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碩士論文

Department of Agricultural Economics
College of Bioresources and Agriculture
National Taiwan University

Master Thesis

寵物死亡對青少年心理健康的影響

Pet Loss and Adolescent Mental Health

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中華民國 112年 7 月

July, 2023

doi:10.6342/NTU202303039

Acknowledgements

和農經最早的淵源，是大二看著教室的榜單和旁邊的王健說「唉唉，還是考這個？」誤打誤撞後來了這裡，現在回顧起來真是一場奇妙的旅程。

得以在這暢所欲言，無疑要感謝我的指導教授 Jimmy。還記得第一次線上面試研究助理時，穿了和口試同一件的襯衫，被說不用這麼拘謹後開啟了我的研究生生涯。謝謝老師讓我選擇有興趣的題目發揮，並且在各種撞牆的時候推我一大把（或是問王老闆你同學還好嗎），在這兩年間幾乎無間斷的開會討論，真心覺得老師非常的用心與偉大。謝謝老師給我很多機會，無論是擔任研究助理、助教、出國報告、或是爬陽明山，和您學習到的不僅僅是學術知識，還有您同時兼具寬宏大量及原則的處事方式，銘記在心。

謝謝周和徐慶無論送機畢典還是遛狗從不缺席，希望你們趕快發達養我；謝謝廖老大無論何時都挺到底，我絕對是妳的無腦頭號大粉絲；謝謝陳寶子和我一起去澳洲，有妳一起去真的安全感爆棚；謝謝王老闆的一路相挺，認識你在農經走路都有風；謝謝嘉恆主持公道，最喜歡聽妳一語道破的發言；謝謝楊林華成為我的影印機天使，希望你早日修成正果；謝謝董整天找打球，祝你新生盃拿冠軍；謝謝鄭典陪我唸農經和練體能，期待你在奧運的表現；謝謝停左講不好笑的笑話，希望你能進步；謝謝軟網的各位，你們是我碩班意外的收穫；謝謝梁七在截稿那天送的續命茶葉蛋，有你真好；謝謝波波，妳一定是全世界最可愛最愛生氣愛睡覺的米格魯，謝謝妳當我的狗狗，我會愛妳一輩子。還有豐安老師、伯茹老師、系辦的各位、一年一見的朋友們、火影忍者疾風傳，族繁不及備載。如果沒有你們，我肯定無法順利畢業，並且在碩班過得如此充實。

最後，我要謝謝我的家人，謝謝爸爸媽媽的養育之恩，哥哥的支持，波波、大笨狗和小黑的陪伴，有你們真好。期許自己做個好人，或快樂的人。

徐嘉辰 謹誌於

國立臺灣大學農業經濟研究所

中華民國一百一十二年七月

doi:10.6342/NTU202303039

摘要

寵物越趨普遍地出現在許多的家庭中，他們在家庭生活中的重要性也隨著出生人口的減少而日漸增加。眾多研究已探討了寵物對心理健康的益處，然而針對寵物過世對心理健康影響的文獻卻相對較少。本研究串聯了四波台灣青少年成長歷程研究追蹤調查之資料，探討寵物過世對於高中與大學階段青少年心理健康的影響。在實證方法上，本研究採用 Callaway 和 Sant'Anna (2021) 提出的雙重差分法，以避免在多個事件發生時間點的情況下，使用傳統固定效果模型在估計可能造成的偏誤。實證結果發現，相對未經歷寵物過世的青少年，經歷寵物過世的青少年感到孤獨的機率平均增加約七個百分點，而此效果在寵物過世約兩年後尤為明顯。透過與父母親或其他親人去世的效果比較，我們發現寵物過世對孤獨感的影響程度接近雙親去世的一半，且高於其他親人去世的效果。此外，異質性分析的結果顯示，男性在經歷寵物過世後，感到孤獨機會上升的幅度相對女性較高，而沒有與家人同住的人受到的影響則高於與家人同住者。最後，我們並未發現經歷寵物過世對學業表現存在顯著關聯。

關鍵詞：寵物死亡、青少年、心理健康、孤獨感、雙重差分法、台灣青少年成長歷程研究

doi:10.6342/NTU202303039

Abstract

Pet ownership is becoming increasingly common in today's society. Many studies have investigated the benefits of pets on mental health. However, there is very limited research on the potential adverse impacts when experiencing the death of a pet. Using the Taiwan Youth Project survey data, this study explores the impacts of pet loss on adolescents' mental health. We apply the difference-in-differences method proposed by Callaway and Sant'Anna (2021) to address the estimation bias that arises from the use of two-way fixed effects models with multiple time periods. The results show that, on average, the likelihood of feeling lonely increases by seven percentage points for adolescents who have experienced the loss of a pet, and this effect is mostly driven by males and those who do not live with their families. We also find that the effect of pet loss on loneliness is nearly half that of parental bereavement and larger than that of any nonparental bereavement. However, there is no evidence showing that pet loss increases the likelihood of other distresses such as feeling depressed or having suicidal thoughts. Lastly, we do not find an association between pet loss and academic performance, as measured by interviewees' college entrance exam scores.

Keywords: pet loss, adolescents, mental health, loneliness, difference-in-differences

doi:10.6342/NTU202303039

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1. Introduction

Pets have been an indispensable part of many families worldwide. In the United States, the country with the largest number of pets, there were approximately 390 million pets, and 67% of US households owned at least one pet in 2022. households owned at least one pet in year 2022. Among these owners, 95% of them considered their pets as family members (Spots.com, 2023). As for Taiwan, the number of registered dogs and cats surpassed 2.22 million in 2022, marking a substantial increase from the 1.4 million reported five years earlier (Ministry of Finance, 2022). On the other hand, in 2022 the population of individuals under the age of 15 is 2.84 million (Taiwan Institute of Economic Research, 2022). Arguably, the presence of pets has been more relevant for many than that of children in Taiwan and other countries with low fertility rates.

Previous research has shown that there are many benefits associated with pet ownership, particularly those related to mental and physical well-being. Pet owners tend to have better physical health because they spend more time engaging in physical activities such as walking their dogs regularly, which contributes to increased physical activity levels (Matchock, 2015). Owning a pet provides opportunities for social interaction and can help reduce social distance. About 40%

doi:10.6342/NTU202303039

of pet owners reported receiving social support from acquaintances made through their pets, fostering new conversations and connections with neighbors while walking their dogs (Wood et al., 2015). In addition, pets themselves provide emotional support to their owners, enhance self-esteem, and help reduce stress and loneliness, all of which contribute to improved mental health conditions (McNicholas and Collis, 2000; Brooks et al., 2018; Wells, 2009).

Pets specifically play an important role in the development of adolescents. Adolescents are at the age of seeking social support and often displaying attachment behaviors towards their pets because they can fulfill attachment needs by interacting with their pets (Melson and Fogel, 1989). Children with inadequate parental attachment often demonstrate inferior social capabilities (Raikes and Thompson, 2008). Establishing bonds with their pets, in place of parents, can help those children to develop secure internal cognitive frameworks that guide their future interactions (Wedl et al., 2015).

However, all good things eventually come to an end, and it is inevitable that pet owners will face the heartbreaking experience of their beloved pets' death. While extensive research exists on the benefits of having pets, relatively little attention has been paid to the impacts of pet loss on well-being (Cowling et al., 2020; Crawford

doi:10.6342/NTU202303039

et al., 2021; Park et al., 2023), even though pets can be the most common bereavement with the short life span of many animals.[1]

A large body of literature has documented that the bereavement of family members, such as spouses, parents, and children, can affect elderlies' mental health in various forms, such as loneliness, depression and anxiety (e.g., Herberman Mash et al., 2013; Bolton et al., 2014). The experience of losing a family member can trigger significant and prolonged psychological distress among the bereaved, including increased incidences of negative emotional symptoms, which can persist over time (Bui and Kemp, 2018; Bolton, 2014). Kamis et al. (2022) examined the effects of parental death in different life stages and found that enduring a parent's death during childhood has deeper and longer-lasting impacts on mental health than experiencing such a loss in adulthood.

Studies have in general suggest that the earlier a bereavement occurs, the larger the effect on mental well-being would be (Silva et al. 2022). People in their young

[1] For example, Crawford et al. (2021) investigate the impact of pet death on young children's development and found that experiencing pet loss is negatively associated with a child's mental health. Cowling et al (2020) find that owners who experienced high levels of grief at the death of their pet had higher levels of loneliness and guilt. Park et al. (2023) provide a recent review.

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adulthood, a stage marked by substantial transitions shaping future experiences, can be significantly affected by the bereavement of a family member (Kendler, 2010). Additionally, the experience of losing a family member can lead to attention and learning issues during adolescence and young adulthood (Johnson, 2007). Previous studies have shown that when adolescents experienced the death of loved ones, such as siblings or parents, it may result in a decline in academic performance and school adaptation (Khang et al., 2020; Liu et al., 2019).

Although pets are now commonly considered to be one of the family members, there is limited discussion about the mental health effects of pet deaths. This study contributes to the literature by understanding the causal impacts of pet loss on the subjective well-being of adolescents. In this study, we focus on loneliness. Although often disregarded, loneliness can have substantial implications for overall well-being. Loneliness has been linked to a range of negative emotions, such as feelings of depression, anxiety and stress (Qualter et al., 2015; Cacioppo et al., 2010). We pay particular attention to the dynamic of the effects and their heterogeneity across different groups, such as gender and living arrangements. To shed light on the importance of pet loss, we compare the impacts of parental and other relative bereavement with the impacts of pet loss. We further explore the potential influence

doi:10.6342/NTU202303039

of pet loss on students' academic performance, measured by the score of college entrance exam.

In this study, we use the Taiwan Youth Project survey data, which began in 2000 and targeted two cohorts of adolescents in the first and third grades of junior high school. The project tracked those adolescents and surveyed them in eight subsequent waves. This longitudinal dataset covers a variety of aspects of the tracked adolescents, including their mental health, academic performance, social interactions, and socioeconomic factors (Yi, 2021).

Leveraging this panel data, we employ a difference-in-differences design, using individuals who do not experience pet losses as a control group, to identify the changes in subjective well-being of those who experience pet losses. To overcome the challenge of different treatment times, we use the staggered difference-in-differences method proposed by Callaway and Sant'Anna (2021). This method is particularly effective for evaluating the effects of events occurring at different times, eliminating biases caused by negative weights and potential dynamic issues arising from the use of the two-way fixed effect regression model (Goodman-Bacon, 2021).

The results show that experiencing pet loss increases the likelihood of feeling lonely by an average of 6.61% for adolescents, and the effect does not appear

doi:10.6342/NTU202303039

immediately after the loss. Moreover, the impact of pet loss on loneliness is more half as pronounced as that of parental bereavement, yet it exceeds the effects associated with the loss of any non-parental bereavement. We also find that upon experiencing pet loss, males are more likely to feel lonely than females, and those living with family are less likely to feel lonely than those living elsewhere. Overall, this study provides some of the first evidence on the mental health impacts of pet loss. Our findings highlight the needs to help adolescents to cope with pet losses, while it appears to be overlooked for long.

The subsequent sections of this article are organized as follows. Section 2 provides a review of literature focusing on pet, mental health, and bereavement. Sections 3 and 4 respectively describe the data and empirical strategy. Section 5 presents the results regarding the effects of pet loss. Section 6 concludes and discuss the implication of the findings.

doi:10.6342/NTU202303039

2. Literature Review

2.1. Pets, bereavement, and mental health

Pets play different roles within the family and often help to smooth relationships between family members and enhance their well-being (Walsh, 2009). The emotional support from pets can reduce the likelihood of experiencing negative emotions such as depression and other forms of distress (Ghasemipoor, 2010). Companionship is the primary purpose of having a pet at home to many families. For children, pets can provide a companionship similar to that of siblings (Endenburg, 1995). Adolescents who have pets tend to exhibit lower levels of loneliness (Black, 2012), as the company of a pet may substitute for the need for human interaction (Zasloff and Kidd,1994). On the other hand, caring for pets can enhance social skills and the ability to care for others, which helps them to build better interpersonal relationships (Young, 2012). The bonds between adolescents and their pets are often particularly strong compared to those between pets and other family members.

Pets play an important role in adolescents' mental health development. Pets serve as a safe haven for adolescents during emotionally distressing times (Kurdek, 2009). When experiencing distress, adolescents can find emotional support through

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not only friends but also their pets (Papini et al., 1990; Kurdek, 2009). Having pets can further benefits the development of adolescents through increased opportunities to socialize (Charmaraman et al., 2020; Halbreich et al., 2023).

In terms of pet loss and mental health, much of the research from the 1990s primarily addressed strategies for coping with the emotions stemming from pet loss. Findings indicated that avenues such as pet loss counseling and hotlines can help reduce grief levels (Turner, 1997; Stallones, 1994; Sharkin and Bahrick, 1990). In recent years, studies have examined the relationship between pet loss and mental health, highlighting that owners who experience pet loss may go through grief reactionsPark and Jeong 2022; Barnard-Nguyen et al., 2016). In contrast to these previous studies, our research suggests a causal effect between pet loss and mental health, rather than just a correlation.

Many may have their first experience of the death of a loved one during their adolescence, and such an experience is likely to have an impact on their mental health (Kamis et al., 2022). Adolescents are also in a crucial stage of life and react uniquely to bereavements. Those who experience parental, peer or sibling bereavement are more likely to experience increased distress and are at greater risk of substance abuse and other health risk behaviors (Herberman Mash et al., 2013;

doi:10.6342/NTU202303039

Bolton et al., 2014; Hamdan et al., 2012). For adolescents who have experienced the bereavement of a parent, the loss of financial support and care can lead to additional stress (Dowdney, 2000).

Bereavement undoubtfully can affect anyone, but its effect can vary with many different factors. The level of attachment to pets and the attitudes towards receiving support when experiencing bereavements can vary greatly across the gender line (Papini et al., 1990; Breen and O'Connor, 2011). Due to the societal expectations, males often prefer not to express their feeling to others, such as peers or parents (Papini et al., 1990; Martin and Doka, 2000). For example, For instance, compared to widowers, widows are generally more open and receptive to seeking assistance from others when they face the loss of a spouse. (Park and Kim, 2021; Carr et al., 2001; Stroebe et al., 2001). Males are at a higher risk of depression and display poorer physical and mental health after spousal bereavement (Siflinger, 2017). However, males tend to establish deeper connections with their pets and lean on them more for emotional comfort compared to females (Kurdek, 2009). The above findings suggest that pet deaths can have greater impacts on men, who may have a stronger bond with their pets but be less likely to seek helps for coping with bereavements.

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The relationships between bereavements and mental health can also vary by age. The relationship between age and loneliness has been studied extensively, although the direction of the relationship remains inconclusive. Some studies find that older people have worse subjective welling-being, including higher level of loneliness (Cohen-Mansfield et al., 2016), while others find the opposite (Losada-Baltar et al., 2020). Loneliness is experienced across all age groups to varying degrees, but the underlying causes may differ (Barreto et al., 2021). For teenagers, in the process of establishing their identities, feelings of loneliness might stem from unfulfilled expectations of forming intimate relationships within their peer groups (Qualter et al., 2015). Studies have also found that the impacts of bereavements generally decrease with age (Kamis et al., 2022; Moor and de Graaf, 2016). Overall, literature has suggested that age may alter the impacts of bereavement on mental health.

In addition to one's own gender and age, the family is another important factor to affect mental health itself and its relationship with bereavements. Soysal (2016) suggests that interacting with siblings can alleviate adolescents' feelings of loneliness. Additionally, individuals with siblings often develop better social skills through interactions with their brothers and sisters (Downey and Condron, 2004),

doi:10.6342/NTU202303039

potentially reducing the chance of feeling lonely when experiencing bereavements compared to those without siblings. Similarly, having parents close by has been found to associated with higher level of mental well-being among adolescents (Graham and Jordan, 2011), and the opportunities to interact with parents may also help adolescents to better cope with bereavements.

Not only having parents available can affect how (well) adolescents process grief, but the type of parents can matter too. Parental education level has been linked to children's mental health (Sonego et al., 2013). Numerous factors form a bridge between parental education and children's mental health, one of which is the amount of time parents spend with their children. Research indicates that better-educated parents, across various countries, spend more time with their children than less-educated parents do (Ravens-Sieberer et al., 2008; Guryan and Kearney, 2008). Craig (2006) also shows households where parents have a university education tend to allocate more daily time to their children's physical care and developmental activities compared to households with less-educated parents. Therefore, having better-educated parents may mitigate the adverse effects of pet loss on adolescents' well-being, likely through sharing more time together and the provision of emotional supports.

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In addition to the support provided by family and friends, attending funerals and engaging in activities offered by support groups can also assist adolescents in coping with the pain of bereavement (Kirwin and Hamrin, 2005). The act of remembrance plays a pivotal role in the healing process. Funerals serve several purposes, such as allowing mourners to come to terms with the reality of death and to receive support from the social network surrounding the grieving family. Burials provide opportunities for people to comfort each other and bid farewell to the deceased, and participation in funerals helps the bereaved cope with their loss in both the short and long term (Kirwin and Hamrin, 2005; Mitima-Verloop et al., 2021).

To sum up, the literature has suggested that factors such as gender, age, and the presence of family members are associated with adolescents' mental health and how adolescents cope with distress. In the empirical analysis we therefore explore the heterogeneity by some of the factors and assess the sensitivity in terms of whether those factors are accounted for.

2.2. Impact evaluation with Difference-in-Differences

The Difference-in-Differences (DID) model has been commonly used to assess the impact of interventions, such as policies or events, because it adeptly addresses

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biases linked to consistent unseen traits varying across groups and shared systematic features within those groups (Wooldridge, 2010). The DID model has proven valuable across a wide range of disciplines in economics.

To illustrate the broad applicability of the DID model, here we provide some more relevant examples where it has been implemented. Card and Krueger (1994), arguably the seminal study making DID to be widely used by practitioners in the last three decades, investigated the effects of raising the minimum wage on employment within the fast-food industry in New Jersey and Pennsylvania. Beyond tangible outcomes, such as wage and medication use (Katz, 1996; Wen et al., 2017), DID has also been applied to evaluate impacts on subjective well-being. Rose et al. (2023) found that the financial assistance program lowered depression rates, thereby enhancing mental health and well-being. Brodeur et al (2021) found that searches for negative terms increased during COVID-19, suggesting that the pandemic and subsequent lockdown may have affected people's mental health. Both Rose et al. (2023) and Brodeur et al. (2021) focus on subjective well-being, with a specific event serving as their treatment.

Despite the proven effectiveness of the DID model, it presents certain challenges when dealing with events that do not align temporally. For example, Yu

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et al. (2021) inferred the effects of income inequality due to carbon emission trading schemes, but the timing of the introduction of carbon trading rights varied across regions. Similarly, Li and Ando (2022) examined the impact of bison reintroduction on local economies, yet the establishment of bison herds occurred at different times across the landscape. Cuadros-Meñaca et al. (2023) faced a similar situation when analyzing the impact of school breakfast programs on student behavior, as students joined the food program at different times. Despite their distinct topics of analysis, all these studies grappled with the issue of treatments occurring at staggered times.

How to address the various treatment timing issue with the DID framework has been a recent focus among applied econometricians, and a number of strategies have been developed (Roth et al., 2023). In section 4, we provide a discussion on the issue and describe the strategy that we apply to accommodate the various timing of pet loss across individuals.

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3. Data

3.1. Taiwan Youth Project (TYP)

The Taiwan Youth Project (TYP), administered by the Institute of Sociology at Academia Sinica, is Taiwan's first longitude survey dedicated to youth development (Yi, 2021). The project explores the ways in which different facets of adolescents' lives, especially their interactions with families, schools, and communities, can shape their physical and psychological growth. In 2000, the first wave of the TYP surveyed two cohorts of students, who were in their first and third year of junior high school (7^{th} and 9^{th} grades), in northern Taiwan. Hereafter, we refer to these two cohorts as the J1 and J3 cohort, respectively. The interviewees were recruited from 40 schools in Yilan County, Taipei City and New Taipei City. A total of 5,586 students were initially interviewed for the TYP, 2,696 of whom were from the J1 cohort and 2,890 from the J3 cohort. The project then tracked these interviewees for about nine years and conducted eight subsequent waves of surveys for both of cohorts.

Among all nine waves of the TYP, four waves include the question on their recent experience with pet bereavement that provides the essential information for our study. We therefore only use the data from these four waves. Figure 1 illustrates

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the timeline of all survey waves used in the study. Specifically, the TYP solicits the information on pet bereavement from the J1 cohort when they were in their *first* year of junior high school, third year of high school, second year of college, and fourth year of college. For J3 cohort, the information on pet bereavement was collect in their *third* year of junior high school, third year of high school, second year of college, and fourth year of college. That is, for the three latter waves, the two cohorts were interviewed at same stages of their academic progression, and each wave was conducted approximately two years apart. As we will discuss in more detail later in the method section, because the long time gap between Wave 0 and Wave 1 (five year for the J1 cohort and three years for the J3 cohort), we focus on the effects of pet bereavement episodes in the three latter waves. Due to attrition and missing information required for the analysis, the final sample includes 1,219 and 1,331 interviewees from the J1 and J3 cohorts, respectively.

The survey instruments comprise of questions regarding three major aspects of interviewees: family, school, and themselves, although the questionnaires were updated from wave to wave to accommodate different academic stages of the interviewees. In the family part, for example, the survey collects basic socio-demographic information of interviewees' family members and probe into family

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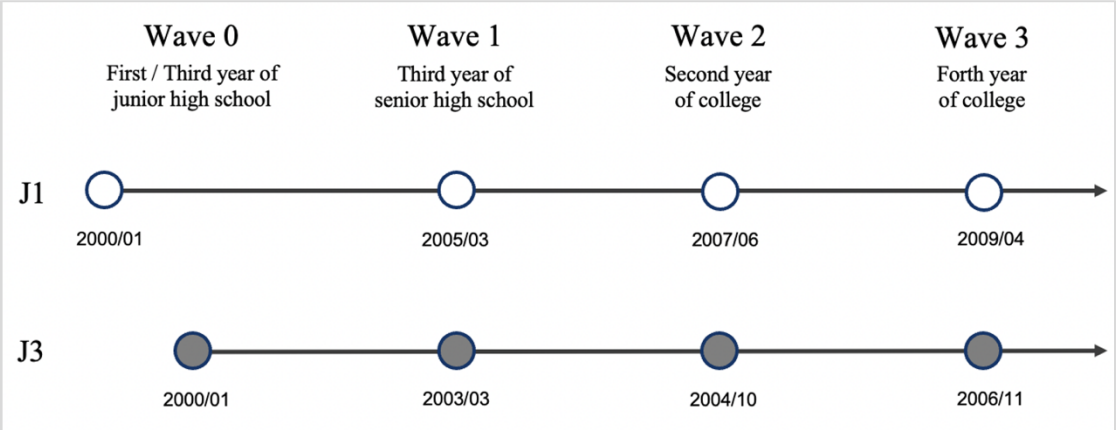
dynamic. In the school part, the questions focus on understanding how interviewees interact with their peers and teachers as well as how they manage school work. To better complete the picture of an interviewee's life, the survey also collects a rich set of information on the interviewees' physical and mental well-being, life attitude, as well as self-recognition and expectations.

Figure 1. Timeline and sampling details of TYP for J1 and J3 cohort



Notes: Figure 1 presents the TYP information used in this study, which includes the grade of the respondents and the survey time periods. The top represents the J1 cohort, and the bottom represents the J3 cohort. Wave 0 represents the first year of data collection, which is only used for basic information collection, while subsequent analyses only use data from Wave 1 to Wave 3. Wave 1 represents respondents in the third year of high school, and Wave 2 and Wave 3 respectively represent the respondents in their second and fourth years of university. The time below each of the circles indicates the survey year and month.

doi:10.6342/NTU202303039

3.2. Descriptions of variables

3.2.1. Subjective well-being

Each wave of the TYP includes a series of questions addressing the interviewees' subjective well-being, which provide the primary outcomes in our study, such as loneliness, depression, excessive worry, the desire to argue with someone, insomnia, and suicidal tendencies. The original questionnaire asked respondents about the frequency of particular subjective well-being feelings, for example, "how lonely have you felt over the past week?" The scale ranges from one to five, symbolizing never, a little, normal, serious, and very serious, respectively. Figure 2 presents the distributions of the answers to each subjective well-being indicator across all four waves, with the x-axis representing the scale of that feeling.

Because data distributions are right-skewed, indicating that most respondents report not having these feelings, we recode the 5-point Likert-scale into a dichotomous response. For example, 1 indicates the presence of loneliness (a little, normal, serious, very serious), while 0 indicates the absence of loneliness. Tseng et al. (2017) demonstrated that converting the subjective well-being scale from a multiple-option response into a binary variable can facilitate easier interpretation of responses, without influencing the results. After transforming the original multiple-

doi:10.6342/NTU202303039

option question into dichotomous variables (Yes = 1, No = 0), we can interpret the results as the effect of pet loss on the likelihood of having a particular mental distress.[2] Panel A of Table 1 reports the shares of interviewees experiencing each of the six distresses.

3.2.1. Bereavement experience

TYP includes information on pet loss, and the demise of parents and other relatives. Pet loss is defined as whether the respondent had experienced the death of a pet in the past year. Parental bereavement as well as bereavement of other relatives are also defined as whether or not they had such experiences in the past year. With this information, we are able to compare the impact of pet loss on mental health with the impact of family bereavements. Figure 3 shows the rates of deaths experienced at different time periods. About 6 to 11% of interviewees reported pet loss experience in the past year. Not surprisingly, pet losses are much more common than parental bereavements. Experiencing the death of a relative is the most common, likely because 'relative' in this context covers a wide range of people other than

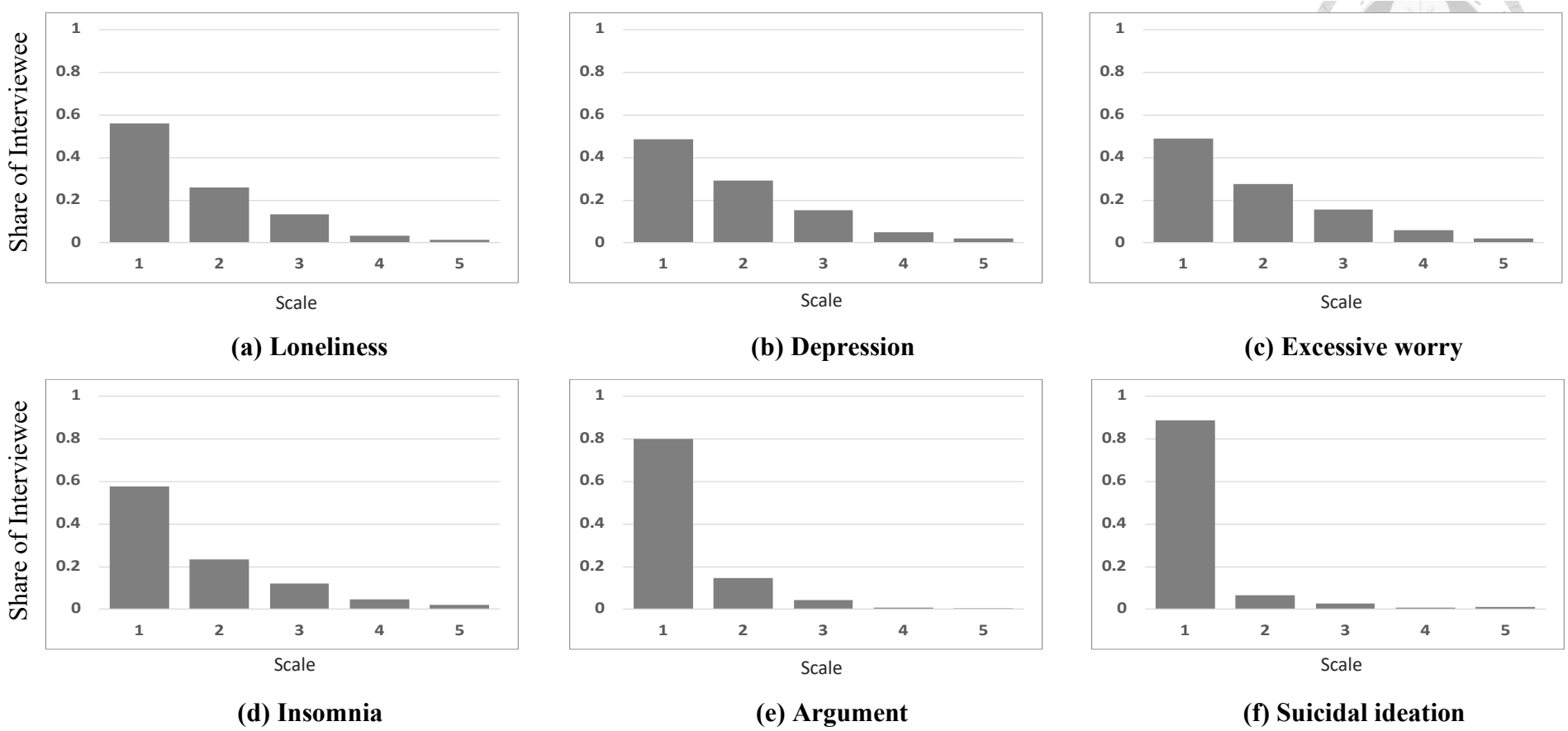
[2] Another reason that we adopt such a recoding strategy is that, other than "never," all other levels are described in varying ways across the four waves. Therefore, our recoding strategy guarantees a consistent interpretation of the coefficients.

doi:10.6342/NTU202303039

parents, including grandparents, siblings and other distant relatives. The overall average shares of interviewees having a certain bereavement experience across all four waves are reported in Panel B of Table 1.

doi:10.6342/NTU202303039

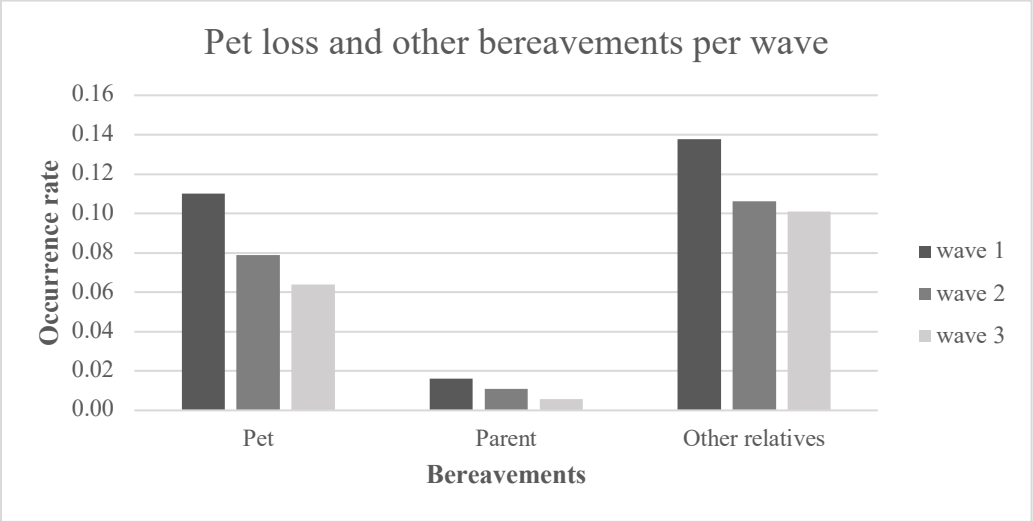
Figure 2. Distribution of frequency for subjective well-being



Notes: Figure 2 presents the original responses for various subjective mental health distresses. The x-axis represents the frequency of distress experience, where 1 indicates a low frequency and 5 indicates a high frequency. The data is right-skew distribution, showing that most individuals reported not experiencing distress. Particularly for argument and suicidal ideation, for which the proportions of never responses reached over 80%.

doi:10.6342/NTU202303039

Figure 3. Pet loss and other bereavements per wave



Notes: Figure 3 presents the proportions of respondents who experienced the death of a pet, the death of a parent, and the death of another relative in the past year.

3.2.2. Socioeconomic characteristics

Our data comprises socioeconomic characteristics such as gender, age, number of siblings, living arrangements (either at home or elsewhere), and parents' education levels. Living at home is defined as residing with one or more direct blood relatives during the second year of college, which includes parents, siblings, grandparents, and other relatives. However, it does not include the situations where individuals live exclusively with other relatives or friends. Parental education is a categorical variable showing a parent's higher degree attained. To include the variable into regression models and ease the interpretation, we recode it into a

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continuous variable representing years of education.[3] The summary statistics of interviewees' socioeconomic characteristics are reported in Panel C of Table 1.

3.2.3. College entrance test score

TYP collects interviewees' college entrance scores of the General Scholastic Ability Test (GSAT) and/or the Joint College Entrance Examination (JCEE) in wave 1.[4] Because the examination subjects for JCEE include major-specific specialized subjects and can be very different across individuals, we only explore the association between pet losses and the college entrance scores of students who took GSAT. Indeed, a large majority (73%) of the interviewees took the GSAT, so our exploration is largely generalizable.

The data include two cohorts who took the GSAT in different years (i.e., 2003 and 2005). To make their test outcomes comparable, we converted the original scores into percentile ranks (PR-values). As shown in Panel D of Table 1, the

[3] This conversion is done by assigning 2 years for below elementary school, 6 years for elementary school, 9 years for junior high school, 12 years for senior high school, 14 years for junior college, 16 years for university, and 19 years for graduate school.

[4] In Taiwan, high school students in the academic track typically take the GSAT, whereas vocational high school students mostly participate in the JCEE.

doi:10.6342/NTU202303039

average PR-value for these interviewees is 56.34, indicating that these interviewees' academic performance is above the national average.[5]

3.2.4. Additional Stressful Events

In addition to pet death, the TYP also tracked other events that could impact mental health over the course of a year. Concerning school-related experiences, the data includes instances of interviewees breaking up with friends. In terms of family dynamics, occurrences such as parental arguments and disputes between the interviewee and their parents within the past year are recorded. These dummy variables may be utilized when analyzing the impact of pet death on academic performance, as we believe that these events could potentially influence exam scores. As can be seen in Panel D of Table 1, the incidence of breaking up with friends is 19%, which is three times higher than arguing with parents. This difference may be due to the long time spent on campus for adolescents, with more interaction and friction between peers.

[5] This is highly plausible given that the large majority of these interviewees were in Taipei and New Taipei City.

doi:10.6342/NTU202303039

Table 1. Summary statistic with variable descriptions

Variables	Description	Mean	S.D.
Panel A: Subjective well-being			
Loneliness	Had ever felt lonely in the past week (Yes = 1, No = 0)	0.45	0.50
Depression	Had ever felt depression in the past week (Yes = 1, No = 0)	0.52	0.50
Excessive worry	Had ever felt excessive worry in the past week (Yes = 1, No = 0)	0.52	0.50
Argument	Had ever had the urge to argue with in the past week (Yes = 1, No = 0)	0.19	0.39
Insomnia	Had ever had insomnia in the past week (Yes = 1, No = 0)	0.43	0.50
Suicidal ideation	Had ever had suicidal ideation in the past week (Yes = 1, No = 0)	0.10	0.30
Panel B: Bereavements			
Pet loss	Had ever experienced pet death in the past year (Yes = 1, No = 0)	0.14	0.35
Parental bereavement	Had ever experienced parental bereavement in the past year (Yes = 1, No = 0)	0.02	0.15
Relative bereavement	Had ever experienced other relative bereavement in the past year (Yes = 1, No = 0)	0.19	0.39
Panel C: Socioeconomic characteristics			
Gender	Respondent's gender (Male = 1, Female = 0)	0.50	0.50
Age	Respondent's age	18.93	2.28
Number of siblings	Number of siblings	1.67	0.87
Father’s education	Father's years of education	10.95	3.55
Mother’s education	Mother's years of education	10.31	3.34
Living arrangement	Live at home (Live at home = 1, Otherwise = 0)	0.77	0.42
Panel D: Other variables			
PR-value	College entrance test score transferred to PR-value	56.34	26.23
Quarrel with parent	Had quarreled with parents in the past year (Yes = 1, No = 0)	0.06	0.24
Breakup with friend	Had had a breakup with friends in the past year (Yes = 1, No = 0)	0.19	0.39
Parent quarrel	Had parents quarreled with each other in the past year (Yes = 1, No = 0)	0.07	0.26

Notes: The table presents the summary statistics and data descriptions. Except that the means of gender and PR-value are respectively based on only Wave 0 and Wave 1 data, all other means are calculated using data from all four waves.

doi:10.6342/NTU202303039

Table 2. Summary statistic for treatment and control group

	Treatment group (n=1412)		Control group (n=8788)	
Variables	**Mean**	**S.D.**	**Mean**	**S.D.**
Panel A: Subjective well-being				
Loneliness	0.47	0.50	0.45	0.50
Depression	0.56	0.50	0.52	0.50
Excessive worry	0.55	0.50	0.52	0.50
Argument	0.25	0.44	0.18	0.38
Insomnia	0.44	0.50	0.43	0.49
Suicidal ideation	0.15	0.35	0.09	0.29
Panel B: Socioeconomic characteristics				
Gender	0.43	0.50	0.51	0.50
Number of siblings	1.71	0.87	1.67	0.87
Father's education	10.88	3.47	10.96	3.56
Mother's education	10.32	3.26	10.31	3.36
Panel C: Other variables				
PR-value	51.68	26.82	56.99	26.03
Quarrel with parent	0.10	0.30	0.06	2.23
Breakup with friend	0.30	0.46	0.17	0.38
Parent quarrel	0.11	0.31	0.07	0.25

Notes. Table 3 presents the summary statistic by treatment and control group. The treated group represents samples that have experienced pet loss, while the control group represents samples that have not or never experienced pet loss.

doi:10.6342/NTU202303039

4. Empirical strategy

In this section, we first describe the conventional setup of DID models with two-way fixed effects and the issue of various treatment timing. We then present the strategy proposed by Callaway and Sant'Anna (2021) and the empirical setup specific to our application.

4.1. Difference-in-Differences with two-way fixed effects model

Our research investigates the impact of pet loss, which could occur at different times for different individuals. This means the timing of the treatment in our study differs from those in the aforementioned studies. Conventionally, a DID model with two-way fixed effects for evaluating the impact on the likelihood of loneliness can be written as follows:

$$Y_{it} = \beta Treated_i \times Post_{it} + \boldsymbol{\gamma X_{it}} + \boldsymbol{v_i} + \boldsymbol{\mu_t} + \varepsilon_{it} \quad (1)$$

where Y_{it} is some measurement of the subjective well-being for individual i in time t. In this study, we primarily focus on the likelihood of feeling lonely. $Treated_i$ is an indicator variable representing the individual's experience with pet loss, where $Treated_i = 1$ if the individual has ever experienced pet loss, and $Treated_i = 0$ otherwise. $Post_{it}$ is a post-treatment indicator, taking a value of 1 if the time is after the individual i first experienced pet loss, and $Post_{it} = 0$ otherwise.

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For example, if individual i states that s/he has experienced pet loss in the past year in wave 1 (the third year of senior high school), $Treated_i \times Post_{it}$ equals to 1 in wave 1 and the subsequent periods. The coefficient β is the parameter of interest, which identifies the treatment effect. A significant positive β suggests that pet loss positively affects the chances of feeling lonely, while a significant negative β indicates that pet loss lowers the likelihood of feeling lonely. We add the vectors of individual and year dummy variables $\boldsymbol{v_i}$ and $\boldsymbol{\mu_t}$ to account for time-invariant individual characteristics such as gender and other genetic traits associated mental well-being and the attitudes toward stressful events as well as time-varying factors that can homogenously affect all individuals in a given wave of survey such as exam stress. $\boldsymbol{X_{it}}$ is a set of time-varying socioeconomic characteristics for individual i, including age, number of siblings, and parents' education levels.[6] ε_{it} is the error term. To account for potential biases in the standard errors, we cluster the standard errors at individual level.

[6] We note that the variations in the number of siblings and parents' education levels are likely small. Also, although it is intuitive to control for other time-varying factors such as employment status of parents and family income, unfortunately the TYP did not collect these data in all waves of the surveys.

doi:10.6342/NTU202303039

Building on the above DID with two-way fixed effects, event study is a generalized approach to study how the treatment effect evolve over time and to assess the validity of the parallel trends assumption, which is one of the most important assumptions when using DID. For instance, if the estimated likelihood of feeling lonely is not significantly different from zero before experiencing pet loss, we can infer that the treatment and control groups had similar differences in the probabilities of feeling lonely prior to treatment. The TWFE with dynamics model is as follow:

$$Y_{it} = \sum_{t=-L}^{-1} \delta_t \, Treated_{it} + \sum_{t=0}^{U} \beta_t Treated_{it} + \boldsymbol{\gamma X_{it}} + \boldsymbol{\upsilon_i} + \boldsymbol{\mu_t} + \varepsilon_{it} \qquad (2)$$

In equation (2), t represents the time relative to the treatment period; L and U are the lower and upper bound of the time periods. δ_t is the parameter for the periods prior to be treated, which is used to examine the anticipation effect and test the validity of the parallel trends assumption. The notation for other parameters remains identical to those in Equation (1). In the dynamic event study model, we focus on the coefficient of β_t, which can be interpreted as the impacts of pet loss on the subjective well-being at varying lengths of exposure within the treatment group, relatively to that within the control group.

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While the two-way fixed-effect (TWFE) linear regression model is widely used, it has drawbacks when applied with multiple treatment timing. Goodman-Bacon (2021) shows that when using TWFE linear regression model with time-varying interventions, the average treatment effect on the treated is a weighted combination of all treatments, with the highest weight assigned to units treated in the middle of the panel. Bacon decomposition provides evidence that TWFE with multiple treatment timings faces the problem of control group selection. The TWFE model not only compares never-treated and not-yet-treated units but also already-treated units, which may introduce bias to the estimation due to dynamic effects (Goodman-Bacon, 2021). Consequently, if the treatment effects exhibit dynamics, meaning that the treatment effect varies across different periods, the TWFE model may encounter negative weights and biased estimates.

4.2. Difference-in-differences with multiple time periods

4.2.1. The issue and the setup of Callaway and Sant'Anna (2021)

The issue of various treatment timing is relevant in our study context. With three waves of the TYP included, an interviewee could experience a pet loss at any wave of the surveys. As illustrated in Goodman-Bacon's (2021) decomposition exercise, when we compare the change in the subjective well-being of interviewees

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who experienced a pet loss in Wave 3 (a later treated group) with that of interviewees who experienced a loss in Wave 2 (an already treated group), we could get the wrong treatment effect if the effect can evolve overtime.

To accommodate the various treatment timing issue that can lead to biased results with TWFE, we adopt the strategy proposed by Callaway and Sant'Anna (2021). For the sake of brevity, we refer the strategy as CSDID hereafter. The idea of CSDID is to use only the "never-treated" and the "not-yet-treated" as the control group. The never-treated group includes those individuals who would never undergo the treatment; in our case, this refers to those who had never experienced pet loss. Conversely, the not-yet-treated group consists of individuals who have not yet received the treatment, which might also include members from the never-treated group. Callaway and Sant'Anna (2021) suggest that using the never-treated as control is in general more appropriate but may be infeasible when the events or programs of interest affect most units eventually. On the other hand, using the not-yet-treat as control can increases the pool for control units but may requires stronger assumptions. In our case, the sample size of the never-treated individuals is large enough, so we opt for the never-treated group as our control group. By employing

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this model, researchers can evade the unreasonably weighted average treatment effects on the treated (ATTs) that could result from the use of the TWFE model.

Following Callaway and Sant'Anna (2021), the estimation model is as follows:

$$Y = \alpha_1^{g,w} + \alpha_2^{g,w} \cdot G_g + \alpha_3^{g,w} \cdot 1\{W = w\} + \beta^{g,w} \cdot \left(G_g \times 1\{W = w\}\right) + \tilde{\gamma} \cdot \boldsymbol{X} + \epsilon^{g,w} \quad (3)$$

Equation (3) regress pet loss on the likelihood of feeling loneliness and other distress (Y) with a set of covariates ($\boldsymbol{X}$). We consider the case of W waves, denoting a particular time wave by w, where $w = \{1 \dots W\}$. $W = 3$ in the setup, and no individual is treated in the initial wave $w = 1$. This is because the treated individuals in Wave 1 are removed as we cannot find a suitable control group for them. G_g is a dummy variable representing if an individual is treated for the first time in wave g; $G_g = 1$ if the individual first experienced pet loss, and $G_g = 0$ otherwise. $\beta^{g,w}$ is the coefficient we are interested in, represents $ATT(g, w)$.

In DID with TWFE, $\boldsymbol{X}$ conventionally include any variables that can be associated with the outcome of interests (e.g., the likelihood of feeling lonely). However, Callaway and Sant'Anna (2021) advise that $\boldsymbol{X}$ should only include "pre-treatment" variables which are not affected by the treatment, at least within CSDID. The idea is that, with the (conditional) parallel trends assumption, the "post-

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treatment" variables, which can be affected by the treatment, can absorb the treatment effect and biased the estimate of $\beta^{g,w}$.

4.2.2. The doubly-robust estimand in CSDID

There are three estimands in CSDID setups: inverse probability weighting (IPW) proposed by Abadie (2005), outcome regression (OR) by Heckman et al. (1997), and the doubly-robust methods by Sant'Anna and Zhao (2020), which relies on both propensity score and OR models. Note that all three methods leverage the pre-treatment variables included. Doubly-robust estimators are highly advantageous as they require less stringent modeling assumptions compared to OR and IPW approaches (Callaway and Sant'Anna, 2021). The DR estimator can identify the ATT as long as either the propensity score or OR model has the correct specification (Sant'Anna and Zhao, 2020).

With the DR estimator, the group-time average treatment effect with never-treated control group can be expressed as follow:

$$ATT_{dr}^{nev}(g,w) = E\left[\left(\frac{G_g}{E[G_g]} - \frac{\frac{P_g(X)C}{1-P_g(X)}}{E\left[\frac{P_g(X)C}{1-P_g(X)}\right]}\right)\left(Y_w - Y_{g-1} - m_{g,w}^{nev}(X)\right)\right] \quad (4)$$

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In the equation above, $ATT_{dr}^{nev}(g,w)$ is the ATT for individuals who first experienced a pet loss during wave g in wave w. C is an indicator variable showing if the individual had ever been treated; i.e., $C = 1$ if the individual has experienced pet loss in any waves, and $C = 0$ otherwise. The propensity score, defined as $P_g(X) = P(G_g = 1|X, G_g + C = 1)$, is the likelihood of being first treated in wave g conditional on a set of individual covariates X and either being a member of group g (so $G_g = 1$) or being treated in any wave (so $C = 1$). Lastly, $m_{g,w}^{nev}(X) = E(Y_t - Y_{g-1}|X, C = 1)$ are population outcome regressions for those who had never been treated.

4.2.3. Aggregation to exposure time

In addition to the ATT representing the overall effect of experiencing pet losses on adolescents' mental health, we are also interested in whether the effect vary over time. Therefore, we aggregate $ATT(g,w)$ through the duration of treatment, the equation is shown as follow:

$$\theta_{es}(e) = \sum_{g \in G} 1\{g + e \leq W\} P(G = g \mid G + e \leq W) ATT(g, g + e) \qquad (5)$$

In equation (5), e represents the event-time, i.e., $e = w - g$ indicating the duration following the initial treatment. For instance, if an individual first experiences pet loss in Wave 2 (the second year of college), then $e = 0$ for that

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individual in Wave 2 and in the subsequent period (the fourth year of college) $e = 1$. $\theta_{es}(e)$ aggregates the $ATT(g, w)$ by event-time, accentuating the heterogeneous effect of pet loss. In our study, $\theta_{es}(0)$ represents the aggregated impact in Wave 2 (3) from pet loss first experienced in Wave 2 (3), and $\theta_{es}(1)$ is the effect from the initial pet loss occurring in Wave 2 after two years in Wave 3.

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5. Results

In this section, we first present the impact of pet death on adolescent loneliness, along with the results after incorporating other covariates. Section 5.2 explores the effect of pet death on other distresses. Subsequently, in section 5.3, we contextualize the significance of pet loss by comparing it to the bereavements of family members. In section 5.4 we explore if the group heterogenous effects of pet bereavement. We investigate whether pet death is associated students' academic performance measured by their college entrance exam scores in section 5.5. Lastly, section 5.6 conducts robustness checks.

5.1. The impact of pet loss on the likelihood of feeling loneliness

Table 2 summarizes the effects of pet loss on the probability of adolescents feeling lonely by using CSDID. The ATT represents the average effect, while e represents event time, which captures the dynamic effect. The estimate at $e = -1$ can be used to assess whether the pre-treatment trends of the treatment and control groups are consistent before pet loss. An insignificant estimate is an indication that the parallel trends assumption holds. The estimation at $e = 0$ represents the average immediate effect of first experiencing pet death in Wave 2 and Wave 3. The effect at $e = 2$ represents the effect in Wave 3 among those who experienced pet loss in

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Wave 2. That is, the change in probability of individuals feeling lonely in their senior year of college, having pet loss in their sophomore year.[7]

Model (1) is the baseline model without controlling other pre-treatment variables. Models (2) to (6) control for covariates such as age, number of siblings, and years of parental education. Based on model (1), on average, pet loss increases the probability of adolescents feeling lonely by 7.37%. The effects at $e = 0$ and $e = 1$ are increases of 2.34% and 12.40%, respectively. This suggests that experiencing pet loss may not immediately increase the likelihood of adolescents feeling lonely, but two years later, the likelihood increases. Note that the significance levels of each event time are determined based on the simultaneous confidence intervals that account for across the dependence across group-time ATT and are therefore more conservative than the traditional pointwise confidence intervals (Callaway and Sant'Anna, 2021).

Model (2) to model (4) respectively add age, the number of siblings, and both of them as covariates in the model. After controlling for these variables, the ATT

[7] With only three waves of data, we do not have the data for estimating the effect at e = 2 for those who experienced pet death in Wave 3.

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does not significantly change, and the effect of pet death at $e = 1$ still significantly increases by approximately 12%. Model (5) adds parents' years of education from model (1), and model (6) control for all covariates. From models (1) to (6), the effects before and after controlling for covariates do not change much, suggesting we have already controlled for most omitted variables. Indeed, as we pointed out earlier, the variations in the number of siblings and parents' education levels over time are likely small.

To assess the impact of not accounting for the issue of various treatment timing, the last column presents the estimated effect using TWFE. With the TWFE model, pet loss does not have a significant impact on loneliness. Taking the coefficient at face value, the average effect of 3.91% is approximately half of the effect estimated using CSDID, which implies that the use of TWFE is likely to lead to an underestimation.

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Table 3. The impact of pet loss on the likelihood of feeling lonely.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	0.0737*	0.0736*	0.0728*	0.0726*	0.0672*	0.0661*	0.0391
	(0.0408)	(0.0400)	(0.0405)	(0.0404)	(0.0381)	(0.0398)	(0.0262)
e = -1	-0.0162	-0.0159	-0.0154	-0.0151	-0.0197	-0.0196	
	(0.0649)	(0.0626)	(0.0639)	(0.0609)	(0.0643)	(0.0631)	
e = 0	0.0234	0.0233	0.0231	0.0229	0.0210	0.0203	
	(0.0412)	(0.0388)	(0.0389)	(0.0384)	(0.0395)	(0.0406)	
e = 1	0.1240*	0.1239**	0.1225*	0.1224**	0.1133*	0.1118*	
	(0.0568)	(0.0543)	(0.0562)	(0.0530)	(0.0538)	(0.0555)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,279	6,279	6,279	6,279	6,162	6162	7,568

Notes. *$p < .10$, **$p < .05$. The outcome variable is the likelihood of feeling lonely. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Models (1) to (6) use CSDID, and standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

5.2. The Impact of pet loss on other distress

In addition to the impact on feelings of loneliness, we also explored whether pet loss increases the probability of other forms of distress. Table 3 presents the impact on various types of distress under specification of model (6) in Table 1, which controls age, number of siblings, and years of parents' education. The results show no evidence that pet loss increases the likelihood of other distress. Therefore, while pet death does affect feelings of loneliness, it appears to have no impact on the likelihood of adolescents experiencing depression, excessive worry, insomnia, or suicidal tendencies.

The results in model (6) also show that pet loss does not increase the likelihood of quarrels with others. This is consistent with the literature suggesting that those who experience pet loss may tend to become more introverted, reducing social activities, and are less likely to express their grief to others and get into disputes. The demonstration of these results further emphasizes the important role that pets play as companions for adolescents. For completeness, we also present the results on each distress using models (1) through (6) in Tables A1 to A5 in the Appendix.

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Table 4. The impact of pet loss on the likelihood of loneliness and other distress

	(1)	(2)	(3)	(4)	(5)	(6)
	Loneliness	**Depression**	**Excessive worry**	**Insomnia**	**Suicidal ideation**	**Argument**
ATT	0.0661*	0.0116	0.0117	-0.0122	-0.0087	-0.0178
	(0.0398)	(0.0391)	(0.0430)	(0.0450)	(0.0238)	(0.0326)
e = -1	-0.0196	0.0544	-0.0343	-0.1000	-0.0293	0.0628
	(0.0631)	(0.0608)	(0.0622)	(0.0641)	(0.0390)	(0.0559)
e = 0	0.0203	-0.0155	0.0075	-0.0198	0.0135	-0.014
	(0.0406)	(0.0370)	(0.0422)	(0.0401)	(0.0251)	(0.0335)
e = 1	0.1118*	0.0386	0.0158	-0.0045	-0.0308	-0.0217
	(0.0555)	(0.0530)	(0.0638)	(0.0574)	(0.0316)	(0.0439)
Number of Obs.	6,162	6,165	6,159	6,165	6,165	6,165

Notes. *$p < .10$, **$p < .05$. This table shows the effect of pet loss on the likelihood of feeling lonely and other distress. All models control for age, sibling number, and parents' education. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced a loss event, and e = 1 is the subsequent wave after the loss experience was recorded. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations.

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5.3. The effects of pet loss relative to other bereavements

To put the effect size of pet death into a more relatable context, here we compare the impacts of the death of a pet, parent, or other relative on the likelihood of feeling lonely and report estimation results in Table 4. The results show that, on average, parental bereavement increases the probability of feeling lonely by 16.11%, which is about as twice as large of the effect of pet loss. If adolescents experience parental bereavement in the past year, the probability of feeling lonely in that year would significantly increase by 30.6%, which means the effect of parental bereavement mainly occurs at $e = 0$. However, the effect of $e = 0$ is only 1.63%, indicating that the effect does not last until two years later. This result is in stark contrast to the effect of pet death, which mainly comes two years after. However, we do not find evidence that bereavement of any other relatives increases the likelihood of feeling lonely. Through these results we can infer that the death of a pet on average has a stronger impact on adolescents' mental well-being than the loss of any non-parent relatives. For the sake of completeness, Tables A6 and A7 in the appendix also present the results for parental and other relative bereavement for each distress. In addition to loneliness, Table A6 shows that on average, the parental bereavement increases the likelihood of depression and excessive worry by 6.05%

doi:10.6342/NTU202303039

and 9.60%, but the effects are insignificant. As for the bereavement of other relatives in Table A7, there is no impact on adolescents' mental health for either loneliness or other distress.

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Table 5. The impact of pet loss, parental and other relative bereavement

	(1)	(2)	(3)
	Pet loss	**Parental bereavement**	**Other relative bereavement**
ATT	0.0661*	0.1611	-0.0227
	(0.0398)	(0.1019)	(0.0382)
e = -1	-0.0196	-0.3378	-0.1394
	(0.0631)	(0.3172)	(0.0785)
e = 0	0.0203	0.3060**	0.0224
	(0.0406)	(0.1177)	(0.0427)
e = 1	0.1118*	0.0163	-0.0677
	(0.0555)	(0.1416)	(0.0491)
Number of Obs.	6,162	3,501	2,916

Notes. **p< .05, **p<.001, ***p<0.001.* The outcome variable is the likelihood of feeling lonely. All models control for age, sibling number, and parents' education. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced a loss event, and e = 1 is the subsequent wave after the loss experience was recorded. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations.

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5.4. Heterogeneous effects

As discussed earlier in section 2.1, studies have suggested that gender and family support can influence how an individual process a loss. In this section, we discuss the heterogeneity across gender and between those live with and without direct relatives. Table 5 illustrates the effects of pet loss on the likelihood of feeling lonely for different genders and living arrangements. The results show that, on average, the probability of feeling lonely after pet loss is higher for males than females, with an increase of 11.83% and 4.08%, respectively. This outcome aligns with the findings discussed in section 2.1, which highlighted the different ways in which males and females cope with bereavement. While females may adjust the grief by confiding in others, males are prone to reducing their social activities (Carr et al., 2001; Stroebe et al., 2001), which could potentially lead to a higher level of loneliness. Additionally, previous studies have indicated that males are generally less likely to display negative emotions than females (Dahlberg, 2021), which suggests that the actual impact could be even greater.

In terms of the heterogeneity by living arrangement, the results in the last two columns in Table 5 reveals that interviewees living at home with direct kins are far less likely to feel lonely after pet loss compared to those living elsewhere. On

doi:10.6342/NTU202303039

average, for those living at home, the probability of feeling lonely increases by 3.94%, while for those living elsewhere, the probability escalates by 9.98%. This finding is consistent with the literature suggesting that family support is an important factor for alleviating adolescents' psychological distress (Chang et al., 2017).

doi:10.6342/NTU202303039

Table 6. The impact of pet loss on likelihood of feeling lonely by groups

Groups	Gender		Living arrangements	
	(1)	(2)	(3)	(4)
	Male	Female	Live at home	Live elsewhere
ATT	0.1183**	0.0408	0.0394	0.0998*
	(0.0603)	(0.0512)	(0.0722)	(0.0587)
e = -1	-0.0347	0.0002	-0.0039	-0.0404
	(0.1027)	(0.0792)	(0.0909)	(0.0870)
e = 0	0.0628	-0.004	0.0231	0.0246
	(0.0666)	(0.0496)	(0.0582)	(0.0559)
e = 1	0.1737*	0.0857	0.0556	0.1749*
	(0.0803)	(0.0746)	(0.0740)	(0.0856)
Number of Obs.	3,114	3,045	3,507	2,655

Notes.*$p< .05$, **$p<.001$, ***$p<0.001$. The outcome variable is the likelihood of feeling lonely. All models control for age, sibling number, and parents' education. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced a loss event, and e = 1 is the subsequent wave after the loss experience was recorded. Living at home means that a respondent resided with one or more direct blood relatives during the second year of college, which includes parents, siblings, grandparents, and other relatives. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations.

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5.5. The effect of pet loss on academic performance

Table 6 presents the results of using ordinary least squares (OLS) to regress GSAT performance on pet loss. The samples in models (1) and (2) consist of all interviewees who participated in the GSAT exam during Wave 1.

Under the assumption of pet loss being purely random, in model (1) we regress the PR-value of GSAT score only on the dummy of pet loss. The results show that pet loss might influence students' academic performance by decreasing the PR-value for 2.82, but the coefficients are statistically insignificant. Because other stressful events might also influence academic performance as mentioned in section 3.2.5., in model (2), we further control for dummy variables such as break up with friend, quarrel with parent or parents quarrel with each other in the past year. After controlling these variables, pet loss is associated with a reduction of 1.42 in the PR-value, although it is also insignificant. Still, we note that these additional controls may be affected by pet bereavement, i.e., the post-treatment variable as suggested by Callaway and Sant'Anna (2021); controlling for these variables may actually contaminated the effect of pet loss on academic performance, if we are willing to take the stand of that pet losses are purely random events.

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As we have been well aware, those who have experienced pet losses may be systematically different from those who have yet had such experiences. To minimize the potential endogeneity, we construct a more suitable control groups, i.e., those with similar number of siblings, parents' education level, and living arrangement to the treatment group but without the experience of pet loss, using propensity score matching. The estimation results based on the matched samples are presented in models (3) and (4).

The results show that pet loss is associated with an increase of 1.47 to 4.481 in the PR-value, although these estimates are also statistically insignificant. Overall, our results do not provide evidence to confirm that pet loss has a direct impact on academic performance.

doi:10.6342/NTU202303039

Table 7. The effect of pet loss on academic performance

Variable/Model	(1)	(2)	(3)	(4)
Intercept	55.67***	57.42***	51.38***	53.10***
	(-0.708)	(-0.778)	(2.290)	(2.330)
Pet loss	-2.821	-1.419	1.47	4.481
	(2.340)	(2.337)	(3.164)	(3.221)
Breakup_friend		-10.85***		-11.47**
		(1.842)		(3.996)
Argue_parent		3.525		-13.37
		(2.660)		(5.966)
Argure_with_parent		2.254		13.37
		(2.857)		(5.966)
S.E type	IID	IID	IID	IID
Number of Obs.	1554	1538	269	268

Notes. *$p< .05$, **$p<.001$, ***$p<0.001$.* This table presents the effect of pet death on academic performance, as measured by the PR-value of GSAT score. Model (1) is an OLS regression for all samples, whereas in model (2) we control for peer and family relationship variables. Models (3) and (4) use the matched sample with propensity score based on number of siblings, parents' education level, and living arrangement.

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5.6. Robustness check

In this subsection, we probe the robustness of the main finding on the effect of pet loss on loneliness with respect to the number of bootstrap replications and method to compute ATE by event time. The results presented above are all based on 1000 bootstrap replications. Here, we assess whether our main results on the overall effect of pet loss on loneliness are sensitive to the number of bootstraps. Figure 4(a) to 4(f) present the results with 0, 500, 1,000, 2,000, 3,000, and 5,000 bootstrap iterations. It is evident that the results are not influenced by the number of bootstraps.

We also examine the robustness of results by adopting different estimands to calculate the ATT by event-time. Figure 5(a) and (b) presents the estimated results using IPW and OR methods, alone with the results using the default DR method. We find the results to be consistent with those obtained using the Doubly Robust method in Figure 5(c). Based on these two examinations, we can confirm that our results are not subject to variations in the number of bootstrap replications or the estimation model used.

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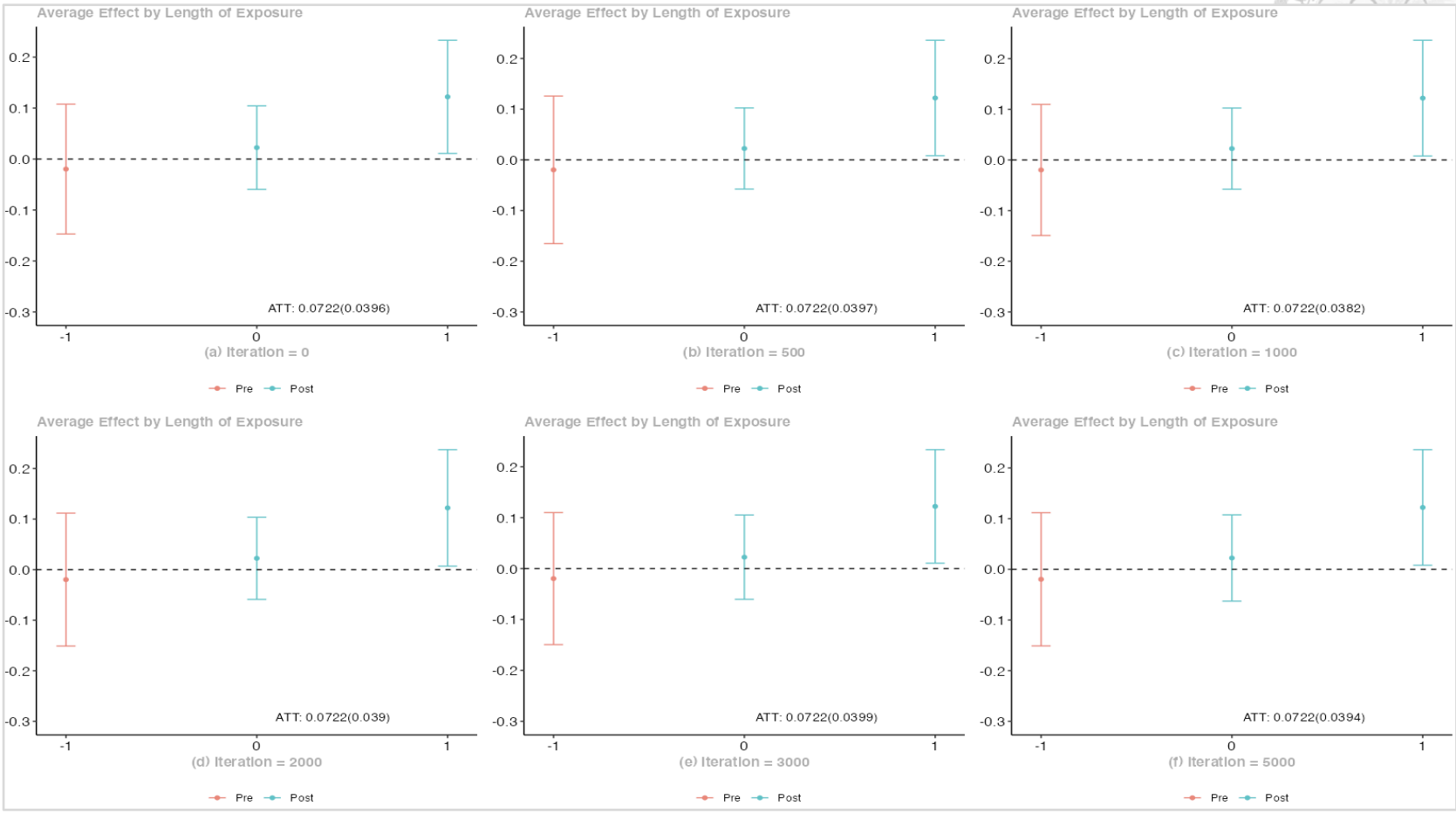
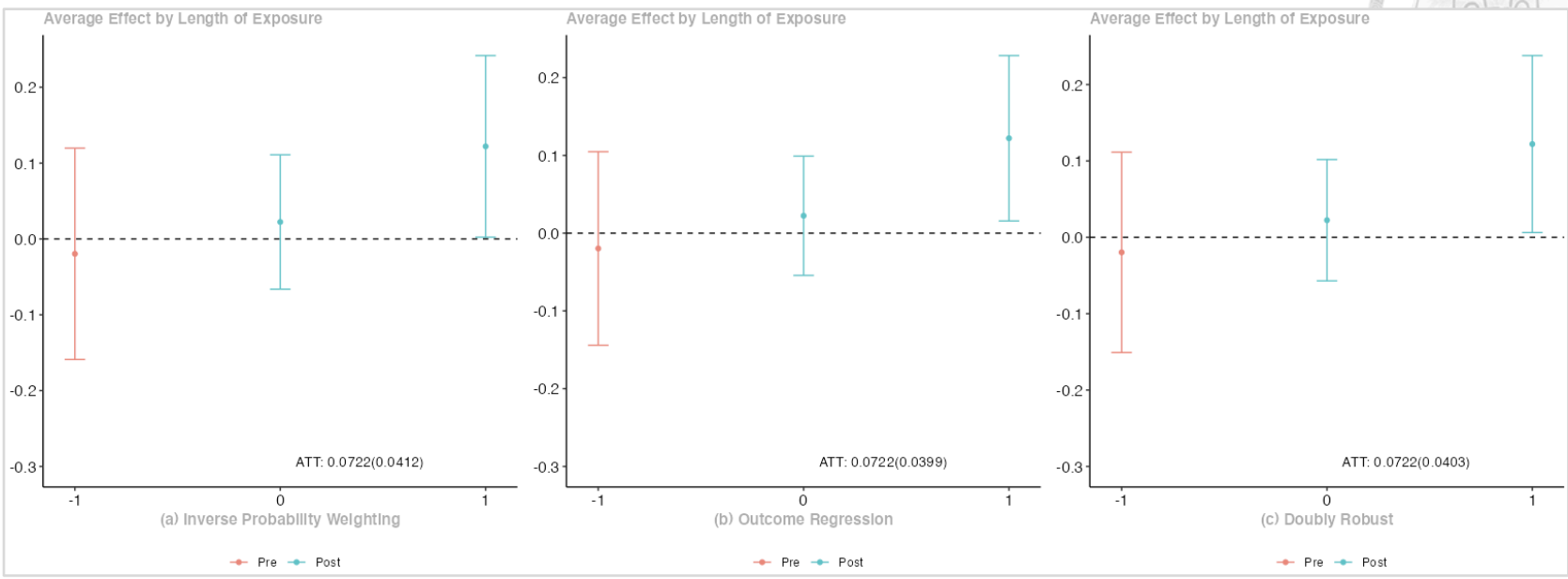
Figure 4. Impact of pet loss on the likelihood of feeling lonely by different bootstrap interactions



Notes: Figure 4 shows the dynamic effect of pet loss on the likelihood of feeling lonely using different bootstrap iterations. Figures (a) to (f) use 0, 500, 1000, 2000, 3000 and 5000 bootstrap iterations respectively. The main results are based on 1000 iterations in Figure (c).

doi:10.6342/NTU202303039

Figure 5. Impact of pet loss on the likelihood of feeling lonely by using different methods to calculate group time ATE



Notes: Figure 5 shows the dynamic effect of pet loss on loneliness by applying different methods to calculate group time ATE. Figure 5(a) and 5(b) apply IPW and OR respectively, and 5(c) is based on the DR method primarily used in this study.

doi:10.6342/NTU202303039

6. Conclusion and Discussion

Loneliness is becoming increasingly important, as loneliness is negatively correlated with well-being and adolescents feel lonelier nowadays (Dahlberg 2021; Groarke et al. 2020; Twenge et al. 2021). Although these fluffy companions enrich our lives, the impact of losing pets could be devastating. To the best of our knowledge, a number of studies have focused on the loss of family members, but not many on the loss of pets. We use Taiwan Youth Project survey data and the multiple treatment difference-in-differences method proposed by Callaway and Sant'Anna (2021) to assess the impact of pet loss on adolescents' mental health.

The results show that pet loss increases the likelihood of adolescents feeling lonely by an average of 6.6%, which is almost half of the effect size of parental loss and large than the effect of losses of any non-parental relatives. Moreover, the impact of pet loss on loneliness is mostly driven by males and those who do not live with direct relatives. The findings not only highlight the role of pets as friends and companions, but also highlight the more vulnerable groups and the importance of family support in coping with pet bereavement.

We find that the effect of pet loss on loneliness predominately appears in the last year of college among interviewees who experience pet losses in their second

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year of college. A potential explanation for this somewhat puzzling result is that the effect of pet loss may be compounded by the anxiety about college graduation. Also, during the fourth year of college, students are often less likely to meet with their colleagues and friends with the completion of most courses. Lack of peer support may further exacerbate the negative impact of confronting death on mental health.

The lagged effect of pet loss is also in stark contrast with the effect of parental loss that shows up more immediately and then dissipate in two years. As mentioned in section 2.1, funerals can be a way for people who have experienced the bereavement of a family member to cope with their grief. A conjecture is that pet losses are often not met with the same funeral rites as the death of a family member, making it harder for pet owners to accept the permanent departure.

Some countries have developed support to cope with pet death. Regarding the assistance provided for coping with pet death, some developments have taken place worldwide. For example, some companies have begun to offer pet bereavement leave, giving employees who need it sufficient time to mourning of pet loss. Moreover, some institutions, such as the American Society for the Prevention of Cruelty to Animals and Blue Cross in the United Kingdom both offer pet loss

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hotlines to provide immediate assistance and an outlet for emotional expression, offering counseling and guidance services.

Despite these findings, there are several limitations to this study. The TYP did not conduct the surveys on a yearly basis, and the question that solicit pet loss experience was also included in four waves of the TYP. We therefore could only select the years with pet loss data available. This might have caused us to overlook the effect of pet deaths occurring in the years that the interviewees were not surveyed. This issue of unobserved losses can result in an underestimation of the effect as samples that should have been categorized in the treatment group were instead classified into the control group. Additionally, the bi-annual nature of our data prevents us from having a more complete understanding of how the effect of pet bereavement evolves over time.

Other than the issue of intermittent survey years, some key information was not available in the TYP. As mentioned earlier in section 2.1, the loss of financial support may adversely affect adolescents' well-being. Therefore, family income and parents' employment status are arguably important time-varying determinants of adolescents' mental health. Unfortunately, the TYP did not collect these variables in all four waves of the project included in our analysis. We can only argue that pet

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losses are unlikely correlated with family income shocks and that our results would not be biased by the omission of variables that capture the effects of financial resources on adolescents' mental health.

Another key omission of the information is that we do not directly know whether a respondent owns a pet or not; instead, we can only infer this from the variable of pet loss. If pet ownership indeed alleviates the feelings of loneliness as previous studies show (McConnell, et al., 2011; Banks and Banks, 2002), our estimates might be underestimated, suggesting the effect of pet loss on loneliness could be more significant. Moreover, the TYP did not collect more detail information regarding the pets owned by the interviewees, such as their species, duration of ownership and cause of death. Previous research has suggested that the level of dependency on a pet could heighten the impact of the pet's death on feelings of loneliness, and this impact could differ based on the duration of pet ownership (Cowling et al., 2020). The contribution of this study is to provide evidence of the impact of pet loss on adolescent mental health. With more complete information, further research would allow for more complete and extended analyses, for example, investigating how different types of pets influence the grief process could provide a more nuanced understanding.

doi:10.6342/NTU202303039

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doi:10.6342/NTU202303039

Appendix

doi:10.6342/NTU202303039

Table A 1. The impact of pet loss on the likelihood of feeling depression

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	0.0016	0.0116	0.0116	0.0115	0.0121	0.0116	-0.0507
	(0.0400)	(0.0362)	(0.0383)	(0.0386)	(0.0390)	(0.0391)	(0.0322)
e = -1	0.0538	0.0539	0.0544	0.0545	0.0540	0.0544	
	(0.0586)	(0.0545)	(0.0603)	(0.0577)	(0.0580)	(0.0608)	
e = 0	-0.0132	-0.0133	-0.0132	-0.0133	-0.0147	-0.0155	
	(0.0387)	(0.0388)	(0.0378)	(0.0411)	(0.0367)	(0.0370)	
e = 1	0.0364	0.0364	0.0363	0.0364	0.0390	0.0386	
	(0.0554)	(0.0558)	(0.0559)	(0.0567)	(0.0527)	(0.0530)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,282	6,282	6,282	6,282	6,165	6,165	7,569

Notes. **p< .05, **p<.001, ***p<0.001.* This table presents the impact of pet loss on the likelihood of feeling depression. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

Table A 2. The impact of pet loss on the likelihood of feeling excessive worry

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	0.0127	0.0126	0.0135	0.0133	0.002	0.0034	0.0166
	(0.0408)	(0.0414)	(0.0403)	(0.0449)	(0.0418)	(0.0416)	(0.0227)
e = -1	-0.0344	-0.0343	-0.0340	-0.0340	-0.0338	-0.0338	
	(0.0650)	(0.0603)	(0.0602)	(0.0601)	(0.0613)	(0.0617)	
e = 0	0.0092	0.0092	0.0097	0.0096	-0.0025	-0.0017	
	(0.0423)	(0.0429)	(0.042)	(0.0411)	(0.0435)	(0.0437)	
e = 1	0.0163	0.0161	0.0172	0.0170	0.0065	0.0085	
	(0.0588)	(0.0552)	(0.0555)	(0.0552)	(0.0627)	(0.0527)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,276	6,276	6,276	6,276	6,159	6,159	7,566

Notes. **p< .05, **p<.001, ***p<0.001.* This table presents the impact of pet loss on excessive worry. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Models (1) to (6) use CSDID, and standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

Table A 3. The impact of pet loss on the likelihood of insomnia

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	-0.0114	-0.0115	-0.0113	-0.0114	-0.0169	-0.0168	-0.0457
	(0.0433)	(0.0448)	(0.0454)	(0.0423)	(0.0452)	(0.0434)	(0.0306)
e = -1	-0.0946	-0.0950	-0.0946	-0.0950	-0.1032	-0.1033	
	(0.0638)	(0.0636)	(0.0669)	(0.0654)	(0.0663)	(0.0624)	
e = 0	-0.0190	-0.0191	-0.0188	-0.0189	-0.0264	-0.0263	
	(0.0432)	(0.0424)	(0.0416)	(0.0429)	(0.0424)	(0.0416)	
e = 1	-0.0038	-0.0038	-0.0039	-0.0038	-0.0074	-0.0074	
	(0.0596)	(0.0594)	(0.0612)	(0.0583)	(0.0621)	(0.0608)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,282	6,282	6,282	6,282	6,165	6,165	7,569

Notes. **p< .05, **p<.001, ***p<0.001.* This table presents the impact of pet loss on insomnia. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Models (1) to (6) use CSDID, and standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

Table A 4. The impact of pet loss on the likelihood of arguing with others

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	-0.0161	-0.0161	-0.0173	-0.0173	-0.0291	-0.0301	-0.0170
	(0.0338)	(0.0305)	(0.0338)	(0.0313)	(0.031)	(0.0324)	(0.0227)
e = -1	0.0608	0.0607	0.0606	0.0606	0.0622	0.0616	
	(0.0579)	(0.0565)	(0.0609)	(0.0567)	(0.0584)	(0.0577)	
e = 0	-0.0122	-0.0122	-0.0129	-0.0129	-0.0184	-0.0193	
	(0.0324)	(0.0333)	(0.0359)	(0.0337)	(0.0359)	(0.0339)	
e = 1	-0.0200	-0.0200	-0.0217	-0.0217	-0.0398	-0.0410	
	(0.0438)	(0.0442)	(0.0458)	(0.0462)	(0.0434)	(0.0438)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,282	6,282	6,282	6,282	6,165	6,165	7,569

Notes. **p< .05, **p<.001, ***p<0.001.* This table presents the impact of pet loss on urge to argue with others. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Models (1) to (6) use CSDID, and standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

Table A 5. The impact of pet loss on the likelihood of suicidal ideation

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ATT	-0.008	-0.008	-0.0088	-0.0087	-0.0165	-0.0172	-0.0156
	(0.0222)	(0.0229)	(0.0243)	(0.0245)	(0.0226)	(0.0216)	(0.0204)
e = -1	-0.0325	-0.0326	-0.0332	-0.0333	-0.0325	-0.0335	
	(0.0411)	(0.0389)	(0.0395)	(0.039)	(0.0392)	(0.0402)	
e = 0	0.0141	0.0141	0.0137	0.0137	0.0086	0.0083	
	(0.0245)	(0.0249)	(0.0234)	(0.0245)	(0.0253)	(0.0248)	
e = 1	-0.0302	-0.0302	-0.0313	-0.0312	-0.0416	-0.0427	
	(0.0290)	(0.0309)	(0.0287)	(0.0267)	(0.0266)	(0.0286)	
Time-varying controls							
Age	No	Yes	No	Yes	No	Yes	Yes
Sibling number	No	No	Yes	Yes	No	Yes	Yes
Parents' education	No	No	No	No	Yes	Yes	Yes
Model	CSDID	CSDID	CSDID	CSDID	CSDID	CSDID	TWFE
Number of Obs.	6,282	6,282	6,282	6,282	6,165	6165	7,569

Notes. **p< .05, **p<.001, ***p<0.001.* This table presents the impact of pet loss on likelihood of suicidal ideation. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced loss event, and e = 1 is the subsequent wave after loss experience was recorded. Models (1) to (6) use CSDID, and standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations. The TWFE model is the two-way fixed effects model controlling for year and individual fixed effects, with standard errors clustered at individual level.

doi:10.6342/NTU202303039

Table A 6. The impact of parental bereavement on the likelihood of loneliness and other distress

	(1)	(2)	(3)	(4)	(5)	(6)
	Loneliness	**Depression**	**Excessive worry**	**Insomnia**	**Suicidal ideation**	**Argument**
ATT	0.1611	0.0605	0.0960	0.0155	-0.0334	0.0541
	(0.1019)	(0.0967)	(0.1012)	(0.0944)	(0.0683)	(0.0666)
e = -1	-0.3378	-0.2317	0.1463	-0.0029	-0.0015	0.1126
	(0.3172)	(0.1829)	(0.2546)	(0.2367)	(0.0912)	(0.1864)
e = 0	0.3060**	0.2276*	0.1503	-0.0004	0.0429	0.0535
	(0.1177)	(0.1154)	(0.1106)	(0.1030)	(0.0677)	(0.0840)
e = 1	0.0163	-0.1065	0.0416	0.0306	-0.1096	0.0548
	(0.1416)	(0.1303)	(0.1358)	(0.1347)	(0.0837)	(0.0782)
Number of Obs.	3,501	3,501	3,501	3,501	3,501	3,501

Notes. **p< .05, **p<.001, ***p<0.001.* This table shows the effect of pet loss on the likelihood of feeling lonely and other distress. All models control for age, sibling number, and parents' education. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced a loss event, and e = 1 is the subsequent wave after the loss experience was recorded. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations.

doi:10.6342/NTU202303039

Table A 7. The impact of other relative bereavement on the likelihood of loneliness and other distress

	(1)	(2)	(3)	(4)	(5)	(6)
	Loneliness	**Depression**	**Excessive worry**	**Insomnia**	**Suicidal ideation**	**Argument**
ATT	-0.0227	0.0413	-0.0111	-0.0568	-0.0019	0.0176
	(0.0382)	(0.0392)	(0.0398)	(0.0368)	(0.0231)	(0.0285)
e = -1	-0.1394	-0.0506	-0.0346	0.1227	-0.0531	-0.0379
	(0.0785)	(0.0715)	(0.0725)	(0.0750)	(0.0433)	(0.0581)
e = 0	0.0224	0.0405	-0.0260	-0.1088*	0.0032	0.0324
	(0.0427)	(0.0391)	(0.0404)	(0.0385)	(0.0191)	(0.0318)
e = 1	-0.0677	0.0420	0.0037	-0.0048	-0.0070	0.0027
	(0.0491)	(0.0491)	(0.0523)	(0.0475)	(0.0311)	(0.0395)
Number of Obs.	2,916	2,916	2,916	2,916	2,916	2,916

Notes. **p< .05, **p<.001, ***p<0.001.* This table shows the effect of pet loss on the likelihood of feeling lonely and other distress. All models control for age, sibling number, and parents' education. ATT denotes the average treatment effect on treated. e denotes exposure time, where e = -1 is the previous survey wave before a loss event, e = 0 is when the respondent first experienced a loss event, and e = 1 is the subsequent wave after the loss experience was recorded. Standard errors (in parenthesis) are calculated across groups and time periods with 1,000 bootstrap iterations.

doi:10.6342/NTU202303039