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Combating loneliness: The role of neighbourhood ICT, environmental attractiveness, and a sense of belonging to a local community

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Abstract

Neighbourhoods can provide a sense of belonging to a local community and support subjective well-being. Our goal was to gain novel insight into the value of neighbourhood information and communication technology (ICT) in combating loneliness. Furthermore, we were interested in how a sense of belonging to a local community can be a potential mediating factor and the role of environmental attractiveness. We used data from a nationwide survey of Finnish respondents ($N = 1,226$) and structural equation modelling for data analysis. We found that perceived environmental attractiveness and a sense of belonging to a local community were negatively associated with loneliness, while the use of neighbourhood ICT was positively associated with loneliness. Perceived environmental attractiveness and use of neighbourhood ICT were positively associated with a sense of belonging to a local community. Perceived environmental attractiveness and use of neighbourhood ICT were negatively associated with loneliness via a sense of belonging to a local community. Our results suggest that perceived environmental attractiveness and use of neighbourhood ICT

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could help reduce loneliness by enhancing a sense of belonging to a local community. Interventions aimed at improving perceived environmental attractiveness and individuals' senses of belonging to a local community could be particularly helpful in combating loneliness. Please refer to the Supplementary Material section to find this article's [Community and Social Impact Statement](#).

KEYWORDS

environmental attractiveness, information and communication technology, loneliness, neighbourhood, sense of belonging to a local community

1 | INTRODUCTION

Loneliness is a negative affective state resulting from the perceived discrepancy between desired and actual social relationships (Peplau & Perlman, 1982). In Weiss's (1973) typology, loneliness is differentiated into social and emotional loneliness, where social loneliness arises from a lack of a broader group of social contacts and emotional loneliness derives from a lack of close emotional attachments to individuals. Although transient loneliness can prompt individuals to make efforts to repair and maintain social relationships, prolonged loneliness is associated with various difficulties (Qualter et al., 2015). Loneliness is a risk factor for early mortality and several negative physical and mental health and health behaviour outcomes (e.g., cardiovascular disease, depression, and lower physical activity; Hawkey & Cacioppo, 2010; Leigh-Hunt et al., 2017).

Combating loneliness is the responsibility of not only the individual but of communities and societies, which can provide people with a sense of belonging to a larger social group. A sense of belonging to a social environment (e.g., a local community) reflects an experience of personal participation in a relationship, organization, or cultural or natural environment of which an individual feels they are an essential part (Hagerty, Lynch-Sauer, Patusky, Bouwsema, & Collier, 1992; Lambert et al., 2013). Other factors can also play a role in loneliness, such as perceived environmental attractiveness, which refers to people's assessment of their physical environment and its correspondence with their preferences. In the context of neighbourhoods, it is crucial to continue investigating the resources that could help combat loneliness—for example, ICT, which can be used for communication and community-building with neighbours. Prior research has addressed the relationship between neighbourhood environment and loneliness (e.g., Domenech-Abella et al., 2020; Kowitt et al., 2020; Mao, Lou, & Lu, 2022), but research on the relationship between the use of neighbourhood ICT and loneliness is limited.

The goal of this study was to gain novel insights into the value of neighbourhood ICT in combating loneliness. Furthermore, we were interested in how a sense of belonging to a local community can be a potential mediating factor and the role of environmental attractiveness. In this study, neighbourhood ICT refers to various tools and resources (e.g., social media, email, web pages) that can facilitate social interaction, information sharing, and exchanges in the neighbourhood. To test our conceptual model, we used data collected in late spring 2021 in Finland through a nationwide, large-scale survey of respondents aged 18–80 years. The findings add knowledge of how to combat loneliness in a neighbourhood context.

1.1 | Loneliness and a sense of belonging to a local community

The need to belong is the fundamental human motivation that drives people to form and sustain relationships with each other (Baumeister & Leary, 1995). To satisfy the need to belong, people need affectively pleasant or neutral

and frequent interactions in a temporally stable and enduring framework of affective concern (Baumeister & Leary, 1995), such as their neighbourhood. As noted in social identity theory, people can form group identities on a minimal basis, and social identification processes can occur without interacting with or knowing others beforehand (Tajfel, 1970; Tajfel, Billig, Bundy, & Flament, 1971). Social identification and social identity continuity are important in managing well-being and health, including loneliness (Fong et al., 2021; McNamara et al., 2022). It has also been suggested that human beings seek to belong to their living environments (Twigger-Ross & Uzzell, 1996).

Hagerty et al. (1992) proposed that a sense of belonging in general has two defining attributes: valued involvement (the experience of being valued, accepted, and needed) and fit (the experience of fitting in or congruence through shared or complementary characteristics). Studies have shown that people who report a weaker sense of belonging to a city or neighbourhood tend to report greater loneliness (Liu et al., 2022; Nyqvist, Victor, Forsman, & Cattán, 2016) and that people who report a stronger sense of belonging to a local community or place of residence tend to report less loneliness (de Jong Gierveld, Van der Pas, & Keating, 2015; Prieto-Flores, Fernandez-Mayoralas, Forjaz, Rojo-Perez, & Martinez-Martin, 2011). In a longitudinal study, Fong et al. (2021) found that increased neighbourhood identification reduced loneliness. The consequences of a general sense of belonging extend beyond the reduced risk of loneliness to include other positive indicators, such as greater social involvement (Hagerty, Williams, Coyne, & Early, 1996). Antecedents of a general sense of belonging include the potential for shared or complementary characteristics, potential and desire for meaningful involvement, and energy for involvement (Hagerty et al., 1992). Both a positively perceived neighbourhood environment and the use of neighbourhood ICT could serve as avenues for meaningful involvement as well as recognition and observation of shared or complementary characteristics.

1.2 | Perceived environmental attractiveness and loneliness

Loneliness research has typically focused on individual characteristics, but recently, more attention has been given to the meso- and macro-level contexts of those who feel lonely, including aspects of buildings, living environment, and neighbourhoods (Nieto & Rubio, 2021; Victor & Pikhartova, 2020). Previous conceptual models have identified direct and indirect pathways linking the neighbourhood environment to loneliness. For example, Kowitt et al. (2020) proposed that neighbourhood poverty is associated with depressive symptoms through one's perceived neighbourhood environment and loneliness, while Mao et al. (2022) found that one's perceived physical neighbourhood environment is related to loneliness directly and indirectly through one's perceived social neighbourhood environment, that is, community-related cognitive social capital.

The physical and social characteristics of perceived neighbourhoods that have been found to be associated with loneliness include safety, walkability, recreational resources, social cohesion, place attachment, and neighbourhood attachment (Bergefurt et al., 2019; Domenech-Abella et al., 2020; Kearns, Whitley, Tannahill, & Ellaway, 2015; Kemperman, van den Berg, Weijs-Perrée, & Uijtdevillegen, 2019; Kowitt et al., 2020; Mao et al., 2022; Weijs-Perrée, van den Berg, Arentze, & Kemperman, 2015; Yu, Cheung, Lau, & Woo, 2017). There is limited evidence on which objective characteristics of neighbourhoods are linked with loneliness. However, research has shown that area deprivation is associated with greater area-based loneliness (Victor & Pikhartova, 2020), while greater green space around one's home is linked to less loneliness (Maas, Van Dillen, Verheij, & Groenewegen, 2009). Research has suggested that perceived neighbourhood characteristics are more strongly related to loneliness than objective neighbourhood characteristics (Matthews et al., 2019; Scharf & de Jong Gierveld, 2008). Hence, focusing on perceived environmental attractiveness is particularly useful in loneliness research.

Some empirical evidence is also available concerning indirect paths to loneliness through a sense of belonging to a local community. Mao et al. (2022) showed that positive perceptions of physical neighbourhood environments are linked to lower loneliness through a sense of belonging to a local community, trust, and caring about and helping each other. Prieto-Flores et al. (2011) reported that residential satisfaction is associated with lower loneliness

indirectly through a sense of belonging to a place of residence. Positive perceptions of one's neighbourhood and its physical environment have also been related to a stronger sense of community (French et al., 2014; Wood, Frank, & Giles-Corti, 2010), which has found to be associated with lower loneliness (Prezza, Amici, Roberti, & Tedeschi, 2001). In addition to neighbourhoods providing people with a geographically close community in which they can feel a sense of belonging, neighbours can increasingly be in contact with each other through technology.

1.3 | Neighbourhood ICT and loneliness

The use of neighbourhood ICT is a scarcely investigated area despite the gradual deployment of different tools, such as social media services, neighbourhood email lists, web pages, reservation systems (e.g., software that can be used for reserving shared spaces in the neighbourhood), and digital displays (e.g., electronic screens that can display multimedia content). In theory, neighbourhood ICT can facilitate social interactions and information exchange and help form and sustain social connections in one's local community. However, no relationship between the use of neighbourhood ICT and loneliness is evident in previous research.

Many studies on the relationship between the use of ICT and loneliness have focused on social media. Research has shown that the use of social media (e.g., posting status updates on Facebook, use of image-based platforms such as Snapchat or Instagram) is negatively associated with loneliness (Deters & Mehl, 2013; Pittman & Reich, 2016). However, the use of social media (particularly when it is frequent and much of one's day is devoted to it) has also been found to be positively associated with emotional loneliness (Bonsaksen et al., 2021; Helm et al., 2022). Nowland, Necka, and Cacioppo (2018) suggested that social Internet use can help reduce loneliness when it is employed to enhance or forge social connections but that it can increase loneliness when used as a means of escaping the offline world. The effects of digital technologies, including social media, have been argued to vary depending on how and why people use them (Latikka, Koivula, Oksa, Savela, & Oksanen, 2022; Lim, Eres, & Vasani, 2020). Some literature reviews have suggested that online digital technology interventions and video calls may have no effect on reducing loneliness (Noone et al., 2020; Shah, Noguera, van Woerden, & Kiparoglou, 2021).

Although previous evidence on the use of neighbourhood ICT and loneliness is limited, some evidence is available on the use of ICT in the context of living environments and a sense of belonging to the social environment—mainly focusing on social media. For instance, van Eldik, Kneer, and Jansz (2019) found that general social media use (through various platforms) was positively associated with a sense of belonging to one's city in that it measured social identification with others living in the city. Gatti and Procentese (2021) showed that the use of Instagram (to look at local social gatherings and places) was positively related to a sense of community through greater awareness of social places and socialization opportunities, and sense of place. Gibbons (2020) discovered that social media participation (specifically, connecting with organizations providing local services) was positively associated with neighbourhood community connections (i.e., belongingness to a neighbourhood, trust, and cooperation with neighbours) regardless of where one lives. Hampton and Wellman (2003) suggested that the Internet, coupled with local online discussion groups, transforms and enhances neighbourhood connections. Researchers have also proposed an interplay between digital and physical neighbourhoods, such as negative social interactions in a physical neighbourhood being reproduced and amplified on social media platforms such as Facebook (Stevens, Gilliard-Matthews, Dunaev, Woods, & Brawner, 2017). Limited evidence is available on the use of other technologies dedicated to the neighbourhood.

Loneliness has found to be associated with factors such as gender, age, income, marital status, parental status, household size, place of residence, and length of residence (Kung, Pudney, & Shields, 2022; Luhmann & Hawkey, 2016; Maes, Qualter, Vanhalst, Van den Noortgate, & Goossens, 2019; Nowland, Thomson, McNally, Smith, & Whittaker, 2021; Pinquart & Sörensen, 2003; van den Berg, Kemperman, De Kleijn, & Borgers, 2016; Victor & Pikhartova, 2020), although studies do not always find these links to be significant. Infrequent social neighbourhood contacts have also been associated with loneliness among younger and older people (Nyqvist

et al., 2016). Considering that a sense of belonging in general has been related to valued involvement and experiences of fitting in with one's environment or system (Hagerty et al., 1992) as well as the extent of one's personal investment (McMillan & Chavis, 1986), factors such as a longer length of residence and mode of living (i.e., rented vs. owned housing) could be important to consider.

1.4 | This study

In this study, we focus on the relationships of perceived environmental attractiveness and the use of neighbourhood ICT with loneliness and ask whether these links are indirect through a sense of belonging to a local community. Based on the “need to belong” hypothesis and social identity theory principles (Baumeister & Leary, 1995; Tajfel, 1970; Tajfel et al., 1971), we expected that people could seek and find a sense of belonging to a local community in their neighbourhoods to combat loneliness. Our hypotheses were based on existing literature on relationships between neighbourhood environment, the sense of belonging to a social environment, and loneliness (Hagerty et al., 1996; Kowitt et al., 2020; Mao et al., 2022; Prieto-Flores et al., 2011); ICT use and loneliness (Lim et al., 2020; Nowland et al., 2018); and ICT use and the sense of belonging to a living environment (Gibbons, 2020; van Eldik et al., 2019). We propose a conceptual model, illustrated in Figure 1. Our hypotheses were as follows:

H1. A stronger sense of belonging to a local community is directly associated with less loneliness.

H2a. Greater perceived environmental attractiveness is directly associated with less loneliness.

H2b. Greater perceived environmental attractiveness is directly associated with a stronger sense of belonging to a local community.

H2c. Greater perceived environmental attractiveness is associated with less loneliness indirectly through a sense of belonging to a local community.

H3a. The use of neighbourhood ICT is directly associated with loneliness.

H3b. The use of neighbourhood ICT is directly associated with a sense of belonging to a local community.

H3c. The use of neighbourhood ICT is associated with loneliness indirectly through a sense of belonging to a local community.

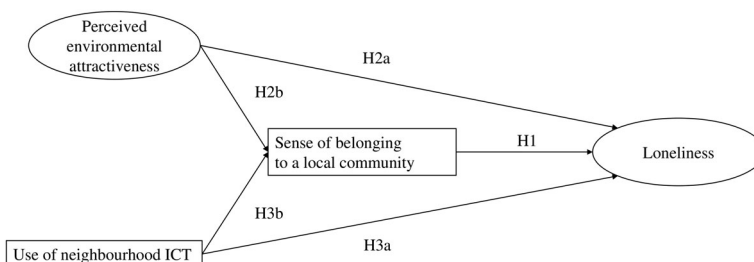


FIGURE 1 Conceptual model based on hypotheses about direct associations.

2 | MATERIALS AND METHODS

2.1 | Participants and procedure

We used survey data collected from a sample of Finnish respondents aged 18–80 years in May–June 2021 ($N = 1,226$; 50.08% female; $M_{\text{age}} = 48.43$; $SD = 17.33$). The structured survey included questions about people's experiences and perceptions of artificial intelligence (AI)-based technologies along with other digital tools, their living environments, and their social relationships. The respondents were recruited in collaboration with Norstat Finland through its web-based research panel, and the response rate was 30.81%. The sample size was determined by the aim of collecting as representative of a sample as possible that would enable an analysis of different subgroups and sufficient statistical power. The data are representative of the Finnish population's age and gender distributions: the gender distribution of residents aged 18–80 in 2020 was 49.90% male and 50.10% female, and the mean age was 48.40 (Official Statistics of Finland, 2022a). The median response time was 16 min and 6 s for the entire survey.

The respondents were informed that the survey was related to AI in society. They were also informed about the general aims of the full research project and made aware of the possibility of accessing more information from the project website: <https://projects.tuni.fi/urbanai/>. Completing the survey was voluntary for the respondents, and they were allowed to withdraw from doing so at any time. Only fully completed answers were counted in the dataset. Informed consent was received from all respondents. The respondents did not receive direct financial compensation for taking part in the research. Before data collection, the Academic Ethics Committee of Finland's Tampere region stated that our research protocol did not present ethical issues.

2.2 | Measures

Loneliness was investigated with three-item scale based on revised UCLA loneliness scale (Hughes, Waite, Hawkey, & Cacioppo, 2004). The questions included the following: “How often do you feel” (a) “that you lack companionship?” (b) “left out?” and (c) “isolated from others?” Answers were given on a scale from 1 to 3 (1 = *hardly ever*, 2 = *some of the time*, 3 = *often*).

Sense of belonging to a local community was measured with a single item—“I feel a sense of belonging to a local community”—that was modified from the sense of community scale by Bachrach and Zautra (1985). Answers were given on a scale from 1 to 7 (1 = *strongly disagree*, 7 = *strongly agree*).

Perceived environmental attractiveness was investigated with one question: “How would you rate the following statements about your neighbourhood?” The three items that followed were (a) “The area is comfortable to walk in,” (b) “The area is safe,” and (c) “There are enough outdoor activities for me in the area.” Responses were provided on a scale from 1 to 7 (1 = *strongly disagree*, 7 = *strongly agree*).

The *use of neighbourhood ICT* was examined with one question: “How often do you use the following technologies in your neighbourhood?” The options included a social media service aimed at the neighbourhood (e.g., a Facebook page, or WhatsApp group), a neighbourhood email list, a neighbourhood web page, a neighbourhood reservation system, and a neighbourhood digital display. Respondents provided their answers on a scale from 0 to 4 (0 = *never*, 1 = *less than weekly*, 2 = *weekly*, 3 = *daily*, 4 = *many times a day*). We created a sum variable with possible values from 0 to 20.

The *control variables* were age in years, gender (0 = male, 1 = female), monthly gross income (values from 1 to 8; below 1,000€; 1,000–1,999€; 2,000–2,999€; 3,000–3,999€; 4,000–4,999€; 5,000–5,999€; 6,000–6,999€; and over 7,000€), living in a rental apartment (0 = no, 1 = yes), marital status (being married or in a registered relationship; 0 = no, 1 = yes), parental status (having children; 0 = no, 1 = yes), living alone (0 = no, 1 = yes), length of residence (0 = less than 6 years, 1 = 6 years or more), and in-person (i.e., face-to-face) interactions with neighbours (values from 0 to 4; 0 = *never*, 1 = *less than weekly*, 2 = *weekly*, 3 = *daily*, 4 = *many times a day*). In addition, we controlled our models for respondents' municipalities' degrees of urbanization and rurality in binary form (0 = semiurban

and rural municipalities, 1 = urban municipality) using Finland's statistical grouping of municipalities (Official Statistics of Finland, 2022b).

2.3 | Statistical analyses

We first collected basic information about our study participants and variables, including omega reliability coefficients for the scales. We used structural equation modelling (SEM) as a general analytic method. Based on the results of the confirmatory factor analysis, the standardized factor loadings for items in loneliness and perceived environmental attractiveness were significant ($p < .001$) and ranged between 0.77 and 0.82. They were treated as latent variables, while the rest were treated as observed variables in the SEM model. We tested the model's background assumptions using a correlation matrix, variance inflation factor values, and Breusch–Pagan tests to detect possible multicollinearity and heteroscedasticity. We detected heteroscedasticity in a regression model including all variables based on a significant Breusch–Pagan test ($p < .001$). To account for abnormal data and potential problems of heteroscedasticity in the SEM model, we used the maximum likelihood estimation method with Satorra–Bentler adjustments (Satorra & Bentler, 1994). Tests of indirect associations were conducted with a 2,000-replication bootstrap (MacKinnon, Lockwood, & Williams, 2004). We used Stata (version 17) to conduct the analyses.

For the regression paths, we report unstandardized coefficients (B), p values for significance, standard errors (SEs), and 95% confidence intervals (CI s). For the reported regression paths, we adjusted the effects of age, gender, income, rental apartment, marital status, parental status, living alone, length of residence, in-person interactions with neighbours, and urbanization. We have recorded their associations in the text and tables but not in the figures. For model fit estimations, we report the chi-square statistic (χ^2) with degrees of freedom and p values along with a set of fit statistics that are compared to the χ^2 statistic less affected by the sample size (Hu & Bentler, 1999). We report the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root-mean-squared residual (SRMR). As Hu and Bentler (1999) suggested, we use cutoff criteria of >0.95 for CFI and TLI, <0.06 for RMSEA, and <0.08 for SRMR.

3 | RESULTS

Table 1 provides a descriptive overview of the study participants. Descriptive information of the variables and a range of factor loadings for the latent variables are reported in Table 2. A correlation matrix of the variables is reported in Table A1. Before we entered the background variables, the model fit indices indicated a good fit between our model and the data ($\chi^2 [16] = 42.886$, $p < .001$, CFI = 0.99, TLI = 0.99, RMSEA = 0.037, SRMR = 0.020). After we added the background variables, the fit remained rather good between the model and the data, ($\chi^2 [56] = 171.459$, $p < .001$, CFI = 0.97, TLI = 0.95, RMSEA = 0.041, SRMR = 0.018).

The estimated direct, indirect, and total effects on loneliness and a sense of belonging to a local community are presented in Table 3. According to the results for direct associations, perceived environmental attractiveness and a sense of belonging to a local community were negatively associated with loneliness, whereas use of neighbourhood ICT was positively associated with loneliness. Perceived environmental attractiveness and use of neighbourhood ICT were positively associated with a sense of belonging to a local community. The results for bootstrapped indirect associations showed that perceived environmental attractiveness was negatively associated with loneliness via a sense of belonging to a local community. The use of neighbourhood ICT was negatively associated with loneliness via a sense of belonging to a local community. Of the total effect of perceived environmental attractiveness on loneliness, 37.54% was indirect through a sense of belonging to a local community. The total effect of use of neighbourhood ICT on loneliness was not statistically significant ($p > .05$).

Among our background variables, older age, higher income, and parental status were negatively associated with loneliness, whereas living alone was positively associated with loneliness. Female gender, living in a rental apartment,

TABLE 1 Descriptive overview of study participants ($N = 1,226$).

	<i>n</i>	%
Age group		
18–24 years	125	10.20
25–34 years	206	16.80
35–44 years	204	16.64
45–54 years	194	15.82
55–64 years	212	17.29
65–74 years	206	16.80
75–80 years	79	6.44
Education		
No degree or certificate	4	0.33
Primary school or equivalent	94	7.67
Vocational undergraduate degree	311	25.37
Matriculation examination	156	12.72
College level or other secondary degree	192	15.66
Polytechnic degree	217	17.70
University degree	252	20.55
Main occupation		
Permanent job	472	38.50
Temporary job	71	5.79
Freelancer	14	1.14
Entrepreneur	34	2.77
Student	104	8.48
Working with a grant	3	0.24
Unemployed, job seeker, or laid off	104	8.48
Maternity or parental leave or unpaid care leave	29	2.37
Retired	374	30.51
Other	21	1.17

Note: There are no missing data.

marital status, length of residence, in-person interactions with neighbours, and urban municipality were not statistically significantly associated with loneliness ($p > .05$). Living in a rental apartment was negatively associated with a sense of belonging to a local community. Longer residence and more in-person interactions with neighbours were positively associated with a sense of belonging to a local community. Older age, female gender, income, marital status, parental status, living alone, and urban municipality were not statistically significantly associated with a sense of belonging to a local community ($p > .05$). Figure 2 shows the results for the direct associations of the path model.

4 | DISCUSSION

The aim of this study was to analyse the role of neighbourhood ICT and perceived environmental attractiveness in combating loneliness. A sense of belonging to a local community was a potential mediator. Our results emphasize

TABLE 2 Descriptive information of study variables, including omega values for scales and factor loadings for latent variables.

Variable	n (%)	Range	M	SD	Omega	Range of factor loadings
Loneliness	1,226				0.83	0.77–0.81
Lack companionship		1–3	1.66	0.66		
Left out		1–3	1.59	0.64		
Isolated from others		1–3	1.57	0.68		
Perceived environment attractiveness	1,226				0.85	0.80–0.82
Comfortable to walk in		1–7	5.43	1.42		
Safe		1–7	5.73	1.28		
Enough outdoor activities		1–7	5.89	1.33		
Sense of belonging to a local community	1,226	1–7	4.42	1.68		
Use of neighbourhood ICT	1,226	0–18	2.91	2.93	0.79	
Age in years	1,226	18–80	48.43	17.33		
Gender	1,226	0–1				
Female	614 (50.08)					
Male	612 (49.92)					
Income	1,226	1–8	3.07	1.55		
Rental apartment	1,226	0–1				
Yes	423 (34.50)					
No	803 (65.50)					
Marital status	1,226	0–1				
Married or registered relationship	454 (37.03)					
Other	772 (62.97)					
Parental status	1,226	0–1				
Yes	724 (59.05)					
No	502 (40.95)					
Living alone	1,226	0–1				
Yes	400 (32.63)					
No	826 (67.37)					
Length of residence	1,226	0–1				
6 years or more	662 (54)					
Less than 6 years	564 (46)					
In-person interaction with neighbours	1,226	0–4	1.72	0.90		
Degree of urbanization	1,226	0–1				
Urban municipality	974 (79.45)					
Semi-urban or rural municipality	252 (20.55)					

Note: There are no missing data.

the importance of a sense of belonging to a local community. Both the use of neighbourhood ICT and perceived environmental attractiveness have the potential to increase a sense of belonging to a local community and indirectly decrease loneliness.

TABLE 3 Estimated direct, indirect, and total effects on loneliness and a sense of belonging to a local community.

Paths	B	Satorra-Bentler SE	p	95% CI
<i>Direct</i>				
Sense of belonging - Loneliness	-0.077	0.011	<.001	[-0.10, -0.06]
Perceived environmental attractiveness - Loneliness	-0.065	0.017	<.001	[-0.10, -0.03]
Use of neighbourhood ICT - Loneliness	0.010	0.005	.043	[0.00, 0.02]
Age - Loneliness	-0.006	0.001	<.001	[-0.01, 0.00]
Female gender - Loneliness	0.046	0.029	.119	[-0.01, 0.10]
Income - Loneliness	-0.033	0.010	.001	[-0.05, -0.01]
Rental apartment - Loneliness	-0.012	0.039	.751	[-0.09, 0.06]
Marital status - Loneliness	-0.011	0.036	.756	[-0.08, 0.06]
Parental status - Loneliness	-0.083	0.037	.025	[-0.16, -0.01]
Living alone - Loneliness	0.103	0.039	.008	[0.03, 0.18]
Length of residence - Loneliness	0.023	0.036	.524	[-0.05, 0.09]
In-person interactions with neighbours - Loneliness	0.000	0.018	.985	[-0.03, 0.04]
Urban municipality - Loneliness	-0.048	0.034	.157	[-0.12, 0.02]
Perceived environmental attractiveness - Sense of belonging	0.502	0.050	<.001	[0.40, 0.60]
Use of neighbourhood ICT - Sense of belonging	0.059	0.013	<.001	[0.03, 0.08]
Age - Sense of belonging	0.002	0.003	.558	[0.00, 0.01]
Female gender - Sense of belonging	0.089	0.079	.259	[-0.07, 0.24]
Income - Sense of belonging	-0.054	0.027	.051	[-0.11, 0.00]
Rental apartment - Sense of belonging	-0.341	0.100	.001	[-0.54, -0.14]
Marital status - Sense of belonging	0.195	0.100	.052	[0.00, 0.39]
Parental status - Sense of belonging	0.068	0.098	.485	[-0.12, 0.26]
Living alone - Sense of belonging	-0.030	0.102	.769	[-0.23, 0.17]
Length of residence - Sense of belonging	0.202	0.097	.037	[0.01, 0.39]
In-person interactions with neighbours - Sense of belonging	0.584	0.051	<.001	[0.48, 0.68]
Urban municipality - Sense of belonging	-0.095	0.104	.359	[-0.30, 0.11]
<i>Indirect</i>				
Perceived environmental attractiveness - Sense of belonging - Loneliness	-0.039	0.007	<.001	[-0.05, -0.03]
Use of neighbourhood ICT - Sense of belonging - Loneliness	-0.005	0.001	<.001	[-0.01, 0.00]
<i>Total</i>				
Perceived environmental attractiveness - Loneliness	-0.103	0.017	<.001	[-0.14, -0.07]
Use of neighbourhood ICT - Loneliness	0.006	0.005	.262	[0.00, 0.02]

Note: 2,000-replication in bootstrap. Sense of belonging = A sense of belonging to a local community.

Our results support previous studies reporting that a stronger sense of belonging to a living environment is associated with less loneliness (de Jong Gierveld et al., 2015; Prieto-Flores et al., 2011). Hence, fostering a sense of belonging to a local community is likely an effective means of combating loneliness. Given the distinct dimensions of

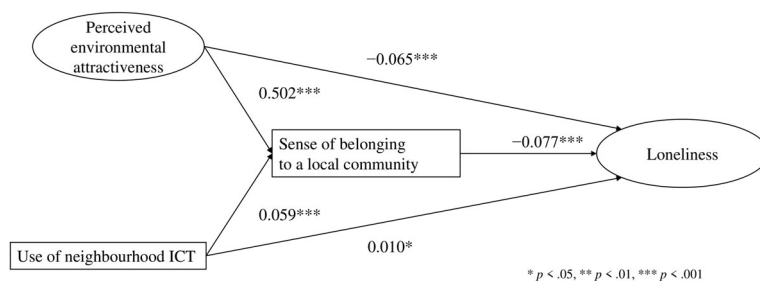


FIGURE 2 Results for the direct associations of the estimated path model.

loneliness that Weiss (1973) proposed, a sense of belonging to a local community could be especially helpful in combating social loneliness. Whereas “neighbouring,” which reflects social interactions and connections in neighbourhoods (Unger & Wandersman, 1985), may not always be positive or of high quality (Nieuwenhuis, Völker, & Flap, 2013), one’s neighbourhood can offer a relatively stable environment in which to encounter other people online, offline, or both.

Our study revealed that greater perceived environmental attractiveness was directly related to less loneliness and a stronger sense of belonging to a local community, while it was also indirectly related to less loneliness through a sense of belonging to a local community. These findings are consistent with prior conceptual models and empirical studies (e.g., Kowitt et al., 2020; Mao et al., 2022; Prieto-Flores et al., 2011), which suggest that individuals can form social bonds with important places, including their neighbourhood environment (Galčanová & Šýkorová, 2015). Phenomenological discourses in the architectural field further support our findings, suggesting that one’s environment can provide a sense of comfort and rootedness, which are essential foundations of a meaningful existence (Pallasmaa, 2021). These discourses are based on the concept of “atmosphere,” which is a synthetic perception of a place resulting from a holistic sensory experience (Pallasmaa, 2014). Similarly, research on restorative environments has demonstrated the importance of high environmental quality in mental health, wellness, and quality of life, including loneliness (Staats, 2012).

Consistent with our hypotheses, we found a direct link between the use of neighbourhood ICT and both loneliness and a sense of belonging to a local community. Even though we did not assume the direction of the associations due to conflicting evidence in prior research, our results align with previous studies suggesting that the use of social media is associated with greater emotional loneliness (Bonsaksen et al., 2021; Helm et al., 2022) and with a higher sense of belonging to a neighbourhood or city (Gibbons, 2020; van Eldik et al., 2019). We also found that using neighbourhood ICT was related to less loneliness indirectly through a sense of belonging to a local community. Notably, we found a suppressive effect, indicating that the use of neighbourhood ICT was associated with higher loneliness after we considered the effect of sense of belonging to a local community. More specifically, without a sense of belonging to a local community, ICT use may even increase loneliness. These findings underline the relevance of the quality of the contents in online social interactions and feelings they evoke in potentially lonely individuals rather than focusing on the mere quantity or frequency of technology use. Loneliness is a subjective experience and relates more to the quality of social relationships than the quantity thereof (Peplau & Perlman, 1982; Pinqart & Sørensen, 2003), which is likely to be true in the online domain as well.

The neighbourhood as a social context may offer ICT designers an extra challenge because neighbourhoods are not typically free from contradictions and controversies between residents (Nieuwenhuis et al., 2013; Unger & Wandersman, 1985). Our findings suggest that designers should consider the possible role of neighbourhood ICT in enhancing one’s sense of belonging to a community beyond facilitating social interaction. Based on some previous research, it seems that neighbourhood ICT might be useful in increasing a sense of belonging to one’s community through visual social cues. For example, Gatti and Procentese (2021) suggested that using Instagram could foster

awareness of local social spots and socializing opportunities through pictures. Pittman and Reich (2016) showed that the image-based use of social media is related to less loneliness, likely due to increased intimacy and social presence. However, it is noteworthy that any content, regardless of its form, can also incite unfavourable psychological mechanisms, such as comparing oneself negatively to others (Yang, 2016) or rumination related to others (Yun, Far-dhassemi, & Joffe, 2022).

Our study had several limitations, including its cross-sectional design, use of self-reported measures, and use of data from Finland only. Future studies should use longitudinal and representative samples from other countries to validate our results and the associations' causalities. We relied on participants' interpretations of what their neighbourhoods were, and therefore, we cannot confirm an exact scale for the concept of a neighbourhood in this study. The data were collected during the COVID-19 pandemic, which should also be considered, although at the time of data collection, there were no lockdowns in Finland, and most, if not all, of the recommendations on social restrictions had been withdrawn. It is also noteworthy that the response rate of the survey was moderate, and the survey was framed with a focus on AI in society; therefore, participant selection bias cannot be completely ruled out. The significant associations reported in this paper can be considered to be low in magnitude. Finally, in this study, we sought ways to combat loneliness as an outcome. Some evidence has suggested that loneliness is associated with more negative perceptions of neighbourhood characteristics (Matthews et al., 2019); hence, the association might be bidirectional.

5 | CONCLUSION

We investigated the potential for combating loneliness through the use of neighbourhood ICT and the roles of a sense of belonging to a local community and perceived environmental attractiveness. This study's main contribution is the novel conceptual model we presented, which builds on existing research examining the relationship between loneliness, a sense of belonging to a social environment, neighbourhood attractiveness, and ICT use. Specifically, our findings offer empirical insight into the value of using neighbourhood ICT as a means of combating loneliness by providing people a sense of belonging to a local community. These results can help professionals and practitioners develop interventions and programs aimed at combating loneliness in neighbourhoods and assist urban and technology designers in acknowledging the relevance of their design solutions to people's social worlds and well-being.

AUTHOR CONTRIBUTIONS

Rita Latikka: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Visualization, Writing—original draft, Writing—review and editing. **Nina Savela:** Conceptualization, Data curation, Funding acquisition, Investigation, Software, Writing—original draft, Writing—review and editing. **Rosana Rubio-Hernández:** Funding acquisition, Investigation, Writing—original draft, Writing—review and editing. **Aki Koivula:** Investigation, Methodology, Software, Supervision, Validation, Writing—original draft, Writing—review and editing. **Jouko Makkonen:** Investigation, Writing—original draft, Writing—review and editing. **Fernando Nieto Fernández:** Funding acquisition, Investigation, Project administration, Supervision, Writing—original draft, Writing—review and editing. **Kaisa Väänänen:** Funding acquisition, Investigation, Project administration, Supervision, Writing—original draft, Writing—review and editing. **Atte Oksanen:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing—original draft, Writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study will be made available in the Finnish Social Science Data Archive after the UrbanAI-project ends.

ETHICS STATEMENT

The ethics committee of the Tampere region in Finland declared in a 2021 statement that the protocol for this research did not present any ethical issues (Statement 29/2021).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

TABLE A1 Correlation matrix of study variables.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	
1. Lack companionship ^a	-																		
2. Left out ^a	.63**	-																	
3. Isolated from others ^a	.60**	.64**	-																
4. Sense of belonging ^b	-.29**	-.29**	-.34**	-															
5. Comfortable to walk in ^c	-.21**	-.18**	-.22**	.39**	-														
6. Safe ^c	-.22**	-.17**	-.24**	.37**	.66**	-													
7. Enough outdoor activities ^c	-.22**	-.16**	-.20**	.32**	.66**	.64**	-												
8. Use of neighbourhood ICT	.02	-.01	.03	.14**	-.04	-.12**	-.08**	-											
9. Age	-.27**	-.24**	-.26**	.24**	.10**	.12**	.19**	.00	-										
10. Female gender	.03	.08**	-.01	.05	.04	.01	.03	.02	.03	-									
11. Income	-.14**	-.16**	-.17**	.09**	.08**	.10**	.09**	.06	.16**	-.20**	-								
12. Rental apartment	.19**	.15**	.18**	-.28**	-.17**	-.17**	-.14**	.01	-.33**	.00	-.26**	-							
13. Marital status	-.22**	-.13**	-.18**	.19**	.10**	.08**	.10**	-.01	.28**	-.07*	.18**	-.33**	-						
14. Parental status	-.22**	-.20**	-.23**	.21**	.09**	.08**	.10**	.10**	.46**	.03	.20**	-.31**	.39**	-					
15. Living alone	.19**	.08**	.13**	-.15**	-.09**	-.06*	-.07*	-.04	.03	.00	-.13**	.29**	-.52**	-.26**	-				
16. Length of residence	-.15**	-.13**	-.17**	.24**	.09**	.16**	.11**	-.05	.46**	.00	.10**	-.48**	.23**	.24**	-.15**	-			
17. Interactions with neighbours ^d	-.15**	-.18**	-.21**	.45**	.19**	.15**	.17**	.25**	.27**	.01	.16**	-.20**	.15**	.25**	-.11**	.19**	-		
18. Urban municipality	.02	-.01	.03	-.08**	-.04	-.16**	-.07*	.04	-.04	-.01	.12**	-.06*	-.05	.08**	-.11**	.00	-		

* $p < .05$, ** $p < .01$.^aLoneliness item.^bSense of belonging to a local community.^cPerceived environmental attractiveness item.^dIn-person interactions with neighbours.