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Association between loneliness and acceptance of using robots and pets as companions among older Chinese immigrants during the COVID-19 pandemic

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Abstract

Objectives: To examine loneliness experienced by middle-aged and older Chinese immigrants and its association with accepting technology as a companion (apps, Internet and robots) versus owning pets, when social distancing measures were implemented in New Zealand during the first COVID-19 outbreak.

Methods: This study conducted a community-based cross-sectional survey. Chinese immigrants who were 45–87 years old ($n = 173$) were invited to answer an online survey in the Chinese language, collecting demographic data, responses to the 6-item De Jong Gierveld Loneliness Scale and experiences in using technology and pet ownership. Descriptive analyses and inferential statistics tests were utilised in the data analysis.

Results: A moderate level of overall loneliness with a mean score of 3.68 (SD 1.84), ranging from 0 to 6, was reported by participants. Emotional and social loneliness ranged from 0 to 3 with mean scores of 1.69 (SD 0.98) and 1.99 (SD 1.24), respectively. Self-reported health, financial status, English language abilities, transportation and experiences of using the Internet and apps were significantly related to experiencing loneliness. Loneliness had a weak association with acceptance of robots and pets, but 67.8% and 58.3% of participants who felt lonely, accepted companionship of robots and pets, respectively.

Conclusions: The level of loneliness among older and middle-aged immigrants increased during the COVID-19 pandemic. Further evidence of the specific dimensions of loneliness and the utility of technology to alleviate loneliness among immigrant groups is needed. Interventions tailored for older people with specific cultural requirements to address loneliness are needed.

KEYWORDS

apps, companion, computational intelligence, culturally diverse, lonely, pet, robot, social isolation, Internet

1 | INTRODUCTION

New Zealand is one of the main destination countries for Chinese immigrants, which includes those from mainland China, Hong Kong and Taiwan.[1] At the 2018 Census, there were 247,770 Chinese aged 45 years old and over living in New Zealand. In terms of age distribution, 20 percent of the Chinese ethnic group in New Zealand were 45–60 years old and 10 percent were aged 60 years and older.[2] With the increasing diversity in New Zealand communities, it was also noted that the ageing population within and across ethnic groups is rising.[2] The Chinese group constitutes the largest ethnic group within New Zealand's older Asian population, and 60 percent of the older Chinese population reside in Auckland.[2]

Older adults are at increased risk of loneliness due to health deterioration and age-related losses, which prevent them from participating in social activities and maintaining meaningful relationships.[3] Moreover, the process of immigration and adapting to a new culture in a host country often heighten the risks of loneliness in older immigrants.[4] For example, the phenomenon called the 'broken social convoy effect'[5] has been noted among immigrants, where social groups and established networks have been disrupted by one's departure from the country of origin. In reference to this phenomenon, older immigrants normally encounter challenges of interrupted social networks and limited opportunities to build up new social relationships, which makes them vulnerable to experiencing loneliness. In New Zealand, intergenerational conflicts and imbalanced reciprocity have been deemed major causes for older Chinese immigrants' loneliness.[6] The expressions of loneliness among older Chinese immigrants were deeply rooted in specific Chinese cultural values,[6] which, if not understood, pose complexities and challenges for healthcare and social care service providers to address these issues. Furthermore, due to the COVID-19 outbreak, public health measures, including social distancing recommendations to contain the spread of virus, have significantly reduced older people's social interactions and increased the risk of becoming lonely.[7]

Loneliness has been identified as a risk factor for older people's poor health, serious illness, increased risk of cognitive impairment and mortality.[8,9] Evidence from the literature has reported adverse impacts of loneliness, including increased symptoms of depression and suicidal ideation, negative health behaviours and diminished quality of life.[4,6] However, evidence of loneliness in immigrant groups during the COVID-19 pandemic remains underrepresented in research in ageing in New Zealand.

Over the past decades, the benefits of pet ownership and animal visitations in hospital and in long-term care, to foster social interactions and decrease loneliness, have

Policy Impact

Our study supports the World Health Organization (WHO) Healthy Ageing strategy in tackling loneliness through the use of digital technology for older people, particularly when the COVID-19 social distancing measures were implemented. Adding knowledge of culturally specific needs could inform future development of technology that can be used to reduce loneliness and in matching the needs and capabilities of older people, particularly those from immigrant and culturally diverse backgrounds.

Practice Impact

The key findings of this study determined the prevalence of loneliness among middle-aged and older Chinese immigrants living in New Zealand, and provided evidence on the association between loneliness and their experiences of using the Internet, apps and the acceptance of robots and pets. It will be helpful for health-care and social service providers in the context of a growing reliance on digital technology and its potential benefit in addressing social issues in ageing.

been widely reported.[10] The effect of pet companionship in loneliness has contributed to the impetus of examining companion robots, which may provide the same advantages as live animals but can be sustained with less care and are more hygienic.[10] Moreover, the COVID-19 pandemic highlighted the importance and need to develop innovative digital and robotic technology-based interventions to address older people's loneliness.[11] Ma and colleagues[12] reported that online communication technology significantly reduced the loneliness of older adults in China. Furthermore, the use of robots in various settings, particularly in Western countries, has significantly reduced experiences of loneliness in older people living in residential care homes in the UK,[13] and among older Americans who live alone in the community.[14] In New Zealand, Robinson's team also reported that residents significantly interacted more (talked and touched) with a companion robot than the resident dog as comparator.[12] Despite the increasing international evidence, there has been limited application of these interventions reported in immigrant groups, which is also the case for Chinese immigrants in New Zealand, particularly among older Chinese. Therefore, this study aimed to examine loneliness among middle-aged and older Chinese immigrants and its association with the acceptance of using

technology (apps, Internet and robots) versus owning pets when social distancing measures were implemented in New Zealand during the first COVID-19 outbreak.

2 | METHODS

2.1 | Study design

A cross-sectional design was employed in this study. We used an online survey to adhere to the social distancing measures. The survey consisted of two sections, with a 5-minute introductory video followed by the questionnaires. The video demonstrated a variety of types of companion robots, with different appearances and features. The content was presented in Mandarin with traditional Chinese subtitles for the purpose of helping potential participants to understand what companion robots are.

2.2 | Participants

Participants were invited if they met the inclusion criteria that they: (1) self-identified as having Chinese ethnicity; (2) held a permanent resident visa/New Zealand citizenship (by grant); (3) were aged 45 years or above; and (4) were able to access the Internet. The relevant questions were listed in the demographic information section to identify eligible participants.

2.3 | Ethical approval

Ethical approval was granted by the National Cheng Kung University's Institution Review Board (Reference no. A-ER-105-509). Before answering the survey, participants were given a brief introduction as to the aims of the survey and were asked to confirm (by ticking a box) if they were willing to proceed. All respondents ticked this box, and responses were anonymous.

2.4 | Recruitment and data collection

The recruitment was supported by a principal stakeholder Age Concern Auckland, who provide Asian services for older people across Auckland, as well as Chinese community groups in different regions. Following ethics approval, a flyer (in Chinese) about the study, containing a link to the online survey, was advertised via word-of-mouth, WeChat and WhatsApp groups of Chinese members. To maximise participation and to increase the response rate, we promoted the flyer more frequently on web platforms

of Age Concern Auckland and obtained support from social workers and group leaders. We received a total of 175 responses. There were 173 valid responses, and two responses were considered invalid as they did not meet the age criterion of the study.

2.5 | Measures

The online survey had traditional Chinese and a simplified Chinese version as a second option. The survey was divided into three sections: (1) social demographic background; (2) self-reported loneliness; and (3) experiences in using technology and eHealth, and experiences and acceptance of engaging with robots and pets.

The Chinese version of the 6-item De Jong Gierveld Loneliness Scale[15] was the primary outcome measure to determine the status of loneliness. This scale consists of emotional loneliness and social loneliness subscales, and each of them contains three items. There are three response categories for each item: 'no', 'more or less' and 'yes'. The scale gives a range of scores from 0 to 6, reading from the least lonely to most lonely.[15] Following the 6 items, participants answered the final, direct question 'Are you feeling lonely?' A score of 0–1, 2–4 and 5–6 represented 'no or mild', 'moderate' and 'severe' loneliness levels, respectively.[15] The scale has been validated and recommended as reliable (Cronbach's α of the 6-item scale was 0.76, the intra-class correlation coefficients ranged from 0.98 to 1.00) to measure loneliness in older Chinese people.[15] Participants' experiences in using the Internet and apps were measured by the eHealth Literacy Scale (eHEALS),[16] with eight questions, scoring from 1 (entirely disagree) to 4 (strongly agree). The instrument has been validated in older Chinese populations (Cronbach's alpha was 0.98).[16] A questionnaire of experience with and acceptance of robots and pets was adopted based on Chiu[17] and colleagues' study to measure the acceptability of robots and pets. It contains questions about the acceptability of choosing a robot or pet as a companion and their past experiences of using robots and owning pets. The question about the acceptability of robots and pets gave a range of scores from 0 to 10, reading from the least acceptable to most acceptable.[17]

2.6 | Data analysis

Descriptive analyses and inferential statistics were performed with the R Studio 1.4.1103 statistical software package. Descriptive analyses, chi-square tests and ANOVA were applied to examine the loneliness status and its relationship with the use of robotic technology and keeping pets.

3 | RESULTS

3.1 | Participants' characteristics

A total of 173 responses were included in this study. The mean age of the sample ($n = 173$) was 62.2 years (SD 9.4 years), and 133 were females and 40 were males. Of the 173 responses, 83 participants were older than 65 years. There were 75.1% participants who had emigrated from mainland China, and the percentage of immigrants from Hong Kong/Macau and Taiwan were 8.1% and 13.3%, respectively. The remaining 3.5% of the participants were Chinese groups, who had emigrated from other Asian countries. Most participants had a Bachelor's degree or above, with good self-reported health and financial status. The majority of the participants were married or had a partner (82.1%) and 87.9% lived with family or with others. Approximately half of the participants (53.2%) had lived in New Zealand for more than 10 years. All of the participants reported living at home, while 64.7% of them lived in their own flats or houses. Around 70% of the participants used a private vehicle as their main mode of transport (see participants' demographic information in Table 1).

3.2 | Status of loneliness

Participants reported a moderate level of overall loneliness with a mean score of 3.68 (SD 1.84), ranged from 0 to 6. Emotional loneliness ranged from 0 to 3 with a mean score of 1.69 (SD 0.98). The mean score of social loneliness was 1.99 (SD 1.24). Around 50% of the participants ($n = 87$) identified feelings of loneliness when ask directly 'are you feeling lonely' (see Table 2). Only 15% of the participants ($n = 26$) scored 'no to mild' levels of loneliness, and 44.5% ($n = 77$) scored a moderate level, while 40.5% ($n = 80$) had reported a severe level of loneliness (Figure 1).

3.3 | Experience and acceptance of using technology or owning pets

The mean score of accepting robots was 5.7 (SD 3.1), higher than the mean score of accepting pets as companions (4.7, SD 3.6). As shown in Table 3, 27.7% of the participants (middle-aged adults $n = 24$; older adults $n = 24$) reported an experience of using companion robots. Participants' experiences of using apps and the Internet were more common than engaging with companion robots. The majority of participants ($n = 161$, 93.1%) had used the Internet, and 60.1% of them ($n = 104$) had used the Internet for

TABLE 1 Sociodemographic characteristics of participants ($N = 173$)

Variables	N (%) /Mean ± SD
Gender	
Female	133 (76.9%)
Male	40 (23.1%)
Age (years)	62.2 ± 9.4
45–64	90 (52%)
65–87	83 (48%)
Marital status	
Married or have a partner	142 (82.1%)
Unmarried/widowed/single	31 (17.9%)
Whether live alone or not	
Yes	21 (12.1%)
No	152 (87.9%)
Original country or region	
Mainland China	130 (75.1%)
Hong Kong and Macau	14 (8.1%)
Taiwan	23 (13.3%)
Other Asian countries	6 (3.5%)
Self-rated health (1–5 points)	3.32 ± 0.79
Self-rated financial status (1–5 points)	3.65 ± 0.83
Self-rated English ability (1–5 points)	2.52 ± 1.25
Highest Academic qualifications	
High school or below	42 (24.3%)
Bachelor's degree or above	131 (75.7%)
Purpose for immigration	
Work	18 (10.4%)
Immigrated with adult children	66 (38.2%)
Take care of grandchildren	28 (16.2%)
Retirement	31 (17.9%)
Government policy	42 (24.3%)
Duration of immigration	
Less than 1 year	4 (2.3%)
1–10 years	77 (44.5%)
10 years or above	92 (53.2%)
Accommodation situation	
Self-owned house	112 (64.7%)
Rental	61 (35.3%)
Employment status	
Retired	129 (74.6%)
Employed	44 (25.4%)
Main transportation	
Self-drive	121 (70 %)
Public transportation	66 (38.2%)
Walk	33 (19.1%)
Family assistance	27 (15.6%)
No travel at all	5 (2.9%)

Note: Self-rated health, self-rated financial status and self-rated English language ability have a range of scores from 0 to 5, reading from 'very bad' to 'very good'.

Purpose for immigration and main transportation measures allowed multiple answers.

over 10 years. Three in five participants ($n = 107$) could download and use apps independently, while 38.2% participants ($n = 66$) had no experience of this. More than half of the participants, 54.3% ($n = 94$), had experience of pet ownership.

3.4 | Associations between loneliness and participants' acceptance and experiences of using technology, Internet and pet ownership

Table 4 presents the significant associations of self-reported health, financial status, English language abilities, transportation and experiences of using the Internet and apps with participants' feelings of loneliness. Lower levels of health, financial status and English language constraints negatively impacted upon the participants' experiences of loneliness. Participants who could drive a vehicle independently ($n = 65$) reported not feeling lonely, while those who identified walking as their main mode of mobility were more likely to report feeling lonely than their counterparts. Those who had experiences of using the Internet and apps, particularly for more than 10 years, found themselves not feeling lonely. The associations between loneliness status and the acceptance of robots and

pets were not statistically significant, but among participants who reported feeling lonely, 67.8% and 58.3% of them accepted the companionship of robots and pets, respectively.

4 | DISCUSSION

Loneliness in old age is an important topic in gerontological research, but how loneliness is expressed in differing ethnic groups, such as in older Chinese immigrants, and the association between loneliness and their experiences of using the Internet, apps and robots, remains underreported. This study examined loneliness and its association with using technology and with the acceptance of robots and pets among middle-aged and older Chinese immigrants in New Zealand. The survey results showed a moderate level of overall loneliness in middle-aged and older Chinese immigrants in New Zealand during the implementation of the COVID-19 social distancing measures. The level of loneliness in this study was much higher than the loneliness of Chinese late-life immigrants in New Zealand reported by a previous study[18] before the COVID-19 pandemic, where the overall loneliness scores measured by the Chinese version 6-item De Jong Gierveld Loneliness scale had a mean of 2.44. The COVID-19 pandemic caused a so-called 'loneliness epidemic'[19] internationally, representing an unspoken toll of COVID-19. There was no significant difference in loneliness reported between middle-aged and older Chinese immigrants in this study. Self-reported health and financial status, and transportation were significantly related to loneliness, consistent with current studies in New Zealand,[6] the United States[20] and Canada.[21] A majority of participants immigrated to New Zealand with their adult children. Previous studies reported that Chinese late-life immigrants usually immigrate to a host country to re-unite with

TABLE 2 Loneliness status

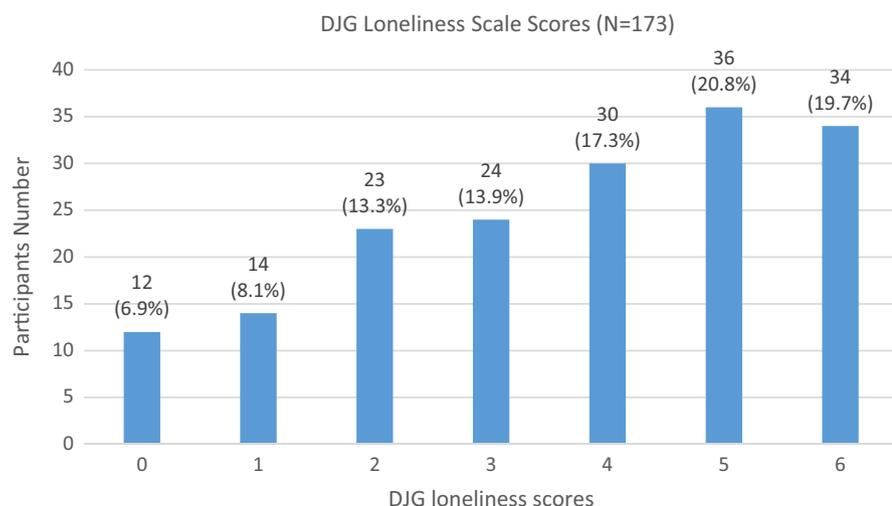| Loneliness score	Mean ± SD
Overall loneliness score (0–6 points)	3.68 ± 1.84
Emotional loneliness score (0–3 points)	1.69 ± 0.98
Social loneliness score (0–3 points)	1.99 ± 1.24
Are you feeling lonely? (Y/N)	**N (%)**
Yes	87 (50.3%)
No	86 (49.7%)

FIGURE 1 Distribution of DJG loneliness scale scores (N = 173)

TABLE 3 Acceptance and experiences of using technology, Internet and owning a pet

Acceptance of companion robot and pet	Mean ± SD
Acceptance of companion robot (0–10 points)	5.7 ± 3.1
Acceptance of a pet (0–10 points)	4.7 ± 3.6
	N (%)
Experience of using companion robot (Y/N)	
Yes	48 (27.7%)
No	125 (72.3%)
Experience of downloading and using apps (Y/N)	
Yes	107 (61.8%)
No	66 (38.2%)
Experience of using the Internet (Y/N)	
Yes and ≥10 years	104 (60.1%)
Yes and <10 years	57 (32.9%)
No	12 (6.9%)
Experiences of owning pet and using animal-assisted therapy	
Experience of owning a pet (Y/N)	
Yes	94 (54.3%)
No	79 (45.7%)
Experience of using animal-assisted therapy (AAT) (Y/N)	
Yes	18 (10.4%)
No	155 (89.6%)

Note: The measurement of companion robot and pet acceptability gives a range of scores from 0 to 10, reading as from the least acceptable to the most acceptable.

their adult children, honouring traditional values and expressions of filial piety.[18] However, the cultural stigma surrounding loneliness could prohibit older Chinese immigrants from disclosing their feelings and the status of intergenerational relationships to others.[6] Researchers need to build a trusting relationship with older Chinese immigrants before exploring loneliness from a culturally related context. Participants of this study who reported loneliness experienced comparatively ideal health, financial status, Internet access and living arrangements. Yet in New Zealand, and indeed globally, the voices of those 'hard to reach' older Chinese immigrants, who lived alone, living with complex chronic diseases or without access to the Internet, mobile devices and apps have been mostly limited in reported studies.

Advances in using technology and the Internet have been identified in this study as having the potential to address middle-aged and older Chinese immigrants' loneliness in New Zealand. The findings are consistent with WHO's strategies on Healthy Ageing in reducing loneliness and social isolation among older adults through technology-based interventions.[22] There has been increasing interest in the use of technological interventions, encompassing the use of the Internet, apps, companion and social robots, social media and virtual reality to increase

social connections and alleviate loneliness in older people.[23] Recent technological development enables older adults to access information through the Internet, to interact with others, and gain social support via online channels regardless of geographical distance.[23] In addition, in Europe, companion robots were found to mitigate feelings of loneliness through building different types of supportive relationships,[24] and they increased social interactions with other people for older Taiwanese in long-term care settings[25] as well as among older Japanese in day care facilities and nursing homes.[26] However, fewer studies on robots have addressed the loneliness of older Chinese immigrants living in their own homes in the community. Studies on older Chinese immigrants' lifestyle[27] and experience of loneliness[18] in New Zealand communities have revealed that some older Chinese immigrants reluctantly discarded prior customary filial piety expectations, in favour of external services/resources to support their care arrangements and to help them cope with loneliness. To fill the research gap, this study examined the association between loneliness and the acceptance of robots and pets among middle-aged and older Chinese immigrants living in the community. Although the association was not statistically significant, which might be due to the limited experience of using robots among participants, we found

TABLE 4 Associations between loneliness and sociodemographic factors, health status, and participants' acceptance and experiences of using technology, Internet and owning pet

	Self-reported feeling 'lonely' ($n = 87$)	Self-reported feeling 'not lonely' ($n = 86$)	X^2(F)	p-value
Sociodemographic and health factors				
Gender				
Female ($n = 133$)	66 (75.9%)	67 (77.9%)	0.02	0.9
Male ($n = 40$)	21 (24.1%)	19 (22.1%)		
Age				
45–64 ($n = 90$)	45 (51.7%)	45 (52.3%)	NA	NA
65–87 ($n = 83$)	42 (48.3%)	41 (47.7%)		
Self-rated health (1 to 5 points)	3.07±0.80	3.58±0.68	20.55	<0.001
Self-rated financial status (1–5 points)	3.41±1.20	3.90±1.25	15.71	<0.001
Self-rated English ability (1–5 points)	2.28±1.34	2.77±1.24	3.23	0.009
Employment status				
Retired ($n = 129$)	67 (77.0%)	62 (81.8%)	0.32	0.6
Employed ($n = 44$)	20 (23.0%)	24 (18.2%)		
Main transportation				
Self-drive ($n = 121$)	50 (57.5%)	65 (75.6%)	5.58	0.02
Public transportation ($n = 66$)	37 (42.5%)	29 (33.7%)	1.07	0.3
Walk ($n = 38$)	24 (27.6%)	9 (10.5%)	7.14	0.008
Family assistance ($n = 27$)	17 (19.8%)	10 (11.6%)	1.50	0.2
No travel at all ($n = 5$)	5 (5.7%)	0 (0%)	3.25	0.07
Purpose for immigration				
Work ($n = 18$)	11 (12%)	7 (12.5%)	0.52	0.5
Immigrated with adult children ($n = 66$)	36 (41.4%)	30 (34.9%)	0.52	0.5
Take care of grandchildren ($n = 28$)	16 (18.4%)	12 (14.0%)	0.34	0.6
Retirement ($n = 31$)	17 (19.5%)	14 (16.3%)	0.13	0.7
Duration of immigration				
Less than 1 year ($n = 4$)	2 (2.3%)	2 (2.3%)	2.65	0.3
1–10 years ($n = 77$)	44 (50.6%)	33 (38.4%)		
10 years or above ($n = 92$)	41 (47.1%)	51 (59.3%)		
Marital status				
Married or have a partner ($n = 142$)	70 (80.4%)	72 (83.7%)	0.13	0.7
Single ($n = 31$)	17 (19.5%)	14 (16.3%)		
Whether live alone or not				
Yes ($n = 21$)	12 (13.8%)	9 (10.5%)	0.19	0.7
No ($n = 152$)	75 (86.2%)	77 (89.5%)		
Original country or region				
Mainland China ($n = 130$)	71 (81.6%)	59 (68.6%)	4.91	0.2
Hong Kong and Macau ($n = 14$)	6 (6.9%)	8 (9.3%)		
Taiwan ($n = 23$)	7 (8.0%)	16 (18.6%)		
Other Asian countries ($n = 6$)	3 (3.4%)	3 (3.5%)		
Highest academic qualifications				
High school or below ($n = 42$)	25 (28.7%)	17 (19.8%)	1.44	0.2
Bachelor degree or above ($n = 131$)	62 (71.3%)	69 (80.2%)		

TABLE 4 (Continued)

	Self-reported feeling 'lonely' (*n* = 87)	Self-reported feeling 'not lonely' (*n* = 86)	X^2(F)	*p*-value
Accommodation situation				
Self-bought house (*n* = 112)	56 (64.4%)	56 (65.1%)	NA	NA
Rental (*n* = 61)	31 (35.6%)	30 (34.9%)		
Experiences with technology, Internet and pet				
Experiences of using robot				
Yes (*n* = 48)	28 (30.4%)	20 (27.3%)	1.303	0.2
No (*n* = 125)	59 (69.6%)	66 (72.7%)		
Experiences of using Internet				
Yes and ≥10 years (*n* = 104)	46 (529%)	58 (67.4%)	7.151	0.03
Yes and <10 years (*n* = 57)	31 (35.6%)	26 (30.2%)		
No (*n* = 12)	10 (11.5%)	2 (2.3%)		
Experiences of downloading and using apps				
Yes (*n* = 107)	46 (52.9%)	61 (70.9%)	5.235	0.02
No (*n* = 66)	41 (47.1%)	25 (29.1%)		
Experiences of keeping pet				
Yes (*n* = 94)	43 (49.4%)	51 (59.3%)	1.326	0.2
No (*n* = 79)	44 (50.6%)	35 (40.7%)		
Experiences of using animal-assisted therapy				
Yes (*n* = 18)	12 (13.8%)	6 (7.0%)	1.486	0.2
No (*n* = 155)	75 (86.2%)	80 (93.0%)		
Robot and pet acceptance				
Robot and pet are highly acceptable (*n* = 55)	32 (36.8%)	23 (26.7%)	2.579	0.5
Only robot is acceptable (*n* = 62)	27 (31.0%)	35 (40.7%)		
Only pet is acceptable (*n* = 19)	10 (11.5%)	9 (10.5%)		
Neither is acceptable (*n* = 37)	18 (20.7%)	19 (22.1%)		

Note: Purpose of immigration and main transportation measures allowed multiple answers.

NA, not applicable.

Statistically significant results are in bold. *$p < 0.05$. **$p < 0.01$.

that participants were more likely to accept companionship of a robot than a pet. The finding is underpinned by previous studies where pet ownership was seen to improve loneliness in later life but where people were challenged by the cost and the physical requirements of their care, the possibility of forgetting to take care of a pet, or tripping or falling over them, and potential emotional difficulties following the death of a pet.[28] Chiu et al[17] also reported that middle-aged and older Chinese women in Taiwan preferred robots with an animal-like appearance, and experience with using apps was associated significantly with the acceptance of robots. Further evidence on the specific dimensions of loneliness and the utility of companion robots to alleviate loneliness among immigrant groups is needed.

People argue that the social involvement and family obligations surrounding Chinese culture among older people are possible reasons for them to prefer physical interactions rather than engaging more with the Internet or online platforms.[10] In the context of COVID-19, participants affected by the social distancing measures might not have had usual face-to-face interactions,[29] which might have influenced the experience of loneliness and perceived acceptance of robots or pet companionship during the pandemic period. The effectiveness of using technology in reducing loneliness should match the diverse needs, capabilities and situations of older people. For older Chinese immigrants, while using digital technology to ameliorate their loneliness, the function of technology should be developed to support them to meet family obligations as well; for example, applications are being developed to assist and support family caregivers and enhance older people's interactions with their children.[30] Further evidence is needed to understand middle-aged and older Chinese immigrants' preferences and challenges of using technology and engaging with robots and/or pets in their own homes and the effect on addressing loneliness.

4.1 | Limitations

There are several limitations to this study. First, the use of an online survey as the method of data collection may have excluded potential participants who did not have access to the Internet or who were unable to complete the online survey. Moreover, the bias of self-reported data via the online survey is possible. Second, the data collection was only conducted in Auckland, New Zealand, limiting its applicability to the whole of New Zealand and in other host countries. Therefore, caution should be exercised when generalising results beyond this locality.

5 | CONCLUSIONS

Older Chinese immigrants in this study cohort were open to the use of technological interventions and pets for companionship. Future research on the dimensions of loneliness in connection with technological solutions is needed. Technology interventions should be tailored for older people in consideration of cultural features in addressing loneliness. In terms of measuring loneliness, commonly used standardised loneliness tools have acceptable utility with older Chinese immigrants; yet, they are not sufficient for understanding the nuanced loneliness experienced by middle-aged and older Chinese immigrants. Mixed methods and co-design research are encouraged to gain a more comprehensive insight into implementing technology-based interventions and how these could reduce loneliness. Co-designing technology will lead to user-friendly products and will cater for older adults to meet their needs.

CONFLICTS OF INTEREST
Dr Jed Montayre and Dr Mu-Hsing Ho are Associate Editors of the Australasian Journal on Ageing. No conflicts of interest declared.

DATA AVAILABILITY STATEMENT
Data available on request from the authors

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REFERENCES
1. Poston DL Jr, Wong JH. The Chinese diaspora: the current distribution of the overseas Chinese population. *Chin J Sociol.* 2016;2(3):348-373.
2. Statistics New Zealand. 2018 Census totals by topic – national highlights. 2019. https://www.stats.govt.nz/information-releases/2018-census-totals-by-topic-national-highlights. Accessed November 21, 2019.
3. Kharicha K, Iliffe JMS, Chew-Graham CA, et al. Managing loneliness: a qualitative study of older people's views. *Aging Ment Health.* 2021;25(7):1206-1213. doi:10.1080/13607863.2020.1729337
4. Jang Y, Park J, Choi EY, Cho YJ, Park NS, Chiriboga DA. Social isolation in Asian Americans: risks associated with socio-demographic, health, and immigration factors. *Ethn Health.* 2021;1-14. doi:10.1080/13557858.2021.1881765
5. Park NS, Jang Y, Lee BS, Ko JE, Haley WE, Chiriboga DA. An empirical typology of social networks and its association with physical and mental health: a study with older Korean. *Imm J Gerontol B Psychol Sci Soc Sci.* 2015;70(1):67-76.
6. Zhao Y, Wright-St Clair VA, Garrett N, et al. Identifying and addressing loneliness among Chinese late-life immigrants in New Zealand (doctoral thesis). Auckland University of Technology, 2020.
7. Fuller HR, Huseth-Zosel A. Older adults' loneliness in early COVID-19 social distancing: implications of rurality. *J Gerontol B Psychol Sci Soc Sci.* 2021;gbab053:1-6. doi:10.1093/geronb/gbab053
8. Salma J, Salami B. "Growing old is not for the weak of heart": social isolation and loneliness in Muslim immigrant older adults in Canada. *Health Soci Care Comm.* 2020;28:615-623. doi:10.1111/hsc.12894
9. Steptoe A, Shankar A, Demakakos P, Wardle J. Social isolation, loneliness, and all-cause mortality in older men and women. *Proc Natl Acad Sci U S A.* 2013;110(15):5797-5801. doi:10.1073/pnas.1219686110
10. Robinson H, MacDonald B, Kerse N, Broadbent E. The psychosocial effects of a companion robot: a randomized controlled trial. *J Am Med Dir Assoc.* 2013;14(9):661-667.
11. Zubatsky M, Berg-Weger M, Morley J. Using telehealth groups to combat loneliness in older adults through COVID-19. *J Am Geriatr Soc.* 2020;68:1678-1679. doi:10.1111/jgs.16553
12. Ma XM, Zhang XF, Guo XT, Lai KH, Vogel D. Examining the role of ICT usage in loneliness perception and mental health of the elderly in China. *Technol Soc.* 2021;67:101718. doi:10.1016/j.techsoc.2021.101718
13. Bradwell HL, Edwards LJ, Winnington R, et al. Companion robots for older people: importance of user-centred design demonstrated through observations and focus groups comparing preferences of older people and roboticists in south West England. *BMJ Open.* 2019;9(9):e032468. doi:10.1136/bmjopen-2019-032468
14. Hudson J, Ungar R, Albright L, Tkatch R, Schaeffer J, Wicker ER. Robotic pet use among community-dwelling older adults. *J Gerontol B.* 2020;75(9):2018-2028.
15. Leung GT, de Jong GJ, Lam LC. Validation of the Chinese translation of the 6-item De Jong Gierveld loneliness scale in elderly

Chinese. *Int Psychogeriatr.* 2008;20(6):1262-1272. doi:10.1017/S1041610208007552

16. Norman CD, Skinner HA. eHEALS: the eHealth literacy scale. *J Med Internet Res.* 2006;8(4):e27.

17. Chiu CJ, Hsieh S, Li CW. Needs and preferences of middle-aged and older adults in Taiwan for companion robots and pets: survey study. *J Med Internet Res.* 2021;23(6):e23471. doi:10.2196/23471

18. Zhao IY, Holroyd E, Garrett N, Wright-St Clair VA, Neville S. Chinese late-life Immigrants' loneliness and social isolation in host countries: an integrative review. *J Clin Nurs.* 2021;1-10. doi:10.1111/jocn.16134

19. Courtet P, Olié E, Debien C, Vaiva G. Keep socially (but not physically) connected and carry on: preventing suicide in the age of COVID-19. *J Clin Psychiatry.* 2020;81(3):e1-e3. doi:10.4088/JCP.20com13370

20. Dong X, Chang ES. Social networks among the older Chinese population in the USA: findings from the PINE study. *Gerontology.* 2017;63(3):238-252. doi:10.1159/000455043

21. Da W-W, Garcia A. Later life migration: sociocultural adaptation and changes in quality of life at settlement among recent older Chinese immigrants in Canada. *Act Adapt Aging.* 2015;39(3):214-242. doi:10.1080/01924788.2015.1063330

22. World Health Organization. Ageing: Healthy Ageing and Functional Ability. 2020. https://www.who.int/westernpacific/news/q-a-detail/ageing-healthy-ageing-and-functional-ability. Accessed May 5, 2021.

23. Barbosa Neves B, Waycott J, Maddox A. When technologies are not enough: the challenges of digital interventions to address loneliness in later life. *Sociol Res Online.* 2021;136078042110292. doi:10.1177/13607804211029298

24. Odekerken-Schr€oder D, Mele C, Russo-Spena T, et al. Mitigating loneliness with companion robots in the COVID-19 pandemic and beyond: an integrative framework and research agenda. *J Serv Manag.* 2020;31(6):1149-1162. doi:10.1108/JOSM-05-2020-0148/full/html

25. Chen S, Moyle W, Jones C, et al. A social robot intervention on depression, loneliness, and quality of life for Taiwanese older adults in long-term care. *Int Psychogeriatr.* 2020;32(8):981-991. doi:10.1017/S1041610220000459

26. Trovato G, et al. The creation of DarumaTO: a social companion robot for Buddhist/Shinto elderlies. 2019 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), 2019: 606–11.

27. Montayre J, Saravanakumar P, Zhao I, Holroyd E, Adams J, Neville S. Holding on and letting go: views about filial piety among adult children living in New Zealand. *J Clin Nurs.* 2021;1-8. doi:10.1111/jocn.16098

28. Tkatch R, Wu L, MacLeod S, et al. Reducing loneliness and improving well-being among older adults with animatronic pets. *Aging Ment Health.* 2021;25(7):1239-1245. doi:10.1080/13607863.2020.1758906

29. Cudjoe TKM, Kotwal AA. "Social distancing" amid a crisis in social isolation and loneliness. *J Am Geriatr Soc.* 2020;68:E27-E29. doi:10.1111/jgs.16527

30. Neil-Sztramko SE, Coletta G, Dobbins M, Marr S. Impact of the AGE-ON tablet training program on social isolation, loneliness, and attitudes toward technology in older adults: single-group pre-post study. *JMIR Aging.* 2020;3(1):e18398. doi:10.2196/18398