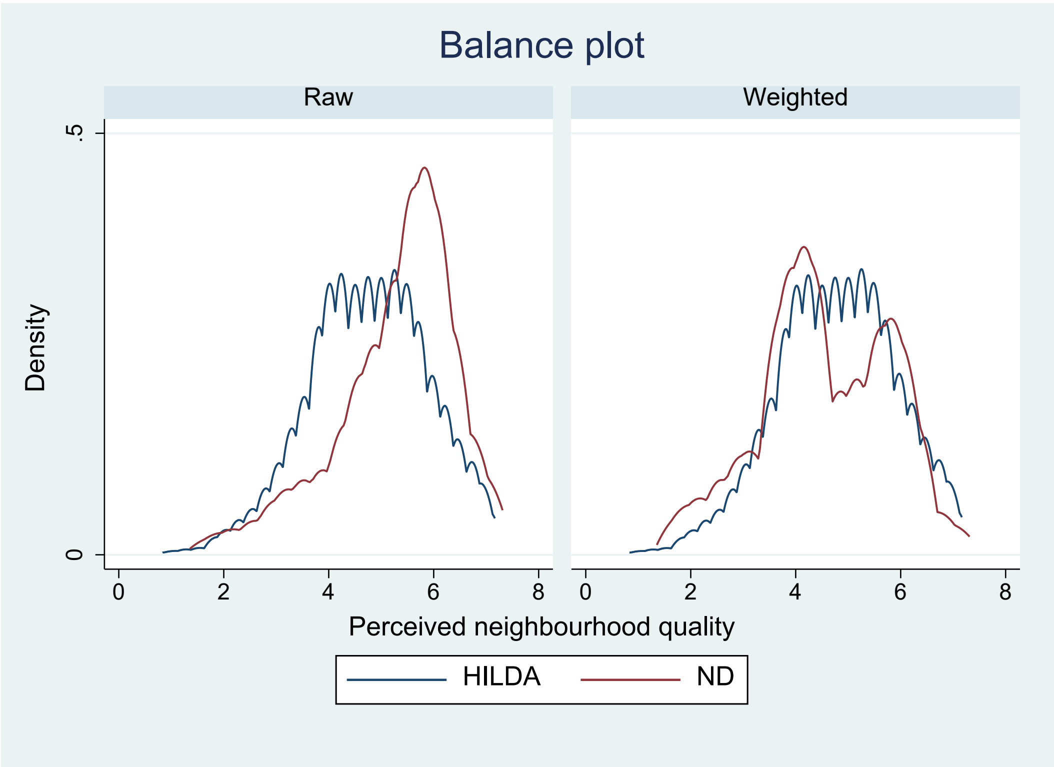


Figure A1. Balance plot for Perceived Neighbourhood Quality

Note. ND = Neighbour Day

Outcome model
Our outcome model for change in loneliness status is:

$$\Delta Lonelystatus = \beta_0 + \beta_1 Exp + \beta_2 X + e$$

Where $\Delta Lonelystatus$ represents each of the four states in Figure 2 (no longer lonely, become lonely, stay lonely and never lonely), *Exp* is exposure to Neighbour Day , β_0 is an intercept term, *e* is an error term and *X* contains all confounders.

Included confounders were age category (18-29, 30-39, 40-49, 50-59, 60-69, 70+), socioeconomic status (proxied by Decile of Socioeconomic Index for Areas (SEIFA)), gender (male, female), labour force status (employed, unemployed, not in the labour force), education status (completed year 12, some university, postgraduate) and household structure (couple with no children, couple/lone parent with children, single parent, lives alone, houseshare, other).

Treatment (selection) model
Our treatment model is given by:

$$Exp = \alpha + \gamma Z + e$$

Where *Exp* represents the probability that each individual is treated given their characteristics and *Z* contains all confounders described in the outcome model, as well as a 3-item sum score for perceived neighbourhood quality (PNQ-3, described below). The PNQ-3 was chosen for inclusion in the treatment model as it is arguably more externally determined to the individual compared to self-rated (subjective) neighbourhood cohesion or neighbourhood sense of belonging, both of which are likely influenced by the individual's level of emotional loneliness, leading to a reverse causality issue.

Treatment effect assumptions
Estimation of the outcome model above must satisfy three assumptions to ensure an unbiased estimate of the Average Treatment Effect (ATE). We summarise these assumptions below.

Independent observations
The first assumption is the independent sampling assumption which ensures that the outcome and treatment status are independent of the outcome and treatment status of other individuals in the population. In other words, there is no spillover of effects among sampled individuals. This assumption cannot be easily tested in the context of observational data where we have not incorporated varying treatment intensity. However, we assume our treatment effect estimate should hold for similar interventions.

Conditional mean-independence or selection-on-observables assumption
The conditional-mean independence assumption restricts the dependence between the treatment model and the potential outcomes. In other words, we assume the common variables that affect selection into treatment and treatment-specific outcomes are observable. This may not hold in our analysis where important variables such as marital status are missing from our Neighbour Day survey dataset.

Common support or overlap assumption
Finally, the estimation of propensity scores underlying the outcome model weighting assumes a common support condition. This condition requires substantial overlap in the

distribution of covariates (via the propensity score) between the participants and non-participants, such that individuals being compared have a common probability of being involved in Neighbour Day. For our base case ATE for the proportion of individuals reporting no longer being lonely, while the test for overidentification in covariate balance was satisfied (fail to reject the null hypothesis that covariates are balanced $\chi^2 = 30.6$, $p = 0.3$), the distribution of propensity scores for the HILDA sample is skewed towards zero. This was attributed to the very low proportion of treated individuals in our sample (2.32%).

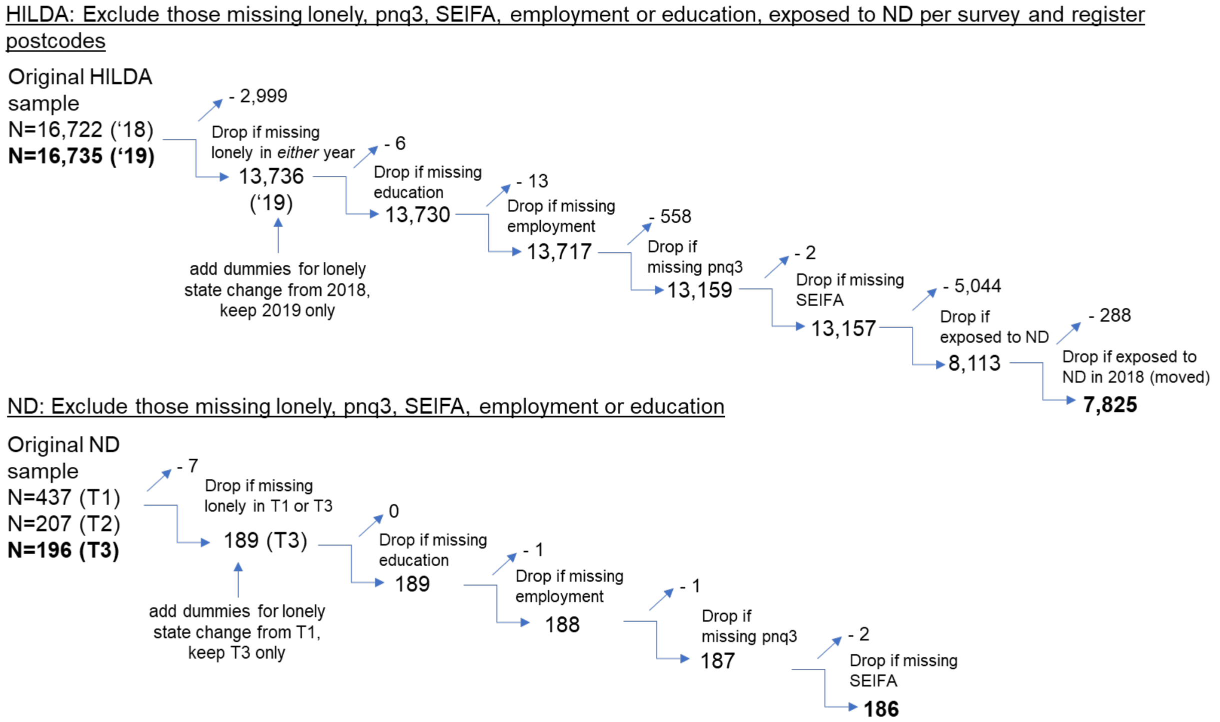
We perform additional re-specification tests to adjust for this potential violation in the overlap assumption, with results summarised in Table A4. In both tests, we re-estimate the outcome model using proportion stabilised weights per Chesnaye et al. (2021). Using the original confounders and a logit outcome model (RT1), we found a larger and statistically significant effect, with reduced skewedness in the HILDA propensity score distribution. In a second test (RT2), we respecify our confounding variables in *X* (e.g. combined age, education categories) to run a Poisson outcome model to account for the low proportion of treated individuals in our sample. Under this specification we remove the skewedness in the HILDA propensity score distribution and find similar result to our base case, albeit at a lower level of significance.

Table A4. Re-specification tests (RT) to test overlap assumption.

	Base case model Unweighted logit outcome model	RT1 – Stabilized weights logit outcome model	RT2 – Stabilised weights, respecified confounders, Poisson outcome model
Overlap assumption	Violated	Potentially violated	Satisfied
ATE and p-value for proportion of people who are no longer lonely post-participation	+7.3%, $p = 0.001$	+8.5%, $p < 0.001$	+7.1%, $p = 0.069$

Sample selection

Our final sample was extracted based on exclusion of participants missing key variables per below:



Specification of loneliness as outcome measure

Several specifications of loneliness as the primary outcome measure were explored as payoffs to the decision tree model. Table A2 compares outcomes between the exposed and unexposed samples by loneliness specification. We used the 7-point Likert scale single item "I often feel very lonely" as the sole common loneliness-related item between datasets. This measure has also been widely used as a signifier of emotional loneliness in other recent prevalence or cost evaluation literature (Relationships Australia, 2018; Majmudar et al., 2023; Duncan et al., 2021)

Comparative analysis of the single item measure between the samples found no significant differences either when considered as a continuous scale (requiring linear regression) or as a binary measure of agreement (≥5, using logistic regression). This is most likely because fewer individuals in the Neighbour Day sample deny loneliness at either timepoint, indicating that Neighbour Day is well targeted to those individuals with the greatest need in terms of social connection.

We therefore chose to model the benefits as the change in binary agreement from baseline (T1 for ND, 2018 for HILDA) compared to after the Neighbour Day event occurred (T3 for ND, 2019 HILDA).

Table A2. Loneliness specification

	"I often feel very lonely". Continuous 7- pt scale	Binary agreement cutoff (Lonely ≥5/Not Lonely <5)	Changes in binary loneliness status between 2018-19 (HILDA) and pre-post (ND)
Method	Linear IPWRA	Logistic (logit) IPWRA	Logistic (logit) IPWRA
Result	Non-significant reduction in loneliness (-0.6, p = 0.6)	Non-significant reduction in proportion of those who are no-longer lonely (-2%, p = 0.9)	Significant increase in proportion of people who are no longer lonely post-participation (+7.3%, p = 0.001)

A noted above, perceived neighbourhood quality was found to be an important predictive variable for Neighbour Day participation in the analysis, which was included in the treatment effects model. A summary of the three items used in the analysis is shown in Table A3. There are a number of assumptions and limitations associated with use of this variable including:

- Within the HILDA sample, these questions are asked only every second year. Therefore, data collected in 2018 (wave 18) were assumed to remain stable at the individual level in 2019 to correspond to Neighbour Day data;
- This scale hasn't been verified in other studies, but it is simply the items that match between the datasets; and
- The discrepancy in response scale items requires an assumption that agreement is equivalent to the reported "scale of the problem".

Table A3. Perceived Neighbourhood quality.

PNQ-3	HILDA	Neighbour Day
Question *Scale*	How common are the following things in your local neighbourhood? *[1-5] 1 Never happens to 5 Very common*	How would you rate the following problems in your local area? *[1-7] 1 Not a problem at all to 7 a very big problem*
LITTER	"Rubbish and litter lying around"	"Rubbish and litter"
NOISE	Average of: "Neighbourhood traffic noise " + "Noise from airplanes, trains or industry"	"Too much noise"
TEENS	"Teenagers hanging around on the streets"	"Unsupervised groups of young people"

9.2 Appendix B | Neighbour Day program cost estimates

The replacement cost approach was used to measures the value of individual (volunteer) unpaid time based on what it would cost to hire a paid worker to perform the same tasks (shadow wage). This is also known as the 'proxy good method' and the 'substitute method'. We applied a shadow hourly wage including 15% employer on-costs (superannuation etc.) of $33.40 based on ABS all employee's (full and part-time) weekly wage in May 2019 (ABS, 2019) as the closest estimate to March Neighbour Day event. This figure is weighted 80% in favor of female wage to align with the participant population per the socio-demographic summary in section 6.1.

Table B1. Hourly replacement wage

ABS May 2019 Average Weekly Earnings, Australia		
All employees (incl full and part time)		
Female weekly wage (80%)	$	1,010.70
Male weekly wage (20%)	$	1,475.50
Weighted hourly shadow wage	$	29.04
Plus 15% employer on-costs*	**$**	**33.40**

*inclusive of superannuation, payroll tax and administration expenses.

This unit wage was applied to the total event hours to calculate a total value of event organising time by individuals of approximately $4.3 million. This is calculated based on an estimated total number of 7,088 Neighbour Day events in 2019 (Cruwys et al, 2019) and organizing activities, hours and percentages of total contribution supplied by Relationships Australia national office.

Table B2. Value of organising time by individuals

	A	B	C	D	E
Event organising time by individuals	**% total contribution per event**	**Hours**	**Events**	**Event hours (B * C)**	**Total value (D * $33.40)**
Arranging online events	2%	7	142	992	$33,143.72
Arranging permits to use public lan(	18%	12.5	1,276	15,948	$532,666.98
Arranging use of public venue	8%	50	567	28,352	$946,963.51
Arranging a festival, fete or market	2%	500	142	70,880	$2,367,408.79
Hiring of private event organisers	30%	5	2,126	10,632	$355,111.32
Other individual action	40%	1	2,835	2,835	$94,696.35
			7,088	**129,640**	**$4,329,990.67**

*Estimated % total contribution per event and hours provided via email from Relationships Australia (national).

The $33.40 unit wage was also applied to staff time (estimated by the national Relationships Australia branch) from state and territory Relationships Australia branches, Very Neighbourly Organisations (VNOs) and local councils as these wage rates are unknown.

Table B3. Value of organising time by other entities

Event organising time by other entities				
Council promotion				
	A	**B**	**C**	**D**
Each 'Engaged' Council gives approx ***0.2 FTE*** *for six months (Oct-March)*	**# Councils**	**Hours per year**	**Total hours (A*B)**	**Total value (C * $33.40)**
	66	174.8	11536.8	$385,331.85
Very Neighbourly Organisations				
60 days of work combined (each organisation puts in 1 day of work for NED on average)	**# VNOs**	**Hours per year**	**Total hours**	**Total value**
	60	7.5	450	$15,030.11
Relationships Australia States and Territories				
Each RA gives approx ***0.2 FTE*** *for six months (Oct-March)*	**# RA's**	**Hours per year**	**Total hours**	**Total value**
	7	174.8	1223.6	$40,868.53

**italics* indicates estimation of time provided via email from Relationships Australia (national).

All direct and indirect costs were then combined to form a grand total of $4.9 million, which was divided by the estimated reach of Neighbour Day of 290,608 individuals (Cruwys et al., 2019) to obtain a cost per participant estimate of $16.95.

Table B4. Total and per participant direct and indirect program costs

Neighbour Day Costs	
Relationships Aust (natl)	
Salary	123,500
Project Expenditure	30,000
Subtotal	**153,500**
Other costs	
Other organisation salaries (direct)	
Councils	$385,332
VNOs	$15,030
Other RA offices (state/territories)	$40,869
Other org costs	**$441,230**
Individual (indirect time) costs	**$4,329,991**
Subtotal	**$4,771,221**
Direct costs	$594,730
Indirect costs	$4,329,991
Grand total	**$ 4,924,721**
ND2019 evaluation:	
Est. total participants	**290,608**
	Base case
Total cost per participant:	$ 16.95
Direct costs per participant	$ 2.05

9.3 Appendix C | Annual healthcare utilisation subgroup analysis

Figure C1a. Point estimate for all individuals by loneliness status

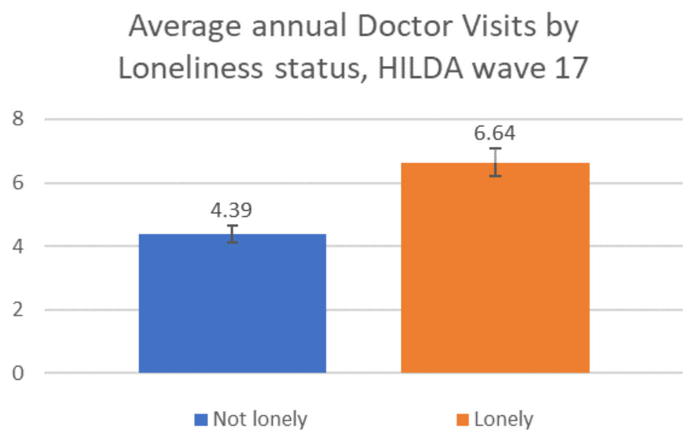
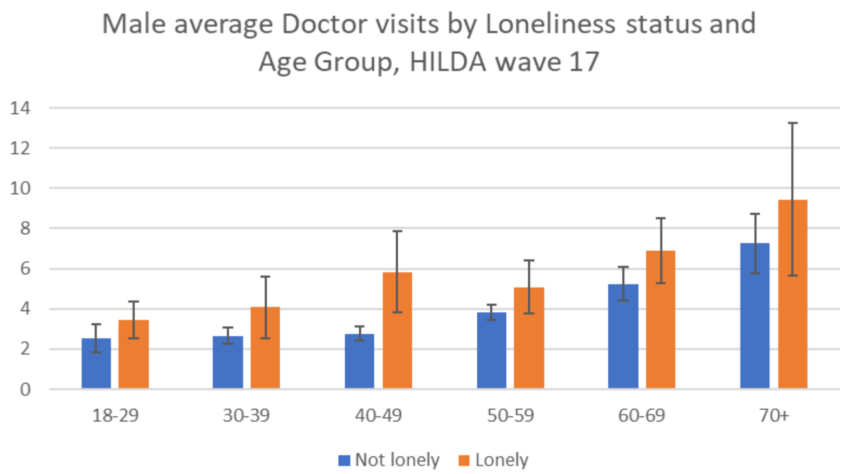


Figure C1b. Average annual doctor visits by loneliness across age-group and gender



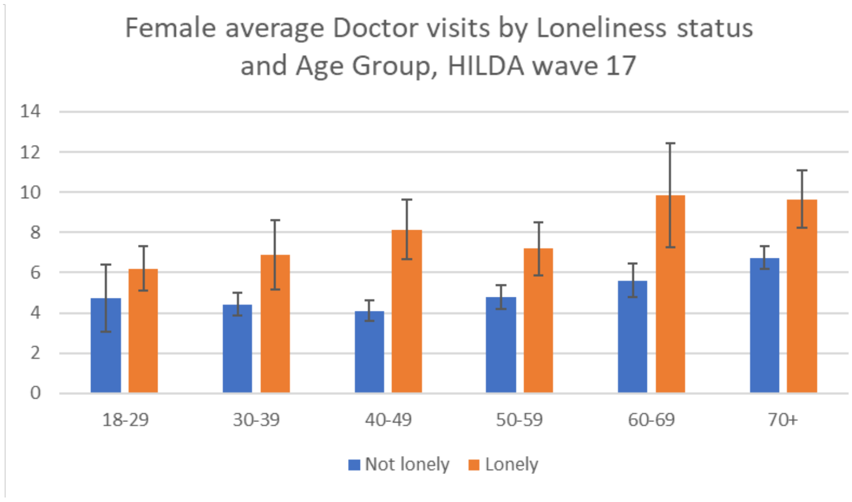


Figure C2a. Average annual hospital admissions by loneliness status

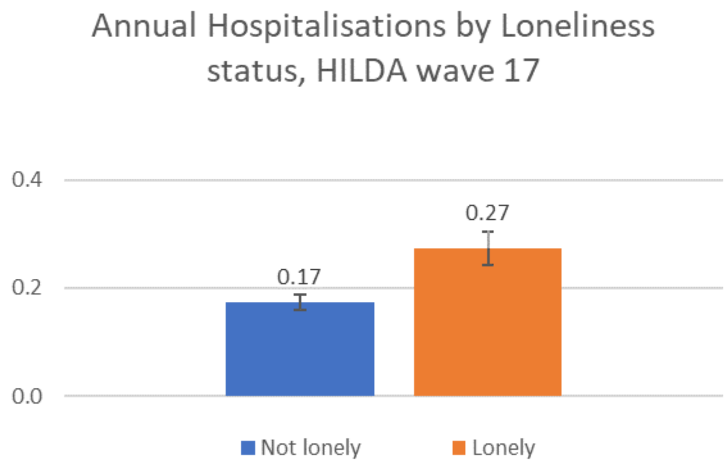
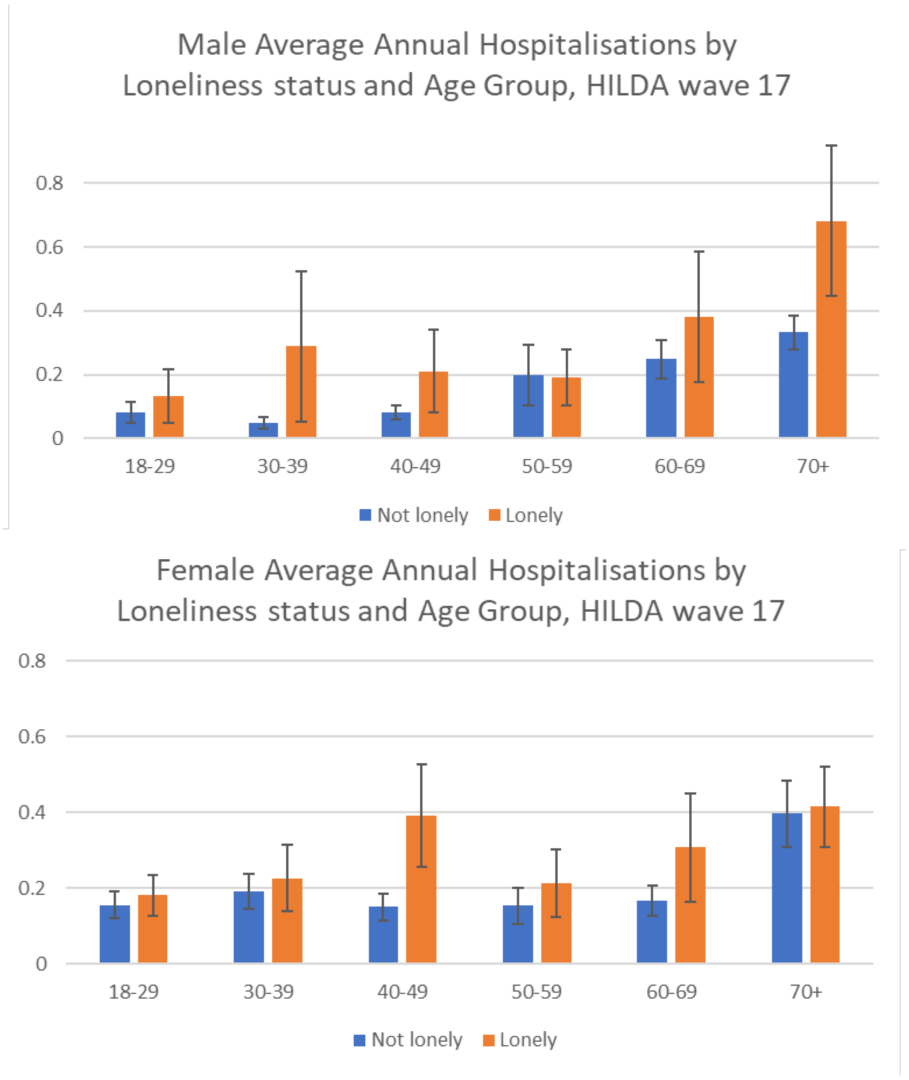


Figure C2b. Average annual hospital admissions by loneliness across age-group and gender



9.4 Appendix D | Estimation using HILDA sampling and complex design weights

Healthcare utilisation and utility sample means were estimated using cross-sectional (wave 19, collected in 2019) person sampling weights to allow inference to the Australian population. Sample weighting controls for both the initial probability of selection into the sample and for non-response or attrition bias using population benchmarks. Population benchmarks are obtained from Australian Bureau of Statistics data and include sex by broad age, location (state), labour force status, marital status, and household composition (number of adults and children) (Summerfield et al., 2021).

Additionally, jackknife standard errors were calculated using replicate weights to account for the complex survey design (see Hayes, 2008). Recent work using a similar large-scale health survey has shown that both incorporating sampling weights and accounting for complex survey design results in unbiased estimates and correct standard errors, which can have meaningful impacts on the interpretation of results compared to unweighted analysis (Birrell et al., 2019).

9.5 Appendix E | Quality of life subgroup analysis

Figure E1. Average quality of life per SF-6D utility score

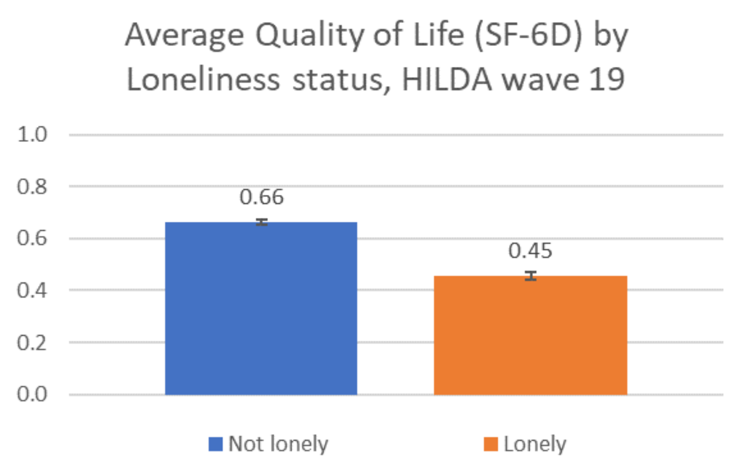
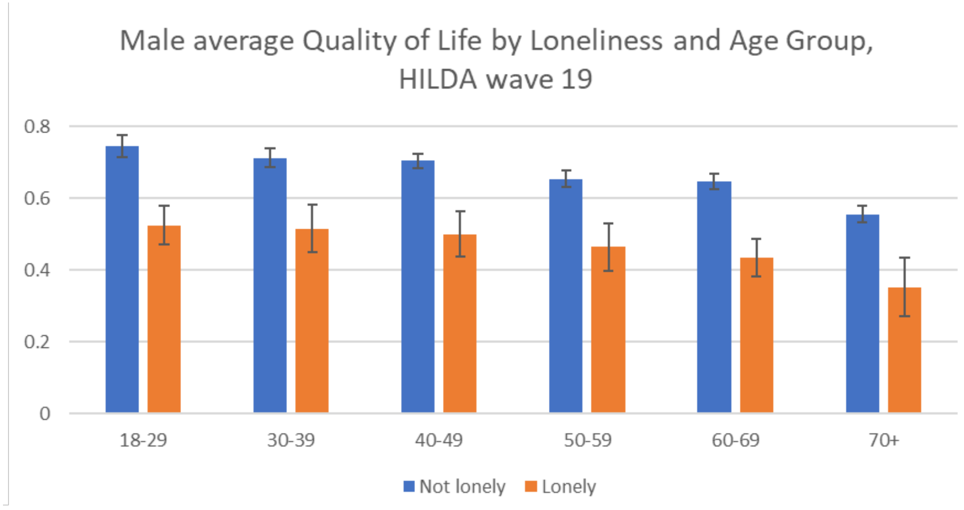
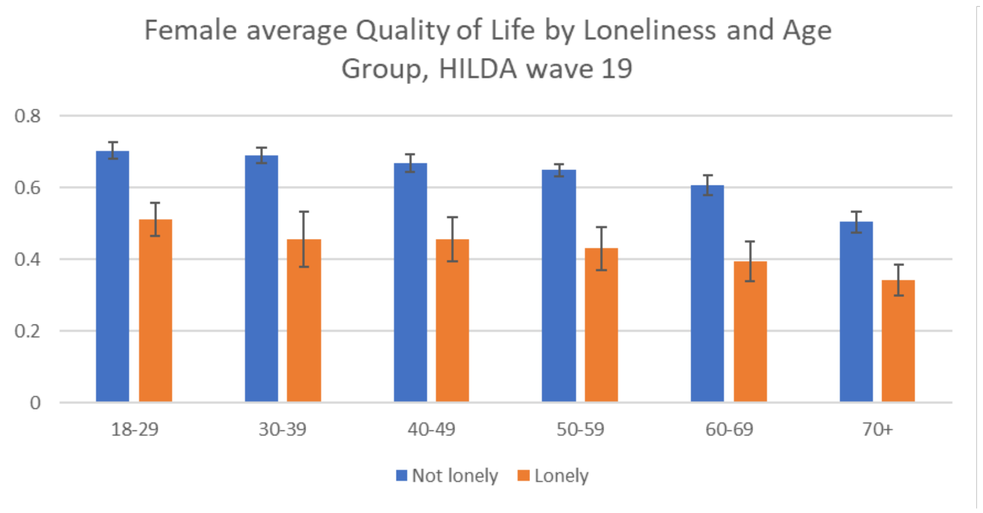


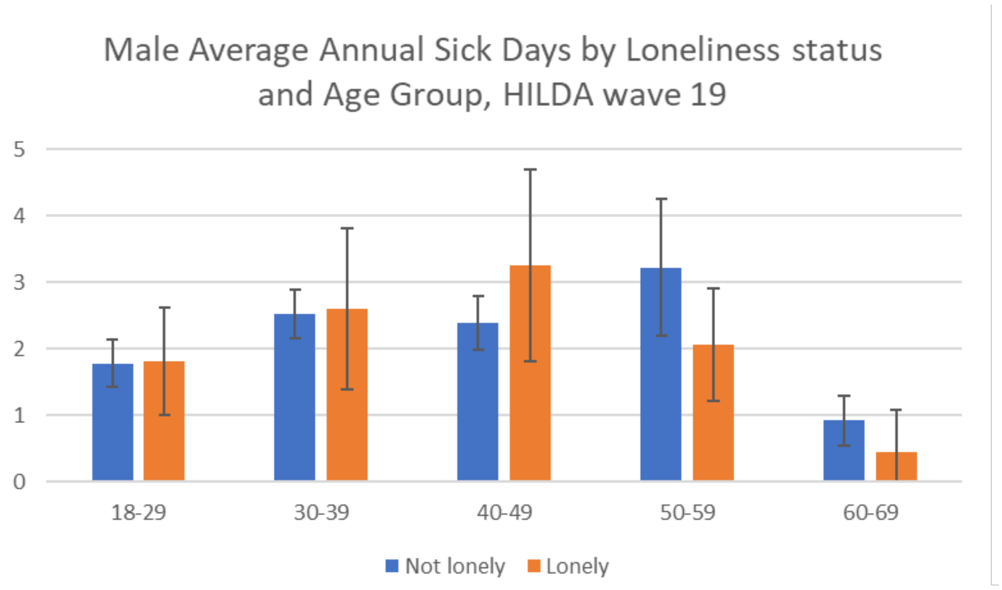
Figure E2. Average quality of life by loneliness across age-group and gender





9.6 Appendix F | Rejected payoffs

Figure F1. Absenteeism (sick days) subgroup analysis.



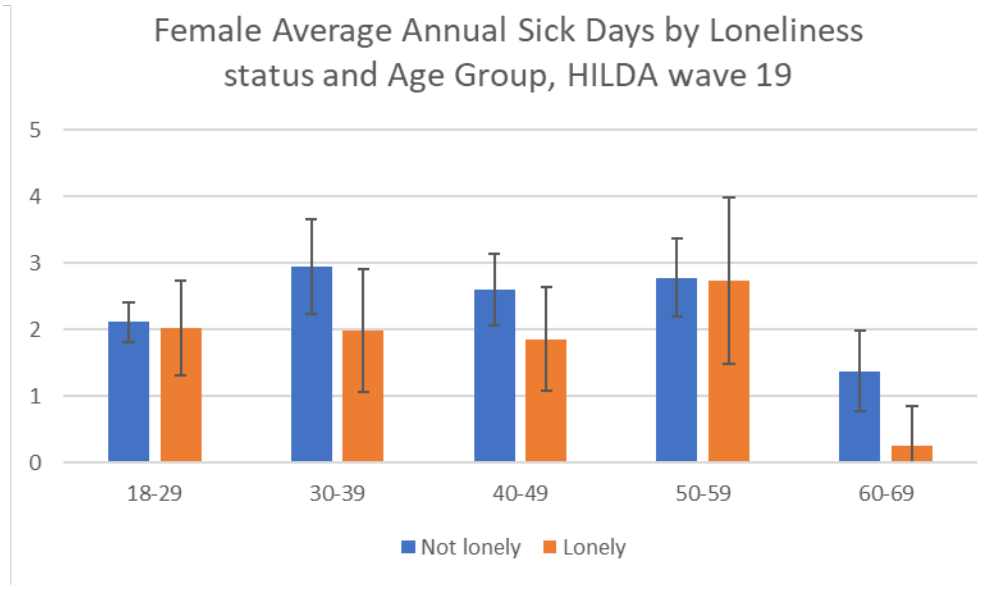


Figure F2. Non-smoker vs current smoker - proportion subgroup analysis.

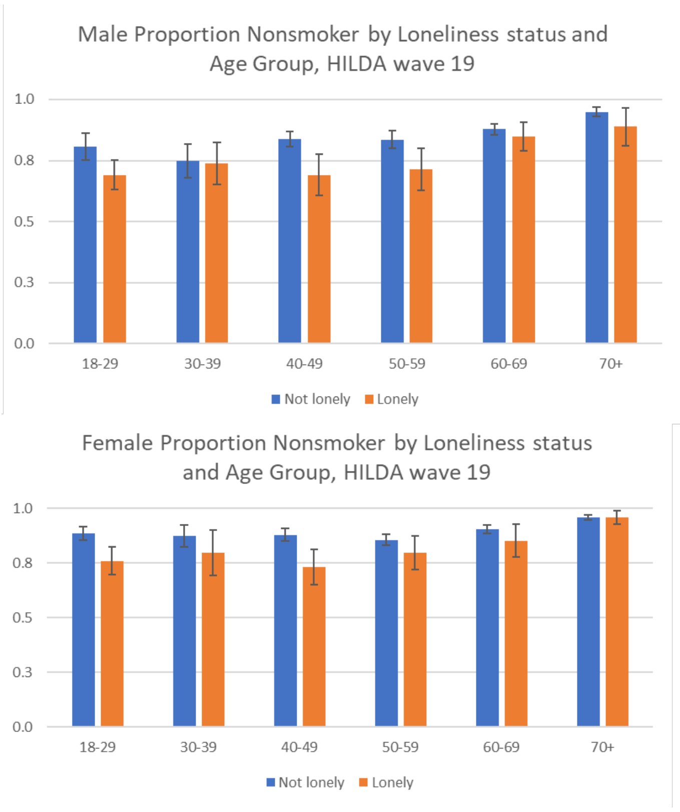
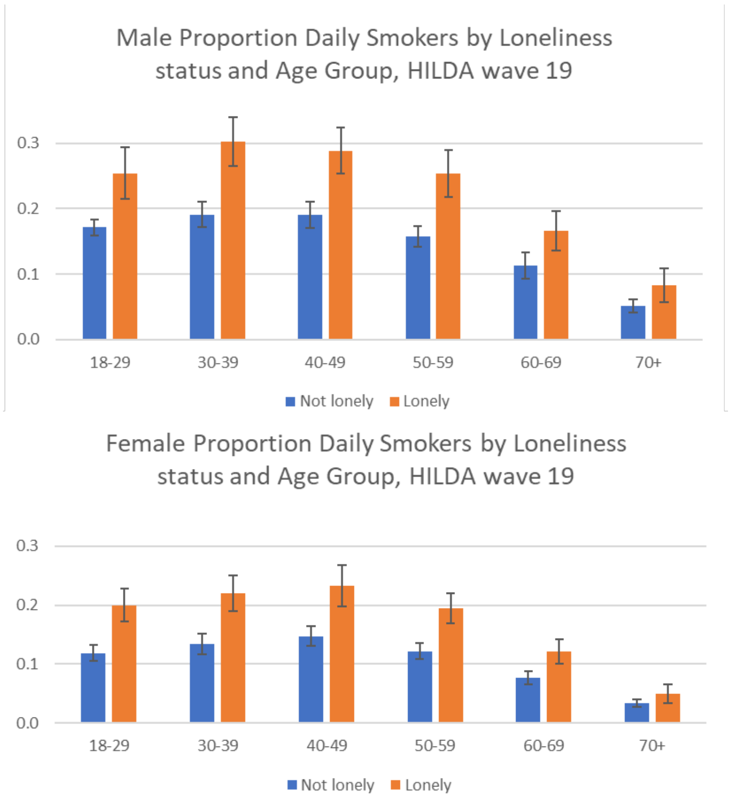


Figure F3. Daily smoker status subgroup analysis.



9.7 Appendix G | Model structure

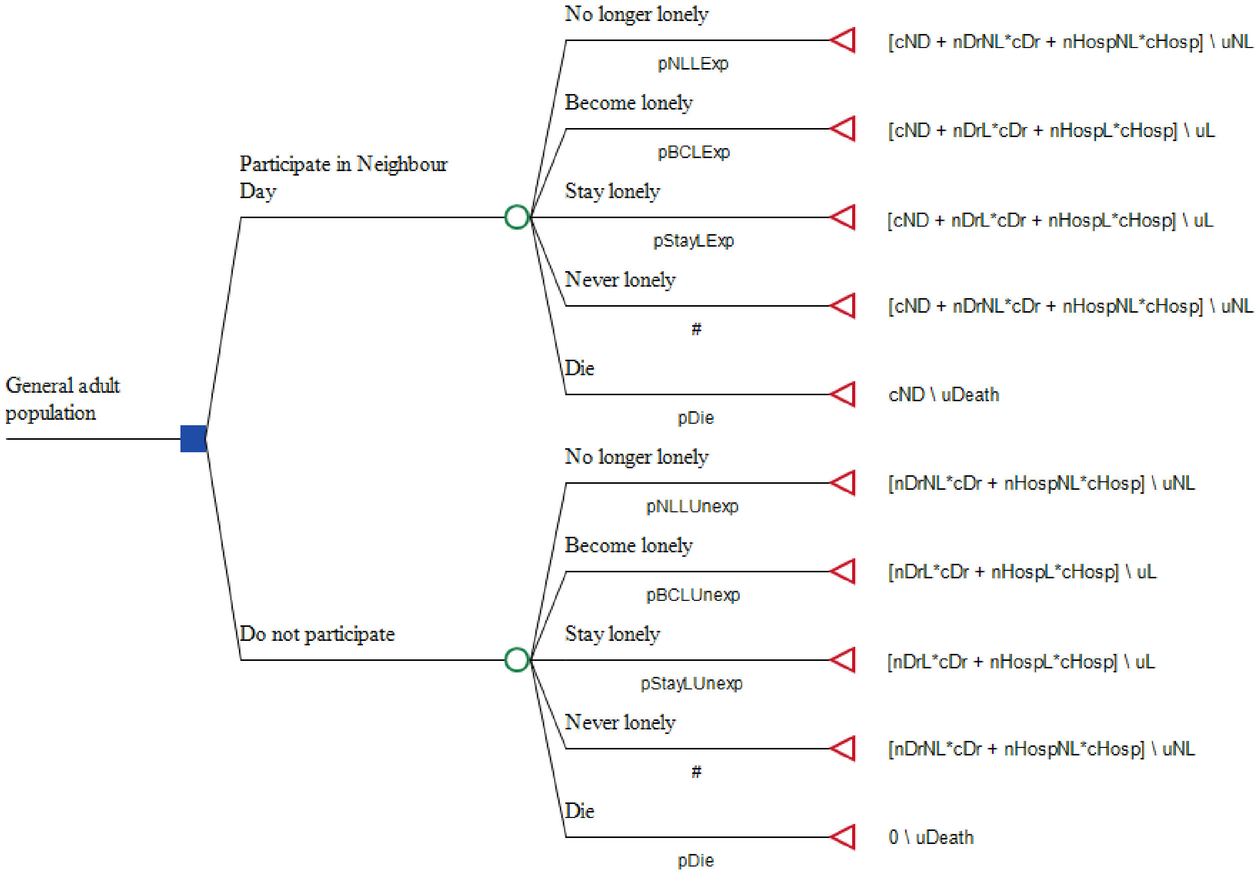


Figure G1. Decision tree structure

Note. Exp = Exposure group (ND); Unexp = Control group (HILDA); c = Costs, n = Number of events; Hosp = hospitalisations; Dr = Doctor (General Practitioner) visits; NL = Not Lonely per single item; L = Lonely; u = Utility (SF-6D); # = complement state (1 – all other probabilities)

9.8 Appendix H | Model parameters

Base-case model parameters are reported in Table H1, alongside standard errors and the standard probability distributions according to variable type for sensitivity analysis. Unit aimed to incorporate both a healthcare payer and societal perspective (e.g., cost of Neighbour Day include volunteer time, doctor visit costs incorporate both government and individual out of pocket costs).

Table H1. Base case model parameters

Parameters (Code)	Mean value	Standard error	Distribution	Source
Event probabilities				
No longer lonely with the intervention (pNLLExp)	0.1641	0.0218	Beta	Weighted potential outcome mean – Participate in Neighbour Day
Become lonely with the intervention (pBCLExp)	0.0681	0.0205	Beta	Weighted potential outcome mean – Participate in Neighbour Day
Stay lonely with the intervention (pStayLExp)	0.0978	0.0167	Beta	Weighted potential outcome mean – Participate in Neighbour Day
Never lonely with the intervention (pNevLExp)	0.6807	0.0272	Beta	Weighted potential outcome mean – Participate in Neighbour Day
No longer lonely without the intervention (pNLLUnexp)	0.0907	0.0032	Beta	Weighted potential outcome mean – Do not participate in Neighbour Day
Become lonely without the intervention (pBCLUnexp)	0.0908	0.0032	Beta	Weighted potential outcome mean – Do not participate in Neighbour Day
Stay lonely without the intervention (pStayLUnexp)	0.0858	0.0032	Beta	Weighted potential outcome mean – Do not participate in Neighbour Day
Never lonely without the intervention (pNevLUnexp)	0.7327	0.0050	Beta	Weighted potential outcome mean – Do not participate in Neighbour Day
Background mortality (pDie)	0.0086	0.0030	Beta	ABS Life Tables 2017-9 (ABS, 2017-19)
Utility weights (Quality of life)				
Lonely (uL)	0.4548	0.0074	Beta	HILDA wave 19 Australian weighted SF-6D utility values if lonely
Not lonely (uNL)	0.6628	0.0046	Beta	HILDA wave 19 Australian weighted SF-6D utility values if not lonely
Annual healthcare use				
Number of doctor visits if lonely (nDrL)	6.6440	0.2286	Normal	HILDA wave 17 number of doctor visits in past 12 months if lonely

Number of doctor visits if not lonely (nDrNL)	4.3891	0.1390	Normal	HILDA wave 17 number of doctor visits in past 12 months if not lonely
Number of hospitalisations if lonely (nHospL)	0.2730	0.0156	Normal	HILDA wave 17 number of hospital admissions in past 12 months if lonely
Number of hospitalisations if not lonely (nHospNL)	0.1726	0.0072	Normal	HILDA wave 17 number of hospital admissions in past 12 months if not lonely
Unit costs				
Annual cost of Neighbour Day (cND)	$16.95	2*	Gamma	Author calculations based on direct and indirect cost estimates provided by Relationships Australia (see Appendix B)
Cost per doctor visit – Government	$41.20	-	-	Medicare Benefits Schedule (MBS) Item 23 (DoHAC, 2023)
Cost per doctor visit - Individual out of pocket	$20.70	-	-	Median out-of-pocket (OOP) cost per average patient (AIHW, 2018) inflated to 2018-19 dollars (AIHW, 2020)
Cost per doctor visit - Total societal (cDr)	$48.20	5*	Gamma	MBS + Individual OOP cost adjusted for proportion who incur costs (AIHW, 2018)
Cost per hospitalisation (cHosp)	$5,027	500*	Gamma	Admitted acute average cost per episode in 2018-19 (IHPA, 2021)

* Underlying data not available – standard error estimated based on applied +/-20% Confidence Interval (not reported) Notes: HILDA: Household Income Dynamics and Labour Dynamics in Australia.

9.9 Appendix I | Robustness tests

Robustness test 1: Remove avoided healthcare costs

Despite a general trend towards greater use, overlapping confidence intervals in the average annual healthcare use (both doctors visits and hospital admissions) between lonely and non-lonely populations suggest the difference does not reach statistical significance among all subgroups (Appendix C). Therefore, we removed these payoffs to test the sensitivity of our results. Table I1 shows this change increases the ICER to approximately $7,615 per QALY and increases the cost per LFY to $230.78. The ICER remains cost effective per the threshold proposed by Edney et al. (2018) even without including health care costs in the model. Note other outcomes (QALYs and number of people no longer lonely) remain unchanged and are therefore omitted.

Table I1. Robustness test 1 – remove avoided healthcare costs.

	Intervention (ND)	Control (HILDA)	Difference
Costs (per person)			
Program costs	$16.95	*Nil*	$16.95
Healthcare costs	*Nil*	*Nil*	*Nil*
Total costs	$16.95	*Nil*	$16.95
Summary measures (per participant)			
Incremental cost per QALY	$7,615.65*		
Incremental cost per LFY	$230.78*		

*Figure subject to rounding

Sensitivity analysis 2: Use survey postcodes only for exposure definition.

A total of 409 unique postcodes were used to define exposure in the base case scenario, which was derived (removing duplicates) from the combination of:

- 274 unique postcodes identified within the 2019 Neighbour Day survey
- 292 unique postcodes identified within the Event Register

We tested whether using only survey postcodes to define exposure to Neighbour Day, rather than postcodes from both the event register and survey, affects our base case results. This was important to test as the survey was completed by actual hosts and attendees of Neighbour Day, while the register included community organisation, council and business representatives that may only be involved in promoting Neighbour Day, rather than direct involvement in events. This specification causes the unexposed population (control group) to increase from 7,825 to 9,256 due to having fewer “exposed” individuals removed. After removing all observations with missing confounders (per Appendix A), changes to the event probabilities are as follows:

Lonely state event	Register + Survey		Survey only	
	HILDA	ND	HILDA	ND
No longer lonely	9.1%	16.4%**	9.2%	16.4%**
Become lonely	9.1%	6.8%	9.0%	7.1%
Stay lonely	8.6%	9.8%	8.6%	9.5%
Never lonely	73.3%	68.1%*	73.2%	67.9%*

HILDA compared to ND sample: ** highly statistically significant p=0.001; * marginally insignificant p = 0.06

The statistical significance remains unchanged for differences in the proportion of individuals no longer reporting loneliness (higher for ND) and who never report loneliness (lower for ND). All other payoffs remain unchanged as they are derived using loneliness status only within the HILDA sample.

Table I2 shows that refining the exposure variable reduces the payoffs resulting in an increased cost per QALY of approximately $5,732 compared to the base case of $4,667. Healthcare cost offsets have increased slightly from $6.56 to $5.76, while QALY gains have reduced from 0.22 to 0.20. The ICER remains cost effective per the threshold proposed by Edney et al. (2018).

Unlike the other robustness tests, the increase in the proportion of those no longer reporting loneliness in the unexposed (HILDA) arm has caused loneliness free years (LFY) to reduce slightly from 7.3 to 7.2 due to the re-specification of exposure. Therefore, the cost per LFY has increased from $141 to $152.

Table I2. Robustness test 2 – Survey postcodes only

	Intervention (ND)	Control (HILDA)	Difference
Costs (per person)			
Program costs	$16.95	Nil	$16.95
Healthcare costs	$1,172.32	$1,178.07	-$5.76
Total costs	$1,189.27	$1,178.07	$11.19
Outcomes (per 100 participants)			
Number people no longer lonely (loneliness free year, LFY)	16.4/100	9.2/100	7.2/100
Quality adjusted life-year (QALY)	62.24	62.04	0.20
Summary measures (per participant)			
Incremental cost per QALY (ICER)	$5,732.08		
Incremental cost per LFY	$152.39		

Robustness test 3: Program costs includes direct costs only (excluding time costs of individual participants)

Robustness test 3 used direct costs only (direct salary and project expenditure by organisations) and excluded the indirect time costs to participants (which accounts for 88% of total costs). This reduced the per participant cost of Neighbour Day (cND) from $16.95 to $2.05. As shown in Table I3, this caused the incremental cost for participation in Neighbour Day to be negative (-$4.51) after the averted healthcare costs of $6.56 are accounted for. Under this scenario, the intervention is the preferred option over not participating in Neighbour Day, and the strategy is referred to as being “dominant”.

Table I3. Robustness test – Direct costs only

	Intervention (ND)	Control (HILDA)	Difference
Costs (per person)			
Program costs	$2.05	Nil	$2.05
Healthcare costs	$1,171.69	$1,178.25	-$6.56
Total costs	$1,173.74	$1,178.25	-$4.51
Outcomes (per 100 participants)			
Quality adjusted life-year (QALY)	62.26	62.04	0.22
Summary measures (per participant)			
Incremental cost per QALY (ICER)		***Dominant***	