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The appeal of cities may not wane due to the COVID-19 pandemic and remote working

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Amidst the COVID-19 pandemic, speculations on the decline of major cities have surged, with studies noting temporary population decreases across various cities worldwide. However, research scarcely addresses the pandemic's enduring influence on perceptions of city living. Rather than exploring mid- to long-term impacts, current literature focuses mainly on comparing changes in residential preferences during and before the pandemic. To fill this gap, we conducted a randomized conjoint experiment to scrutinize altered residential preferences and attitudes toward residing in the Tokyo Metropolis due to the pandemic. Scenarios encompassed reminders of potential pandemic re-occurrence and teleworking options. Despite variations depending on the scenarios and socio-demographic characteristics of the survey participants, overall, results show that the COVID-19 pandemic and the surge in remote working did not diminish the allure of Tokyo, implying a low probability of an urban decline. These outcomes advocate for compact urban development to bolster resilience against forthcoming stressors like climate change.

The COVID-19 pandemic swiftly spread across numerous cities following its initial outbreak in Wuhan, China. It took a heavy toll on large cities in the early stages due to their extensive regional and global connections[1,2]. Large cities experienced a disproportionate number of reported mortalities and infections compared to other areas[3,4]. As a result, there was widespread speculation among the public and in popular media about the future and potential demise of large cities[5,6]. Some reports also showed noticeable increases in real estate transactions occurring outside major urban areas in countries such as Australia, France, Germany, Japan, Spain, Sweden, the UK, and the US[6–10]. The pandemic also significantly impacted internal migration patterns across the globe[5,11–13].

Several factors have been identified as important catalysts for potential shifts in perceptions towards urban areas, resulting in outmigration from some cities. These include a higher prevalence of infections in dense urban areas, widespread anxieties about crowded public spaces, closure of schools and the adoption of online education, business closures, shutdowns of recreational facilities that reduced the appeal of city living, implementation of social distancing measures, remote work arrangements and subsequent shifts in human behavior as teleworking, limited home space availability to repurpose for teleworking, and housing affordability[5,12,14–16]. Some of these changes such as the increase in teleworking, online schooling, and remote shopping activities reduced the need for individuals to travel long distances for work, education, or leisure purposes.

Although there are concerns about the future of cities and the changing trends, some scholars maintain that cities have traditionally demonstrated resilience and will emerge from the pandemic even stronger[17,18]. Also, some studies confirm that urban outmigration trends have gradually reversed after the relaxation of COVID-19 protective measures[5,11,17,19]. However, there are studies demonstrating that urban outmigration has increased in some contexts. For instance, a study from Tokyo shows that following the pandemic, migration from the center of the Tokyo Metropolitan Area to its suburban areas increased[16]. In another study based on the analysis of inter-prefectural migration data in Japan, Fielding and Ishikawa[7] found that the pandemic has slowed down migration to major cities in Japan. In fact, net inter-prefectural migration was negative in 2020 in major prefectures such as Tokyo and Aichi. Examining the relationship between net migration and population density, they demonstrate that the pandemic has decreased interest in high-density metropolitan areas and remote rural areas have gained interest for the first time in decades. In particular, Tokyo has lost its position as the major internal migration destination. Instead, more rural prefectures such as Nagano, Tottori, Shimane, and Kochi have attracted the attention of internal migrants. Similar results have been reported in

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Australia, Germany, and Sweden[8,9,14]. For instance, research shows that the pandemic has accelerated outmigration from the Stockholm inner city[9]. Despite this, it is necessary to allow more time to analyze census and population data to determine whether the decline in population in major cities is a temporary phenomenon. However, in the absence of population data, residential surveys can be utilized to explore potential long-term implications and examine various factors that determine urban residential preferences in the post-COVID era. This approach can provide urban planners and policymakers with early insights into changes that may occur in the future and allow them to prepare evidence-based plans to ensure urban resilience and sustainability[20–22].

Despite this, there have been limited efforts to examine the mid- and long-term impacts of the pandemic on perceptions toward living in large cities. Existing research has mainly focused on comparing residential perceptions/preferences changes during and before the pandemic[23]. For example, a survey conducted in Tokyo and Osaka revealed changes in residential priorities before and after the pandemic among individuals who have relocated to suburban areas. The study found a notable increase in the preference for detached houses, particularly among households with children enrolled in elementary school or above. This is attributed to the desire for more spacious living arrangements, including gardens and balconies, to enhance child-rearing quality. Furthermore, households with children of elementary school age or older were more inclined to work from home during the pandemic. Prioritizing proximity to workplaces was the main determinant of residential preferences before COVID-19 but has been overshadowed by other factors such as community dynamics and environment amidst the pandemic, especially concerning families with school-aged children[12].

Also, based on a before-after comparison, survey results revealed that individuals in Poland placed a high value on owning a plot of land outside their place of residence and being close to natural green spaces before the pandemic[24]. Conversely, having a balcony or terrace and a private garden by the house were considered less important. However, during the post-pandemic period, people's priorities shifted significantly. Proximity to natural and urban green spaces became paramount for them while owning a plot of land outside their residence and having access to balconies or terraces lost much importance[24]. Another survey conducted in Korea in 2020 revealed that a considerable proportion of residents have developed concerns about urban living due to the pandemic. Particularly, the residents of Seoul, which has a higher population density compared to Daegu and Kyeongbuk, showed a greater likelihood of considering relocation to suburban and rural areas. Interestingly, commuters expressed higher levels of apprehension regarding city living than non-commuters; however, they did not show a strong inclination towards moving away from urban environments[25].

To build on existing research and go beyond just before-after comparisons, in this study, we aim to examine if the pandemic has changed people's residential preferences and has affected the preference for living in Tokyo Metropolis. Tokyo Metropolis is a distinct administrative boundary and is different from the Tokyo Metropolitan Area as will be explained in the Methods section. For this purpose, we implemented a conjoint experiment to examine residents' preferences toward hypothetical residential profiles with randomized attributes. It is important to acknowledge that the scope of this survey was limited to post-pandemic conditions, thus preventing us from establishing a direct causal relationship between the pandemic and residents' preferences. However, we attempted to examine the effects of the pandemic by incorporating reminders of pandemic re-occurrences within the scenario settings of our experiment. Furthermore, to investigate the impact of remote work on urban outmigration, which has been noted as a driving force in Los Angeles[26] but not observed in Stockholm[9], we introduced an additional scenario into our experiment incorporating the option for remote work.

This study is significant as it examines how the pandemic and changes in remote working patterns could impact residential preferences. By comprehending these effects, urban planners and decision-makers can make informed decisions to foster sustainable and resilient urban development. This empirical investigation offers valuable insights into how residents' preferences may have changed following the pandemic. The findings from Tokyo, being a prominent global city, can provide valuable insights for urban planning and policy-making in other major cities across the globe. Furthermore, Tokyo's unique circumstances during the pandemic make it an intriguing case. Unlike many other major cities worldwide, Tokyo did not implement strict lockdown measures[27]. This is, among other things, due to Japan's postwar constitution that gives strong protection for the citizen's liberties and the reluctance of the government to face the economic consequences of the strict measures[28]. Despite the lack of strict lockdown measures, a 60% reduction in morning rush hours was observed upon the state of emergency declaration following citizens' voluntary "self-discipline" practices, reflected in school closures and crowd or business event cancellations[29,30].

Results

Here, we elaborate on the effects of residential attributes on residential choice, the effects of treatment intervention on relocation preference, and the heterogeneous effects of individual characteristics on the tendency to relocate.

Effects of residential attributes on the residence choice

We examine and compare the results achieved when participants have the option to freely decide whether to relocate or stay in their current residence, as opposed to situations where they are compelled to choose from the proposed residence options. The force-choice scenario serves as a baseline against which we can evaluate an ideal residence's profile that could potentially entice individuals to relocate from their existing homes.

In 40% of the cases, respondents opted to relocate from their current residences when offered alternative housing options. Upon examining the detailed AMCEs for each attribute and comparing forced-choice scenarios with free-choice ones, we observed consistent shifts in attribute preferences (see Fig. 1). Supplementary Table 6 provides detailed regression results. As the results show, urban green space availability and community support are only slightly significant in force-choice situations by +1.2 percentage points (hereafter referred to as p.p.). Public transportation availability only affects the force-choice preferences, and the train station's availability is +6.1 p.p. more highly preferred than a bus stop availability. Also, both of these attributes are significantly preferred compared to the no public transport. However, even though the respondents are aware of the significance of these attributes, as indicated by the force choice results, they do not deem them important enough to warrant relocation from their current residences.

Terrace housing is not preferable in either case (force-choice and free-choice). It reduces the probability of respondents choosing a residence between 1.9 to 4 p.p. when single/semi-detached housing is the baseline reference. Meanwhile, while not significant, apartment or mansion (See Supplementary Table 2 for definitions of housing types) housing is slightly preferred by +0.9 to +1.4 p.p. when respondents decide between the two proposed residences. This finding is interesting as it suggests that individuals who wish to relocate are not concerned about the type of housing they move into, whether it is single/semi-detached houses or apartments/mansions, as long as it is not a terrace house.

In both free-choice and force-choice situations, respondents strongly preferred to avoid residential profiles located in Tokyo's 23 wards, out of 23 wards but within Tokyo, and outside Tokyo. This finding suggests that respondents find the inner city wards more desirable. Yet, the probability of the proposed residence being chosen vastly differs between the two situations. In the case of force choice, there is no preference for the inner city wards compared to Tokyo's 23 wards. Also, the preference for residences located out of the 23 wards but within Tokyo, and outside Tokyo is reduced by −11.5 p.p. and −16.6 p.p., respectively. On the other hand, respondents who have the freedom to choose where they live tend to show a decreased likelihood of selecting options other than the inner city. Specifically, the Tokyo 23 wards option experienced a decrease in probability by −2 p.p.,

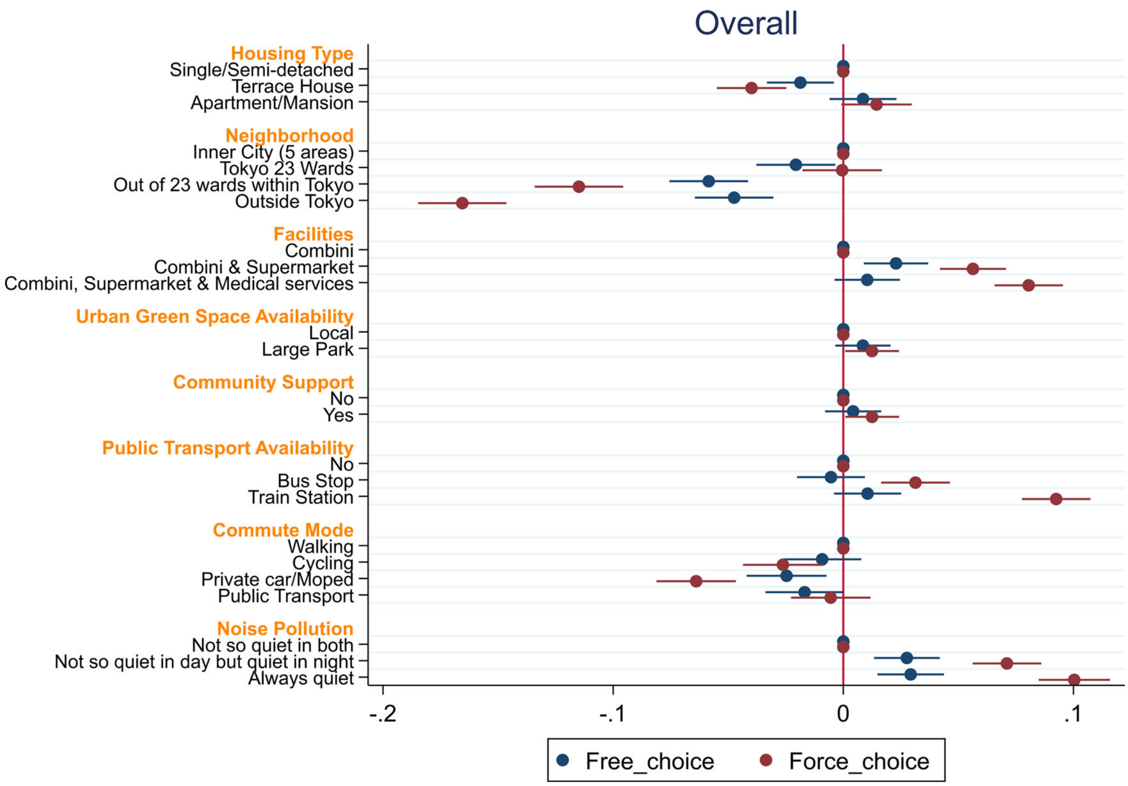

Fig. 1 | The coefficient plot of AMCEs for free choice and force choice situation. This plot estimates the effects of randomly assigned residential attribute values on the probability of preferring a residence in the coming five years. Blue represents a situation where one can choose to move to the proposed residences or stay at the current residence. In contrast, red represents the situation where one is forced to decide between the two proposed residences. Dots represent the coefficients of the OLS with clustered standard errors. Lines represent 90% confidence intervals. Dots without lines represent the reference categories.

Fig. 2 | The percentage of respondent's choices to relocate across different parts of the study area.

while areas out of the 23 wards but within Tokyo saw a larger decline of -5.8 p.p., and those outside Tokyo faced a reduction of −4.7 p.p. This suggests that individuals prefer residing within the inner city more strongly than other choices. However, the reduction in the negative probability between the force-choice and free-choice groups suggests a weak inclination toward leaving Tokyo. However, this preference is not strong enough to be considered a positive one.

The extent of preference to relocate from current residences is shown in Fig. 2. This aligns with the results reported above and shows less tendency to relocate for those residing in the inner-city neighborhoods and neighborhoods located within the Tokyo 23 wards. Figure 3 shows the extent of preference for the proposed neighborhood categories over the current neighborhood in different parts of the study area. Figure 3a, b indicates that the tendency to relocate to inner city neighborhoods or 23 wards is high even among those currently residing in areas within Tokyo but outside 23 wards and outside Tokyo. From Fig. 3d, we can see that the highest percentage (>50% of the choices) of respondents who prefer to move out of Tokyo are currently residing in Bunkyo ward.

In both choice situations, the preference for commuting by public transport is seen as comparable to walking (reference category). This means that individuals do not significantly prefer one mode of transportation over the other in both choice situations. However, commuting by cycling and

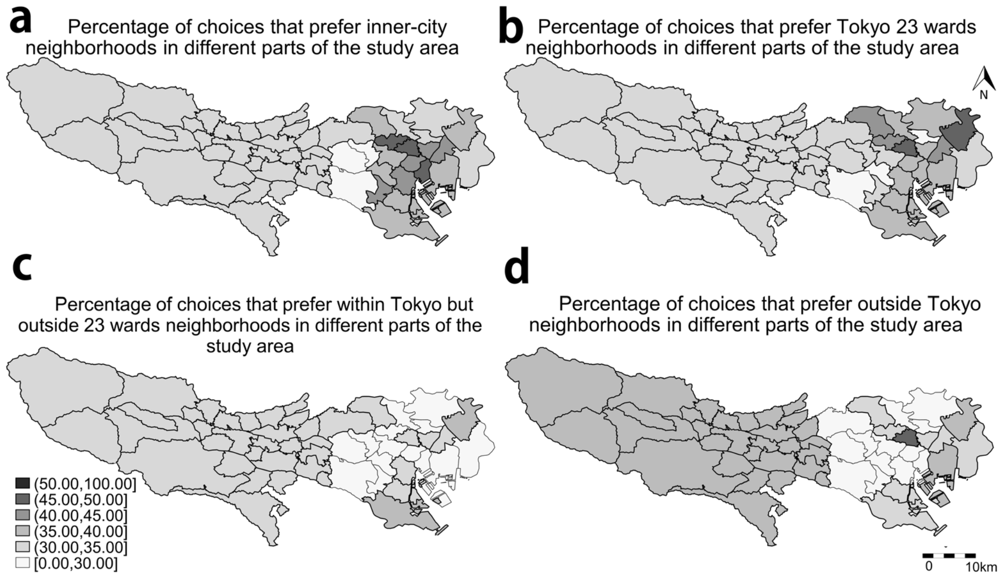

Fig. 3 | The extent of preference to relocate to areas other than the current location. a–d to (**d**) show the preference breakdown for different parts of the study area. Darker colors indicate higher preference.

Table 1 | Mean differences in the proposed residence acceptance rate by RCT groups under the free-choice situation

	Mean	No. of respondents	N	Mean difference with Control × Control group
Control × Control	0.388	331	4634	–
Control × Reminder	0.382	330	4620	−0.005 (0.010)
Remote × Control	0.426	342	4788	0.038** (0.010)
Remote × Reminder	0.404	330	4620	0.016* (0.010)

N refers to the total number of choices. Standard errors are in parentheses.
*$p < 0.1$.
**$p < 0.01$.

private car/moped is not favorable for the respondents when making residential choices. In the force choice situation, the preference for a residence accessed by private care/moped is -6.4 p.p. less than the reference category (walking). However, the difference is +3.9 p.p. under the free-choice situation. This indicates that, among individuals who desire to relocate from their current residences, the presence of private car/moped commuting options does not seem to significantly diminish the appeal compared to the force-choice situations.

Effects of remote work option, reminder, and remote plus reminder on the preference to move

We now focus on the results of the RCT matrix, under the free-choice scenario, including the following sub-variants: (i) the control group (control-control), (ii) the reminder of future pandemic occurrences group (*Control-Reminder*), (iii) the remote work option group (*Remote-Control*), and (iv) the remote work plus reminder group (*Remote-Reminder*). The free-choice scenario represents a more realistic situation in which individuals can decide whether or not to remain in their current residence. This aligns with our research objective of examining the tendency for urban dwellers to relocate from their existing residences.

To check the viability of RCT, we conducted a t-test for the sociodemographic variables of each group with the control group. See Supplementary Table 5 for the mean difference outcome. There is no evidence of mean differences between the control group and other treatment groups in household income categories, respondents' age categories, employment status, education level, and the availability of facilities within 15 minutes of walking distance. Yet, we found significant differences in the following aspects: (1) 9.1% more respondents in the *Reminder-Remote* group stay in fully-detached houses compared to the control group, (2) 11.3% more respondents in the *Reminder-Control* group, and 9.7% more respondents in the *Reminder-Remote* group have a shorter commute time compared to *Control-Control* group, (3) in the Reminder-Remote group, a slightly lower percentage of respondents (4.3%) reported changing their transportation mode after the pandemic compared to the Control-Control group, and (4) The proportion of respondents who indicated a personal or familial experience with Covid-19 was 7.4% higher in the Reminder-Control group compared to the control group. These differences may influence the viability of the random assignment. Thus, we include these variables in the related model to control the confounders and exclude them from the discussion in the heterogenous effect subsection.

As part of the RCT, the t-test was conducted to examine the acceptance rate of our proposed residence profile, and the results are presented in Table 1. Compared to the Control-Control group, which had a 38.8% acceptance rate of the proposed residence profile or intention to relocate from their current residence, the Control-Reminder group was indifferent. This suggests that reminders of future pandemic occurrences did not impact the respondents' decision to move from their current residence. However, the Remote-Control group shows a statistically significant 3.8% higher intention to move from their current residences compared to the Control-Control group. Yet, the Remote-Reminder scenario resulted in a slightly smaller increase in the intention to relocate, showing only a 1.6% increase compared to the control group. These findings demonstrate that the availability of remote work options can catalyze individuals to relocate from their current places of residence. On the contrary, informing individuals

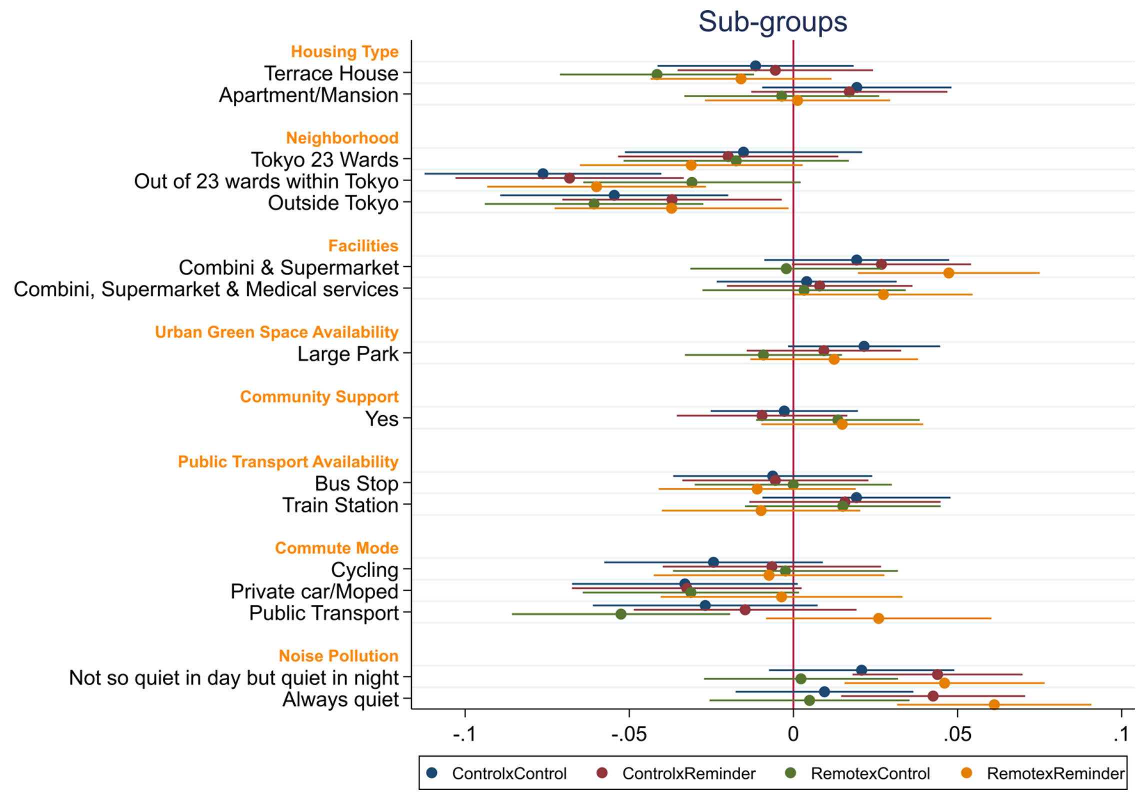

Fig. 4 | The coefficient plot of AMCEs for RCT subgroups. This plot estimates the effects of randomly assigned residence attribute values on the probability of being preferred as a residence in the coming five years by four groups of respondents: Control-Control (blue), Control-Reminder (red), Remote-Control (green), and Remote-Reminder (Orange). Dots represent the coefficients of the OLS with clustered standard errors by respondents. Lines represent 90% confidence intervals. Reference categories are excluded.

about the possibility of another pandemic outbreak does not have a similar effect. The conjoint impact of the increased prevalence of remote work and the potential for future outbreaks of the pandemic results in a positive tendency among individuals to relocate from their current dwellings. This may bring about alterations in population distribution within Tokyo in the foreseeable future. To delve deeper into this matter and gain insight into the regions that individuals prefer, it is imperative to examine the impact of neighborhood attributes closely.

In line with the discussions regarding free-choice and force-choice among all participants, it is also possible to analyze the outcomes pertaining to four distinct groups by breaking them down into AMCEs for each attribute, as shown in Fig. 4. The complete regression results are available in Supplementary Table 6. To account for the non-balanced socio-demographic variables during the RCT, Supplementary Table 7 presents a version that includes these non-balanced covariates as control variables.

No statistical significance is observed in the AMCEs for various residential profile attributes, such as urban green space availability, community support, and public transport availability across all subgroups. The Remote-Control group had a significant negative preference for terrace houses, with a difference of −4.2 p.p. compared to fully detached houses. For other groups, the corresponding values range between −0.6p.p. and −1.6p.p. and are insignificant.

Neighborhood attributes are highly influential in determining residents' preferences. They play a significant role in shaping various outcomes. All samples have similar trends for *Control-Control, Control-Reminder, and Remote-Reminder* groups. There is little difference in preference for residences in Tokyo 23 wards and the Tokyo inner city residences. Residential properties located outside the 23 wards but still within Tokyo are considered the least desirable, with values ranging from −3.1p.p. to −7.6p.p. Similarly, residences outside Tokyo exhibit unfavorable conditions, with values varying from −3.7p.p to −6.1p.p. A distinct trend was observed among participants in the Remote-Control group, whereby their preferences were ranked as follows: Inner city = Tokyo 23 wards > outside the 23 wards but still within Tokyo > outside Tokyo. These findings reveal that even when allowed to work remotely, individuals still prefer to remain in Tokyo, specifically inner city areas or within the Tokyo 23 wards. Conversely, residences outside these boundaries are perceived as less appealing, as evidenced by the negative percentage points (−6.1p.p.). The Control-Reminder group and Remote-Reminder group, which were both given a reminder of the potential re-occurrence of the pandemic, also showed a preference for staying in Tokyo. However, their level of aversion to moving outside Tokyo was lower compared to the remote-control group (with a value of −3.7 p.p. compared to −6.1 p.p.).

The attributes of facility availability only mattered for the *Reminder-Remote* group. The Remote-Control group showed a lower preference for using public transport as their mode of commuting. This can be attributed to the availability of remote work options, which have reduced the need for individuals in this group to travel frequently for work purposes. Consequently, there is a diminished concern about the choice of commute mode among these individuals. This aligns with findings from Oslo, which indicate that individuals who telework frequently tend to have fewer concerns regarding commuting and the proximity of their residence to their workplace[31].

Last but not least, the attributes related to noise pollution impacted both the Control-Reminder and Remote-Reminder groups significantly. Participants in both groups preferred residential areas that were not excessively quiet during the day but became quieter at night, with +4.4 p.p for the Control-Reminder group and +4.6 p.p for the Remote-Reminder group. Similarly, the preference values for a residence that is always quiet are +4.3p.p. and +6.1p.p. for Control-Reminder and Remote-Reminder groups, respectively. Prior research on noise annoyance during the pandemic has indicated that individuals tend to prefer a quieter environment

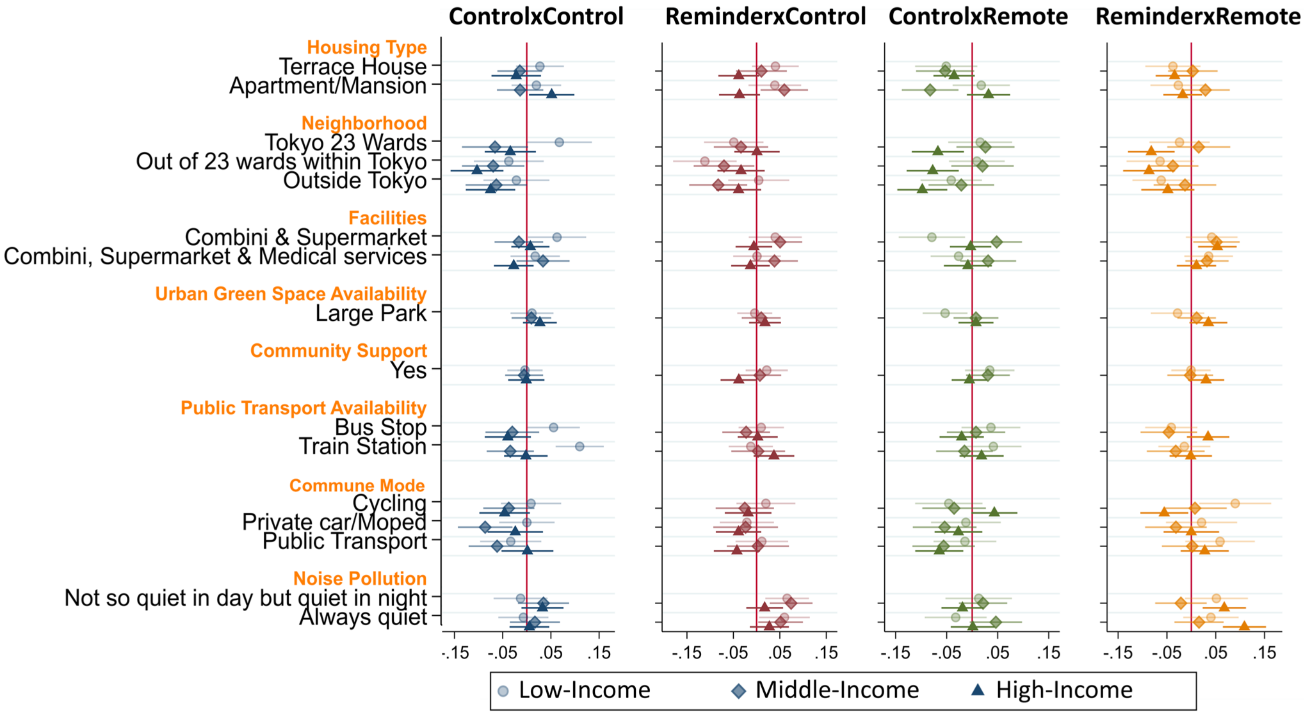

Fig. 5 | The coefficient plot of AMCEs for RCT subgroups and three income groups. This plot visualized the heterogenous effects of randomly assigned residence attribute values on the probability of choosing a specific residence in the coming five years by four groups of respondents [Control-Control (blue), Control-Reminder (red), Remote-Control (green), and Remote-Reminder (Orange)]. These groups were further divided based on income: low-income (<4 mils. represented by round marker), middle-income (4 mils-7 mils. represented by diamond marker), and high-income (>7 mils represented by triangle marker). Markers represent the coefficients of the OLS with clustered standard errors by respondents. Lines represent 90% confidence intervals. Reference categories are excluded. Unbalanced covariates are included as control variables.

and are more easily irritated by noises originating from their surroundings while in lockdown. Consequently, it is common for people to express complaints about these disturbances. Furthermore, studies have found a positive relationship between lower levels of environmental noise and higher satisfaction with one's dwelling[32–34]. Aligned with these findings, when our survey participants were reminded of the possibility of another pandemic, they preferred residential areas with less noise pollution.

However, the Remote-Control group was not inclined to prefer residences with less noise pollution. This could be explained by the fact that before the pandemic, most remote work in Japan was not done from home. Instead, individuals commonly engaged in "mobile" or "satellite" remote work. This involved working from coworking spaces, joint offices, cafes, or other locations outside the traditional office setting. A survey conducted by the Ministry of Internal Affairs and Communications supports this finding[35].

Heterogenous effects of respondent characteristics on the tendency to move

Here, we report the sources of individual-level heterogeneity effects in different subgroups: income, age, and self-reported mental status. Other factors, such as housing tenancy, household size, green space accessibility, and accessibility to medical services, are also examined and documented in Supplementary Figures 2–6.

First, the heterogeneity effect of income groups on the ACMEs of the sub-groups is visualized in Fig. 5. The income groups are divided into three groups based on annual household income: (i) below 4 million yen (approx. $30k USD), (ii) between 4 and 7 million yen (approx. $30k USD–$52k USD), and (iii) above 7 million yen (approx. $52k USD). Important findings based on residential profile attributes are as follows:

(1) Housing Type: High-income groups in both the Control-Control and Control-Remote groups prefer apartment/mansion-style housing rather than fully detached houses. However, when respondents are reminded of the potential for another pandemic outbreak, their preferences regarding housing types shift significantly towards favoring fully detached houses over apartments or mansions. In contrast, the middle-income group showed a distinct preference pattern. When reminded of the pandemic, they favored apartment or mansion-style housing options. Conversely, when presented with remote work opportunities, their preferences shifted toward fully-detached houses.
(2) Neighborhood: Low-income groups in the Control-Control scenario express a higher preference for residences within Tokyo's 23 wards, with a + 6.7 p.p., compared to the inner city. However, their preferences for these wards cease to exist in the Reminder-Control scenario. Additionally, there is no significant difference in this scenario between preferring a residence outside Tokyo versus one within the inner city. For high-income groups, the preference is more significant; they dislike the 'out of 23 wards but still within Tokyo' and 'outside Tokyo' options by -10.3p.p. and -7.5p.p., respectively, under the *Control-Control* scenario. The aversion toward neighborhoods outside Tokyo was further raised to -9.8p.p. with a remote work setting. Nevertheless, the aversion toward these neighborhoods was no longer significant when reminded of the possibility of another pandemic outbreak. In contrast, a combination of remote work and reminder scenarios makes the outside Tokyo option relatively more desirable than 'Tokyo 23 wards' or 'within Tokyo but out of 32 wards'.
(3) Public transport availability: Only low-income individuals in the *Control-Control* group significantly preferred access to bus stops and train stations by +5.6 p.p. and +11p.p. This can be attributed to the limited availability of public transportation in their current residential areas. However, when it comes to the reminder case or the combination case, even low-income groups were indifferent to public transportation availability.

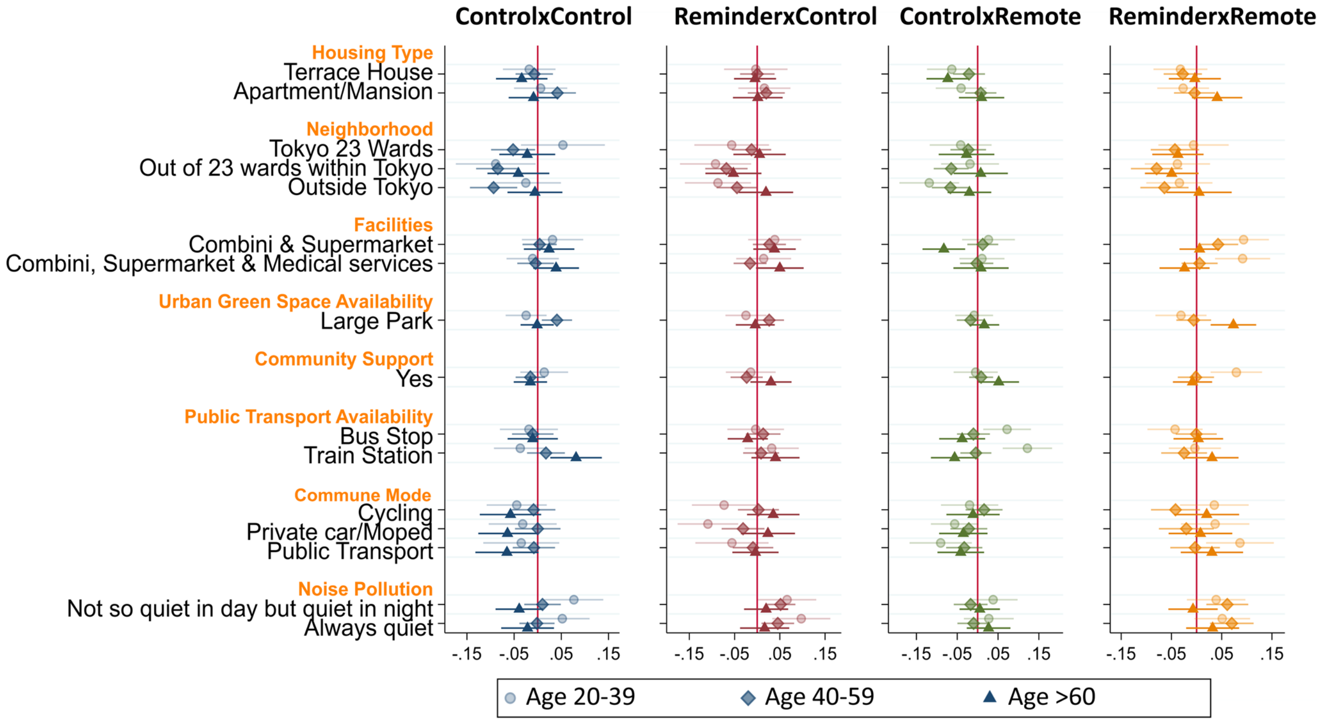

Fig. 6 | The coefficient plot of AMCEs for RCT subgroups and three age groups. This plot visualized the heterogenous effects of randomly assigned residence attribute values on the probability of choosing a specific residence in the coming five years by fourgroups of respondents [Control-Control (blue), Control-Reminder (red), Remote-Control (green), and Remote-Reminder (Orange)]. These groups were further divided based on age: age 20–39, age 40–59 and age > 60. Markers represent the coefficients of the OLS with clustered standard errors by respondents. Lines represent 90% confidence intervals. Reference categories are excluded. Unbalanced covariates are included as control variables.

(4) Commuting mode: Middle-income individuals in the Control-Control group express a significant aversion toward residing in areas where private cars/mopeds and public transportation are the main modes of commuting (-8.6p.p. and -6.1p.p., respectively). However, regarding the reminder or combination scenarios, participants did not exhibit any discernible preferences toward a particular mode of commuting.
(5) Noise pollution: All income groups, except for the high-income Reminder-Remote group, display similar preferences. This group significantly prefers not so quiet during the day but quiet at night or always quiet attributes (+ 6.8p.p. and +10.9p.p., respectively).

Second, the heterogeneity effect of age groups (20–39; 40–59; >60) on the ACMEs of the sub-groups is shown in Fig. 6. Respondents aged>60 were generally less reluctant toward residences outside Tokyo regardless of RCT group assignment. They only care more about the availability of urban green space in the Reminder-Remote scenario. This is inconsistent with the findings of a survey conducted in Korea, which revealed that older individuals have greater apprehension toward urban living after the outbreak of the pandemic and are more inclined to relocate outside cities compared to younger people[25]. Based on our survey, the younger generation aged 20-39 shows significant reluctance (−11.9p.p.) to relocate outside Tokyo when allowed to work remotely. However, their reluctance to relocate decreased when reminded of the possibility of another pandemic. The young generation in the Control-Remote scenario prefers the availability of bus stops and train stations, but not in the other RCT scenario. They also show interest in residences with facilities and community support availability under the Reminder-Remote scenario. Further, they prefer quiet residences in all RCT scenarios except when they are presented with the remote work option.

Finally, the heterogeneity effect of post-pandemic changes in individuals' self-assessment of mental health on the ACMEs of the sub-groups plays an important role in shaping their preferences and choices, as shown in Fig. 7. Respondents who experienced worsened conditions after the onset of the pandemic were more likely to disapprove of residences located outside of the 23 wards, especially when reminded of the re-occurrences of the pandemic. They also positively and significantly preferred residences that are not quiet during the day but quiet at night, especially in the *Reminder-Control* and *Reminder-Remote* scenarios. This suggests that individuals with worsened mental health are more inclined to seek environments with reduced noise levels.

Discussions

In this study, we investigated how the coronavirus pandemic influenced individuals' housing preferences and their inclination to reside in Tokyo. To achieve this objective, we conducted a conjoint experiment where participants were presented with hypothetical residential profiles featuring randomized attributes. In order to assess the effects of the pandemic, reminders of its potential re-occurrence were incorporated within our experimental scenarios. Moreover, as part of our investigation into the impact of remote work on urban outmigration trends, we introduced an additional scenario that included provisions for working remotely.

Our findings show an average 40% preference toward moving from the current residence. Based on our findings, despite being informed about the potential for another pandemic outbreak and having the option to work remotely, people continue to prefer living in Tokyo. We also investigated the variations in residential location preferences within Tokyo's 23 wards', 'outside of Tokyo's 23 wards but still within the city limits', and 'outside Tokyo'. These comparisons were made with reference to living in the five inner-city wards. We found that the pandemic re-occurrence reminder option generally does not influence the preferences compared to control groups, while under the remote scenario and the scenario combining remote working with a reminder of the re-occurrence of the pandemic, the likelihood of relocation increased. However, based on our analysis of the AMCEs for different residence attributes, we discovered that individuals who were provided the option to work remotely strongly disliked residences outside of Tokyo. Further, their opinions remained relatively indifferent

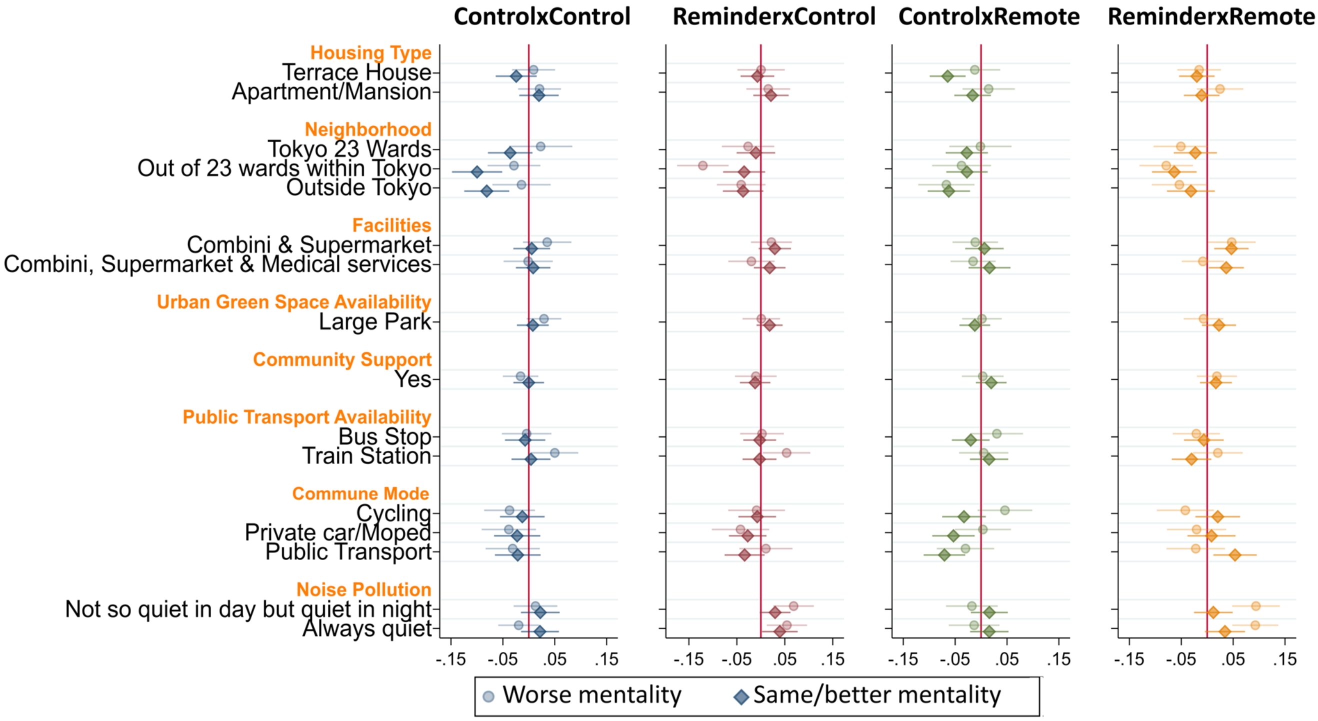

Fig. 7 | Coefficient plot of AMCEs for RCT subgroups and mentality status. This plot visualized the heterogenous effects of randomly assigned residence attribute values on the probability of choosing a specific residence in the coming five years by four groups of respondents [Control-Control (blue), Control-Reminder (red), Remote-Control (green), and Remote-Reminder (Orange)]. These groups were further divided by their self-reported mental status after the pandemic. Markers represent the coefficients of the OLS with clustered standard errors by respondents. Lines represent 90% confidence intervals. Reference categories are excluded. Unbalanced covariates are included as control variables.

regarding residences located within the inner city or Tokyo's 23 wards. These results suggest that, unlike other global cities like London and New York and cities in other parts of the world, which have seen a major decline in their central areas[13,36,37], Tokyo's inner city wards may not be significantly affected. Among other things, this could be explained by the differences between these cities in terms of policies and perceptions toward remote working. Unlike other global cities[36], research shows that remote working remains low in Japan, as Japanese firms prefer working at the office, and the Japanese culture favors collectivist behavior that is more compatible with face-to-face communication[38].

Further, the survey respondents had less preference for public transportation as a mode of commuting and terrace housing. Similar results regarding interest in having a balcony or a terrace have also been reported in Poland[24]. However, different results have been reported in other contexts. For instance, results of a structural equation modeling in Oslo, Norway, show that people have shown more desire for quality outdoor properties such as gardens, terraces, and balconies[31]. This indicates the importance of properly considering context-specific conditions.

Based on their preferences, those reminded about the pandemic re-occurrence tend to strongly dislike residences outside the 23 wards and prefer quieter living environments. The combination of remote work and the potential pandemic recurrence produced similar outcomes, albeit with a reduced aversion towards living outside the 23 wards and an increased preference for more quiet residential areas.

Among the various socio-demographic and pandemic-related variables, it was observed that individuals from higher-income groups were more reluctant to relocate from Tokyo due to remote work opportunities. When combining remote work with the potential of pandemic re-occurrence, high-income households preferred quieter residences. Younger individuals, specifically those aged between 20-29, were more reluctant to reside outside the five inner wards. They prefer housing options that offer improved amenity availability and accessibility. Furthermore, this group tends to hold positive attitudes toward community support. Individuals who exhibited a decline in mental well-being, including those in the control group, displayed a relatively neutral preference toward relocating to areas beyond Tokyo. This suggests they were less resistant to moving away from the city center. In addition, they show greater concern over the noise pollution attributes. This is consistent with results reported in previous research[39]. The differences in housing preferences among various socio-demographic groups indicate that factors such as public health concerns and shifts in employment circumstances have distinct effects on different groups. Similar results have been found in other studies. For instance, in their analysis of the employment characteristics of outmigrants in Stockholm, Vogiazides and Kawalerowicz[9] found that public sector workers (e.g., healthcare workers), those working in other public services (e.g., teachers and police officers), and self-employed people are more likely to leave the Stockholm inner city area to medium-size cities, small cities, and rural areas. Interestingly, they found that the probability of leaving the inner city is less for those categorized as occupations with a higher possibility of teleworking. In many countries, including Japan, the tendency to telework is higher among younger generations that are more educated and have higher ICT skills[40]. Vogiazides and Kawalerowicz[9] also found that people with tertiary education are less likely to move to small cities and rural areas compared to those with primary education. This indicates that teleworking may not necessarily result in urban decline. Elsewhere, in Beijing, China, it was found that the pandemic led to a decrease in the suburbanization of middle-income residents while promoting the suburbanization of high-income residents[41]. Such results implies that implementing blanket policies would not be appropriate, as the impact of the pandemic and external influences varies across demographics.

The key finding is that the allure of Tokyo (particularly inner city wards and areas within the 23 wards) has not diminished following the pandemic, implying a low probability of massive urban outmigration. Reluctance to relocate is particularly strong among younger people. These findings

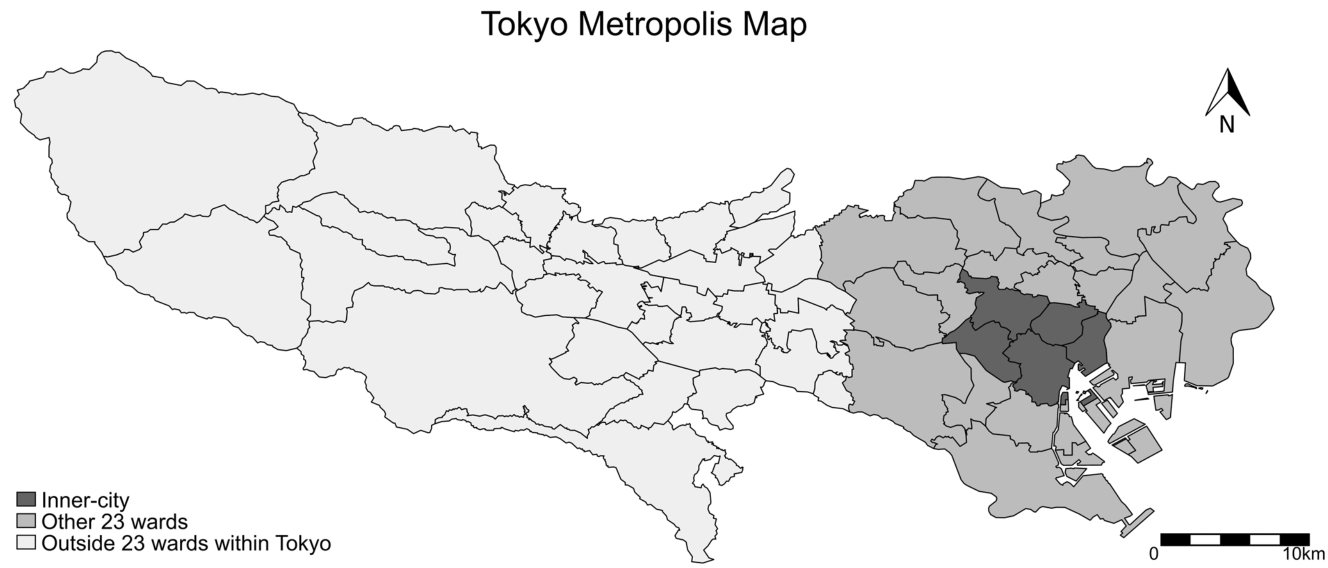

Fig. 8 | The map of Tokyo Metropolis excluding its island regions.

provide promising insights and could alleviate concerns regarding large-scale migration from urban areas, which could lead to unsustainable urban growth patterns[18,42]. It is argued that well-designed compact urban development provides multiple co-benefits for sustainability and resilience by, among other things, facilitating efficient resource management, decreasing energy and travel demand, reducing risk exposure, enabling better emergency response, providing better access to services, and promoting better community support during times of crisis[43–45]. However, the pandemic has shown that proper design measures are needed to achieve optimal levels of compact development that could minimize potential trade-offs that may emerge when making cities more compact[46].

The findings corroborate the assertions of other researchers who predicted that the pandemic would bring about major changes at the micro- and meso-levels. However, it is less probable for the pandemic to exert a substantial influence at the macro-scale by significantly transforming population dynamics and spatial distribution patterns[5,17]. Some scholars have proposed alternative perspectives asserting that cities may experience a decline in their appeal due to various factors. These include the increasing flexibility of employment opportunities, limited availability and affordability of housing, and a growing inclination towards residing in rural regions[7,8].

We argue that further research is required to comprehensively comprehend whether metropolitan areas such as Tokyo will encounter enduring patterns of population decline in the forthcoming years. Although some news sources in 2023 reported that migration trends are reversed as people are moving back to Tokyo, it has also been noted that the trends are yet to return to the pre-pandemic level[47,48]. Thus, it is particularly important to do statistical analysis based on updated population data. Such analysis can address the limitations of relying solely on stated preferences, which may not always align with actual behaviors due to unrealistic hypothetical scenarios or biases resulting from imperfect self-awareness. Moreover, an empirical study based on population data can offer valuable insights into human behavior in real-world settings and its impact on urban dynamics.

Methods

Pandemic in Tokyo

Our study was specifically focused on the Tokyo Metropolis, which includes all areas within its administrative boundary but excludes the island regions. Tokyo Metropolis is a distinct administrative boundary and is different from the Tokyo Metropolitan Area, which is made up of 62 municipalities that can be divided into 23 special wards, 26 cities, 5 towns, and 8 villages. The 'Tokyo Metropolitan Area' or 'Greater Tokyo Area' has different boundaries and can extend up to the surrounding three prefectures (Chiba, Kanagawa, Saitama) or seven prefectures (Chiba, Kanagawa, Saitama, Ibaraki, Tochigi, Gunma, Yamanashi) depending on the context. In the study design, neighborhoods in Tokyo Metropolis were purposively divided into three different groups, which are inner-city neighborhoods, within 23 wards neighborhoods (wards other than the five inner-city wards), and within Tokyo Metropolis but outside 23 wards, as presented in Fig. 8. This division follows the common real estate agents' way of categorizing the area and is familiar to respondents. The inner-city neighborhoods are commonly associated with high land prices and consist of five wards located in the city center: Chiyoda Ward, Chuo Ward, Minato Ward, Shibuya Ward and Shinjuku Ward. Approximately, 70% of the population in Tokyo Metropolis resides in the 23 wards area, which has a total land area of about 627 km^2.

Since the first case of COVID-19 in Tokyo was confirmed on January 24, 2020, there have been eight waves of COVID-19 up until January 2023. During these periods, the population in Tokyo has experienced changes that vary across different neighborhoods, as shown in Fig. 9 together with some major events timeline. Despite the annual seasonal increase observed in April each year due to new job or school enrollments, it is evident that one to two months after each wave (the second, third, fourth, and fifth), the 'other 23 wards' experienced a decrease in total population. This indicates more people moving out than those moving into these neighborhoods. In contrast, there were no noticeable changes in population within the 'inner city' and 'within Tokyo but outside 23 wards'. Prior to the COVID outbreak, all these areas experienced some increase in population not only in April but also during other months. However, this influx has ceased since the pandemic started. This situation raises the question of whether neighborhood location influences the choice of residences. This is another reason for using this categorization in our survey design.

Survey and experiment design

Data for this study was collected through a resident survey. The survey was carried out in Tokyo prefecture, Japan, during two days from June 28th to June 29th, 2022. The respondents were selected from panels affiliated with the marketing company "Rakuten Insight". Rakuten Insight is one of the most well-known online survey companies in Japan, with a large number of panels and a robust system to detect and eliminate fraudulent respondents. Accordingly, various researchers have relied on it for survey data collection[12]. The purpose of the survey was to assess the preferences and tendencies of urban residents regarding potential relocations from their current residences following the pandemic. The survey was conducted after

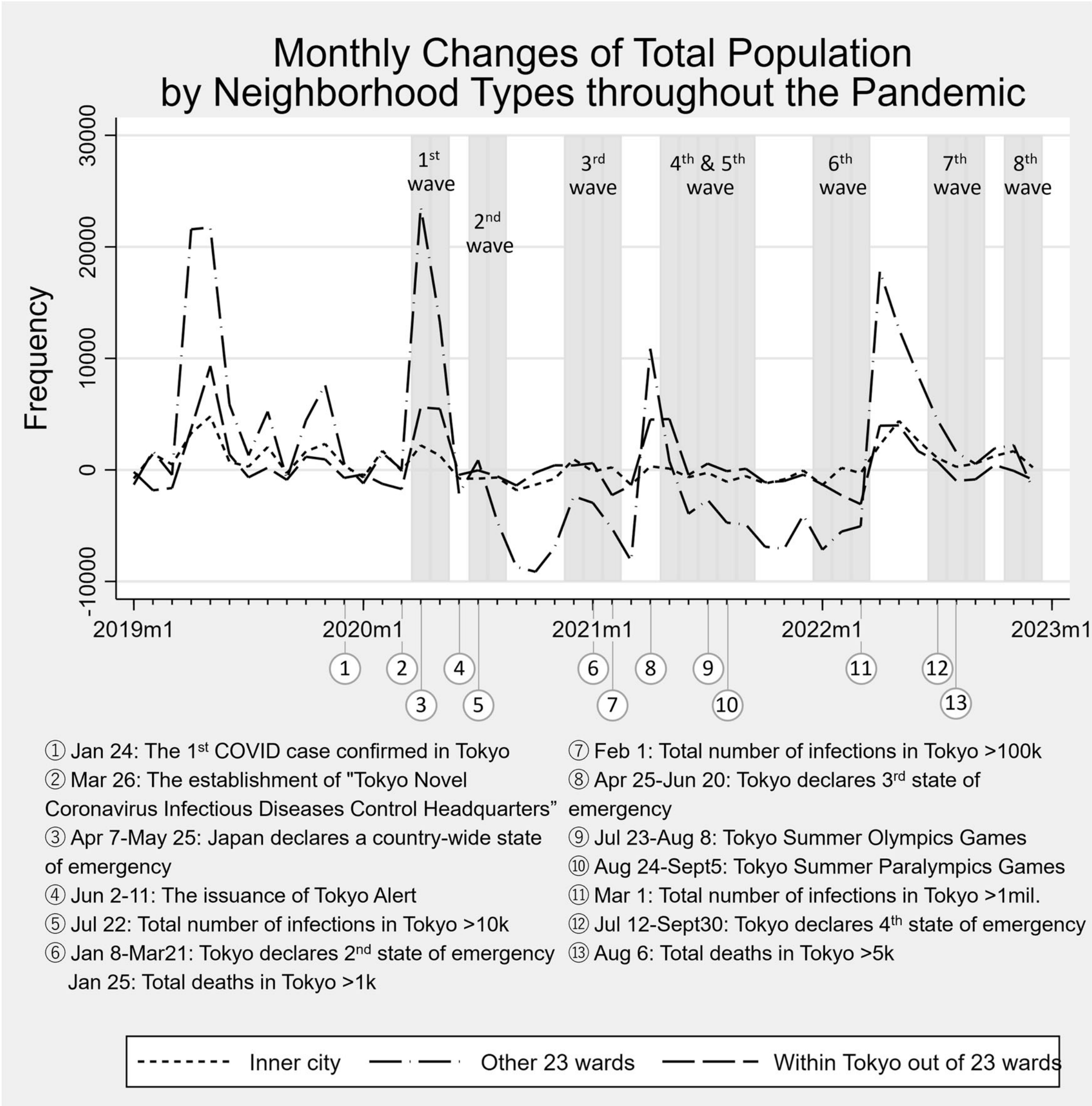

Fig. 9 | Changes in total population compared to the previous month based on different neighborhood types. The overlay of various waves is represented by gray shading. Source: Authors based on data from refs. 53–56.

the Tokyo metropolis experienced a population decline for the first time since data collection began in 1975. According to the Statistics Division of the Bureau of General Affairs, the total population was 13,964,096 as of January 2022, excluding the island regions.

Stratified random sampling was used for survey design. The survey was conducted in Tokyo's 23 wards, with equal weight given to each ward. The area within Tokyo but outside 23 wards, also known as Tama region, located in western Tokyo, was the only area that was weighted twice that of any other area as it includes roughly 30.8% of the population (4,292,955 as of January 2022) and 65% of the total land area (1155 km^2) of Tokyo Metropolis. Random sampling method was employed within each stratum of the survey. A total of 1871 individuals participated in the survey. After excluding those who live outside Tokyo Metropolis (24 individuals), those who did not give their consent to participate in the survey (162 individuals), and respondents with incomplete responses (354 respondents), we obtained a valid sample size of 1333 individuals. This corresponds to a response rate of 71%. See Supplementary Table 1 for the breakdown of respondents by wards. Also, descriptive statistics of the respondents are reported in Supplementary Table 4. The entire process is carried out online using the Qualtrics platform in Japanese.

The survey and experiment can be broken down into two primary components. The first part involves a Randomized Controlled Trial (RCT), which includes presenting participants with a scenario before conducting seven sets of conjoint experiments. The second part consists of questions related to socio-demographic factors and experiences during the pandemic.

After obtaining consent, each participant was randomly assigned to one of four groups based on a 2 × 2 matrix design. To compare with the control group, the two treatments used in the study were "Reminder" and "Remote," resulting in the following distinct groups of respondents: Control-Control, Reminder-Control, Control-Remote, and Reminder-Remote. Supplementary Table 3 provides a detailed breakdown of participants by each group.

In each set of conjoint experiments, participants were asked to prioritize their preferred choice between two potential residential options that differed in certain attributes (see Supplementary Table 2). They were also given the option to remain at their current residence within the next five years, assuming that the price would be similar or fall within an affordable budget range. The conjoint experiment is suitable for our research because it can capture the multidimensional nature of housing and moving decisions. This approach recognizes that finding an ideal living situation takes time, as individuals need to carefully reflect on their options before deciding on relocating. This experiment aims to assess individual preferences by measuring the importance of various issues, such as the different housing attributes and identifying any associations between them, an individual's existing housing characteristics, and demographic factors.

The 'reminder' treatment presents respondents with a concise paragraph indicating that the likelihood of encountering a pandemic similar to COVID-19 could increase twofold in the upcoming decades. This information is supported by references from an academic article by Marani, et al.[49] published in PNAS and a Japanese news article titled "How often will a large-scale pandemic occur in the future?"(大規模パンデミック、今後の発生頻度は? in Japanese)[50]. The 'reminder' treatment aims to allow exploring the impact of the pandemic and refresh respondents' memory about the recurring nature of the pandemic prior to engaging in the choice experiment. It is crucial to acknowledge that a comparison between the 'reminder' treatment and control groups does not reveal the impact of the pandemic on housing choice. This is because all our survey participants experienced the effects of the pandemic. Instead, this comparison highlights how reinforcing experiences related to the pandemic by reminding individuals can influence their decisions regarding residential choice.

In the 'remote' treatment, participants were presented with a scenario where their workplace offered an extensive remote working option. This was in contrast to the control group scenario, which emphasized office-based work. The 'remote' treatment identifies two distinct categories of company policies regarding work style. This is an important consideration for respondents when deciding where to live in the next five years. According to a survey conducted by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in Japan, approximately 27.15% of self-employed or employed workers engaged in remote work in 2021[51]. This underscores the fact that numerous companies have not adapted or are hesitant to permit remote work. However, it provides a rationale for incorporating the 'remote' work alternative in our experimental design. Additionally, having a distinct 'remote' option enables us to disentangle the impact of broader trends toward remote work from the specific effects stemming from remembering pandemic experiences.

Respondents are presented with two residence profiles that include eight attributes during each of the seven choice experiments. These attributes encompass neighborhood type, housing type, access to public transportation, access to amenities, access to open/green spaces, mode of transport to the office, strength of community network and social supports, and noise levels. The design ensures that all eight attributes and their respective levels align with the factors individuals consider when selecting a post-pandemic housing option.

Following Hainmueller, et al.[52], the attributes of different residence profiles are randomly chosen from a predetermined set of levels. Each attribute has various levels that represent specific characteristics. For instance, the first attribute is neighborhood types, which includes four levels: inner city (with 5 wards), 23 wards within Tokyo, outside 23 wards but within Tokyo, and outside Tokyo. The inner city refers to Chiyoda, Chuo, Minato, Shibuya, and Shinjuku. Different population densities at each level of the first attribute may influence individuals' housing choices concerning pandemic risk. Supplementary Table 2 shows the complete list of attributes and their corresponding levels.

By multiplying the number of levels for each attribute (i.e., $3 \times 4 \times 3 \times 2 \times 2 \times 3 \times 4 \times 3$), we obtain a total of 5,184 potential residential profiles. As a combination of "No" "public transportation accessibility" and "commuting" by "public transport" does not make sense, we removed profiles with that combination, resulting in 4,752 possible residence profiles. Having each of the 1333 respondents answer seven choice experiments yields 18,662 different profiles.

To mitigate the influence of attribute sequences, the system randomly determines the presentation of attributes in each choice experiment for every respondent. However, it should be noted that the sequence of attributes remains consistent across all seven sets of choice experiments for each respondent. An illustration of a representative choice set can be found in Supplementary Fig. 1.

Identification strategies

The groups can be labeled as G_1 to G_4, representing 'Control – control', 'Reminder – control', 'Control – Remote', and 'Reminder – Remote', respectively. Let subscript i be the respondent, j be the choice set $\in\{1, 2, 3, 4, 5, 6, 7\}v$ and $y_{ij} \in \{0, 1\}$ be the binary choice variable that represents the likelihood that an individual would prefer to relocate to a new residence offered. In other words, y_{ij} represents the choice of individual i in their choice set j.

The causal effect of Reminder, Remote, and Remote plus Reminder treatments can be expressed as the difference in the mean values in the groups for individuals' preference to relocate to a new residence (Eq. 1):

$$E[y_{ij}] = E\left[y_{ij}\middle|G_z\right] - E\left[y_{ij}\middle|G_1\right] \tag{1}$$

Where $z\in \{2, 3, 4\}$. To compute the heterogeneity in the response of individuals to different attributes based on the group they are being allocated, we follow Hainmueller et al.[52]'s analytical model in estimating the respondent's preference for moving to the proposed residence, which is known as the Average Marginal Component Effect (AMCE). The simple AMCE regression model is as follows (Eq. 2):

$$y_{ijkt} = \beta_{k0} + \sum\nolimits_{l=1}^{L}\sum\nolimits_{d=2}^{Dl}\beta_{ldk}\alpha_{itjld} + \mu_{ijkt} \tag{2}$$

Where β_{ldk} is the coefficient of interest that indicates the AMCEs of attribute l with level d in case of $k \in \{free_{choice}, force_{choice}\}$. Also, α_{itjld} is the dummy variable for d-th level of attribute l of profile $t \in \{A, B\}$ in the choice set j of respondent i. L indicates the number of attributes, Dl indicates the number of levels of attributes l, and μ_{ijkt} is the clustered standard error at the respondent level. For k= free_choice, y_{ijkt} takes a value of 1 when profile t in choice set j is preferred over current housing. For k = force-choice, y_{ijkt} takes a value of 1 when profile t in choice set j is preferred over the other profile $\widetilde{t} \neq t, \widetilde{t} \in \{A, B\}$.

In a direct way, β_{ldk} or AMCE captures the marginal effects of having an attribute with a certain level on the probability of the respondents preferring the residences offered. In our context, we first run the model for free-choice and force-choice situations as outlined by the model above to compare their AMCEs.

After that, we fix k = free-choice, and add one more subscript of $z \in \{1, 2, 3, 4\}$ for each sub-group of RCT assignment, G_z. The impact of RCT assignment on the heterogeneity differences by assignment of G_z can be computed by taking into account the difference in means of AMCE conditions to G_1 with other G_z status. For instance, from the AMCE equation above, our interest can be expressed as follows (Eq. 3):

$$E[y_{ijkt}] = E\left[y_{ijkt}\middle|G_z\right] - E\left[y_{ijkt}\middle|G_1\right] \tag{3}$$

However, instead of these direct differences, we report all the subgroup AMCEs using a coefficient plot to visualize the difference between subgroups better.

Furthermore, we introduced a subscript h to the model which encompasses all categories related to socio-demographic and pandemic-related variables. This was done in order to analyze the impact of individual-level heterogeneity effects. For example, in the age group case, we introduced $h \in \{1, 2, 3\}$ which refers to three age groups: 20–39, 40–59, and >60. Similarly, the outcomes are visualized with a coefficient plot.

Reporting summary

Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability

All codes used to process the data are available from the authors upon request.

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Author contributions

A.S: Conceptualization, methodology, writing-original draft, writing-reviewing, and editing; C.Y.L: Conceptualization, methodology, data analysis, writing-original draft, writing-reviewing, and editing.

Competing interests

The authors declare no competing interests.

Ethics

We have complied with all relevant ethical regulations and guidelines provided by the Research Ethics Review Board of the Graduate School of Humanities and Social Sciences, Hiroshima University.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s42949-024-00151-2.

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