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Unit Nonresponse in a Dwelling Panel Study – The Role of Residents' and Housing Characteristics

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Abstract

Assessing the reasons behind nonresponse is essential in survey research. In this paper, we investigate unit nonresponse in a dwelling panel (Cologne Dwelling Panel, five waves between 2010 and 2022), in which dwellings constitute the sampling units. One resident of each dwelling is interviewed in each panel wave. Using information from previous panel waves, we model an individual's propensity for nonresponse by applying multinomial logistic regression, with socio-demographic information and indicators of satisfaction with their current housing situation and the neighborhood as predictors. Further, we assess whether there is systematic attrition at the dwelling level. We find that when respondents express greater satisfaction with their current housing situation, nonresponse is reduced at the individual level, while smaller apartments and a more heterogeneous and deprived neighborhood are indicative of higher nonresponse on the level of dwellings.

Keywords: nonresponse, panel, area-based sampling, attrition, dwelling panel

Unit nonresponse is a prominent problem in survey research. A high nonresponse rate may endanger the generalizability of results, as it undermines probability-based statistical inference, as well as potentially introducing nonresponse bias in survey estimates (Peytchev, 2013). While survey researchers have been assessing the mechanisms and predictors of nonresponse since the beginning of probability sampling (Hansen & Hurwitz, 1946), in recent years falling response rates have aggravated the need for analyses (Daikeler et al., 2020; Wolf et al., 2021). Particularly in cross-sectional surveys, assessing predictors for unit nonresponse can be challenging, as there is usually little information on nonrespondents (Vandenplas et al., 2015). In longitudinal surveys, the problem of unit nonresponse is twofold: Both initial nonresponse at the beginning of the survey as well as dropout in later waves can threaten the validity of results (de Leeuw & Lugtig, 2014). Nonresponse in later waves of longitudinal surveys is a complex phenomenon that is influenced both by respondents' characteristics and by fieldwork strategies (Lepkowski & Couper, 2002). Nevertheless, the availability of information from at least one earlier wave allows for the assessment of predictors of nonresponse that go beyond mere sample demographics.

In this paper, we aim to contribute to the literature by examining characteristics of unit nonresponse in a dwelling panel, where dwellings constitute the primary sampling units. One resident of each dwelling in the sample is interviewed in each panel wave, making individuals in dwellings the secondary sampling units. Our data source, the Cologne Dwelling Panel, is a study specifically designed to observe small-scale neighborhood changes in the context of gentrification processes (Blasius & Barth, 2025; Friedrichs & Blasius, 2015). The interviewed persons supply information on (1) dwelling characteristics (size, rental costs, facilities) and changes (e.g., renovation or modernization works), (2) the persons residing in the apartment or house (e.g., number of adults and children, household income, reasons for moving in), and (3) their individual attitudes (e.g., perceptions of the neighborhood, satisfaction with housing situation, expected changes in the neighborhood).

When the entire household moves out (and another one moves in), a new inhabitant of the same dwelling is invited to be interviewed in the following wave. By

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collecting data on both dwellings and their residents, the panel enables, on the one hand, longitudinal analyses at the dwelling level (e.g., rental price dynamics; Barth & Blasius, 2023) or patterns of residential mobility within apartments. On the other hand, individual-level data can be used to study socio-structural change in the research areas (Blasius & Friedrichs, 2019), residents' attitudes towards their neighborhood and its development (Atakan & Barth, 2024), and to compare the lifestyle characteristics of long-term residents and new in-movers (Leßke & Blasius, 2021).

In the Cologne Dwelling Panel, the use of dwellings as primary sampling units means that persons and households who move out of a sample dwelling are not followed, which puts certain limits on analyses of intra-individual change. The focus on two residential neighborhoods in Cologne enables detailed analyses of change within small areas, as well as the assessment of systematic variation in the perception of the same physical space by different groups of residents (Atakan & Barth, 2024). At the same time, the spatial compactness of the study area limits the potential to combine survey data with geo-referenced and administrative data from other sources, as there is little to no variation between the units (dwellings and residents of dwellings) with regard to the characteristics of their surroundings (e.g., the ethnic heterogeneity of the neighborhood or distance to local amenities). In terms of fieldwork, a study in two contiguous neighborhoods is ideally suited for face-to-face interviews, as interviewers do not need to cover large distances.

For the assessment of variables associated with unit nonresponse, the specific structure of the dwelling panel has important implications:

1. The decision to participate in the survey is made by individuals. We thus model the propensity for nonresponse on the individual level based on information from the previous wave. The dwelling panel structure means that respondents from Wave t-1 can have the states "participation", "noncontact", and "refusal", but also "moved out" in Wave t; by design, outmovers are not followed.

2. The use of dwellings within a pre-defined area as primary sampling units means that changes in the sample prevalence of socio-structural characteristics are not necessarily evidence for bias. On the contrary, from the state of research on gentrification it is expected that, for example, young, highly educated persons are comparatively likely to move into the neighborhoods and thus become part of the panel.

3. An assessment of potential attrition bias must include the dwelling level, as dwellings are the primary sampling unit. If dwelling characteristics such as size or location are significant predictors of unit nonresponse in later panel waves, this might compromise the panel's ability to unbiasedly depict socio-structural change in a specific area.

Consequently, we look at unit nonresponse in the dwelling panel from two perspectives: individuals and dwellings. For both analyses, we apply multinomial logistic regression to wave-to-wave transitions, predicting an individual's and a dwelling's response status in Wave t from information in Wave t-1 (cf. Nicoletti & Peracchi, 2005; Watson & Wooden, 2009)[1].

Estimating individuals' response status in the subsequent wave based on socio-demographic and housing-related variables in the preceding one contributes to the state of research on unit nonresponse in panel surveys. In addition, we assess whether there are dwelling characteristics that are related to data availability for the primary sampling unit in later panel waves, thereby enabling conclusions on potential attrition bias in each neighborhood's sample of dwellings. The special feature of the analysis on the level of dwellings is that the impact of household moves as well as dwelling size and location on the propensity of future survey participation is estimated, which can be informative for researchers conducting similar regional analyses or area-based sampling.

Previous Findings on Nonresponse in Longitudinal Surveys

Building on a general theory of survey participation by Groves and Couper (1998), Lepkowski and Couper (2002) propose a framework of the potential reasons for unit nonresponse in the second wave of longitudinal household surveys: non-location, non-contact, and refusal to cooperate. The idea is that these three processes, all of which entail nonresponse, operate according to different mechanisms and should, therefore, be regarded separately. In the following, we elaborate on the state of research for each nonresponse category and discuss how the concepts can be transmitted to a dwelling panel, differentiating between dwellings as the primary sampling units and current residents as the secondary sampling units. While the concept of defining dwellings as primary sampling units bears resemblance to panel surveys of establishments or businesses, the decision to take part in the dwelling panel survey is more comparable to participating in longitudinal household surveys (König & Sakshaug, 2023; Willimack & Nichols, 2010).

[1] While many studies on unit-nonresponse and attrition in person or household panels distinguish between temporary dropout (research units only miss one or more waves) and attrition (research units leave the panel permanently), this distinction is not uniformly applicable to a dwelling panel. Considering the integration of new residents by design, dropouts of dwellings are only temporary, as one household's permanent attrition may end once a new household has moved in. For this reason, we do not distinguish between temporary and permanent dropouts, but look at wave-to-wave-transitions.

Non-Location

In household panel surveys, non-location occurs when the contact details of sample members change between waves, often due to an individual (or the entire household) moving. The probability of losses due to non-location thus depends on the one hand on sample members' residential mobility (Minderop & Weiß, 2022; Washbrook et al., 2014) and, on the other, on the time intervals between waves and the survey organization's efforts in tracking sample members (Uhrig, 2008). As buildings cannot change their location, non-location of primary sample units is functionally impossible in a dwelling panel: The rare cases in which dwellings genuinely cannot be located in a subsequent wave due to demolition or conversion (e.g., into commercial space) are counted as "out of sample" (see below). The location of secondary sampling units is dependent on their status as current residents of the primary sampling unit—even those dwellings where the name of the current resident cannot be determined before fieldwork begins are visited by interviewers, who then encourage the current residents to participate in the survey. In summary, there are no specific nonresponse mechanisms pertaining to the category "non-location" in our case study.

Non-Contact

Once a panel sample member has been (re-)located, they can be asked to participate. For this, a contact must occur between the survey organization or interviewer and the prospective respondent. In a dwelling panel, the realization of an interview is contingent on making contact with an eligible secondary sampling unit (i.e., a current resident of the dwelling). As such, the likelihood of (non)-contact is—as is usual in face-to-face-surveys taking place at a respondent's current residence—dependent on the respondents' patterns of being physically present at home, the absence of possible impediments (e.g., a broken doorbell, a threatening dog), and the interviewers' efforts regarding the number of visits and attempts at different times of the day or the week (Groves & Couper, 1998; Uhrig, 2008). Households with young children or elderly adults are easier to contact, as someone tends to be home more often (Groves & Couper, 1998; Nicoletti & Peracchi, 2005). The same is argued for larger household sizes (de Leeuw & de Heer, 2002; Nicoletti & Peracchi, 2005), as well as for people living longer at their current address (Nicoletti & Peracchi, 2005) and homeowners as compared to renters (Nicoletti & Peracchi, 2005; Rothenbühler & Voorpostel, 2016; Uhrig, 2008).

Refusal

Similar to non-contact, the decision to refuse participation is not attributable to the dwelling, but to its residents. Therefore, we draw on findings from panel

surveys with persons to assess characteristics that may predict an individual's refusal in the subsequent wave. Research shows that active refusals comprise the largest share of non-respondents in panel surveys (Behr et al., 2005; Haunberger, 2011; Lipps, 2009). At the same time, the propensity to refuse decreases over time, as respondents who agreed to be interviewed before are more likely to participate in a subsequent wave (Nicoletti & Peracchi, 2005). Research results on socio-demographic predictors of refusal in panel surveys are, for the most part, inconclusive (Haunberger, 2011). Some studies show that men refuse to participate more often than women (Behr et al., 2005; Rothenbühler & Voorpostel, 2016), while others find no gender effects (Lugtig, 2014). Several studies find that older participants are more likely to refuse (Lipps, 2009; Uhrig, 2008), but others point to a possible u-shaped effect of age, in which refusal probability decreases with age until a minimum is reached, after which it increases again (Rothenbühler & Voorpostel, 2016). Uhrig (2008) reports that respondents with small children and socially highly active persons had a high probability of participation, whereas in a study by Rothenbühler & Voorpostel (2016), having children was associated with a higher likelihood of refusal. Lipps (2009) reports that larger households are less likely to refuse cooperation, but could only find this effect in one of three analyzed panel studies. Additionally, home ownership has been shown to lead to a higher refusal probability (Rothenbühler & Voorpostel, 2016), while frequent contact with neighbors lowers it (Nicoletti & Peracchi, 2005). Quite unanimously, though, higher educational attainment is associated with lower refusal rates (Rothenbühler & Voorpostel, 2016; Satherley et al., 2015). In addition, Lepkowski and Couper (2002) argue that respondents with high attachment to their community and satisfaction with their home are more cooperative towards survey requests. Refusal can also be attributed to respondent satisfaction, as the survey experience (e.g., problems in the interaction between respondent and interviewer, or a badly designed survey) can successfully predict attrition in later waves (Gummer & Daikeler, 2020; Lugtig, 2014; Struminskaya, 2014). While there are no direct indicators for survey satisfaction available in the dwelling panel, we assume that participation in a survey which focuses on dwelling and neighborhood characteristics is more pleasant for residents who are satisfied with their current housing situation, and thus test for the effect of satisfaction with the current housing situation.

Out of Sample/Moved Out

The question of sample units that become ineligible for the panel survey is not explicitly treated in the framework of Lepkowski and Couper (2002), but they mention the exclusion of respondents who died between waves. In the case of dwellings, the equivalent of death is when residential buildings are demolished, transformed into non-residential space, or completely rebuilt in such a way that

the original apartments are no longer identifiable and possibly not comparable to the original units. These events, which are relatively rare (see the "Data" section), are treated as "out of sample", meaning that these cases are excluded from the analysis. For individual residents in the dwelling panel, moving out of the sampled dwelling means that they automatically drop out of the panel, as outmoving individuals and households are not followed in the design of our dwelling panel study. Therefore, "moved out" is used as a separate category when assessing the response status of individuals in the panel. The likelihood of a move is associated with respondents' and household characteristics, that is, age, residential status (renter or homeowner), household stability, and life course events such as a new job or the birth of a child (Clark & Huang, 2003). Higher educational attainment has also been shown to increase residential mobility (Causa & Pichelmann, 2020). Context-related factors such as neighborhood attachment, perceived collective efficacy in the neighborhood, or perceived social disorder also play a role in households' decisions to move (Coulton et al., 2012; Sharp & Warner, 2018; Uhrig, 2008).

Hypotheses on Individuals' Nonresponse

As argued above, we conduct separate analyses for individuals (secondary sampling units) and dwellings (primary sampling units), while acknowledging that there are mutual interdependencies. To assess the unit nonresponse of individuals in longitudinal surveys, we can draw on the wealth of results from studies that analyze nonresponse in panels of households and persons. We adapt the framework proposed by Lepkowski and Couper (2002) to our circumstances: In the following analysis, the dependent variable "response status" has the categories "participation", "non-contact", "refusal", and "moved out", with the latter replacing "non-location", which is not applicable to individuals in the dwelling panel.

Thus taking the current state of research into consideration, we develop the following hypotheses concerning the different nonresponse statuses:

1. **Hypotheses on moving status**

   1.1 Younger respondents are more likely to move out.

   1.2 Respondents with higher educational attainment are more likely to move out.

   1.3 The higher respondents' satisfaction with their current housing situation, the lower their propensity to move out.

   1.4 A higher level of perceived collective efficacy in the neighborhood lowers the propensity to move out.

1.5 Renters are more likely to move out than homeowners.

2. Non-contact hypotheses

2.1 Respondents with children in the household have a lower probability of non-contact.

2.2 There is a u-shaped relationship between age and non-contact: Compared to younger and elderly respondents, middle-aged respondents have a higher probability of non-contact.

2.3 Larger households have a lower probability of non-contact.

2.4 Homeowners have a lower probability of non-contact.

2.5 Living at the current address for longer lowers the probability of non-contact.

3. Refusal hypotheses

Given the varying results from earlier studies, we test the effect of *gender, household size,* and *presence of children (up to 14 years old) in the household* without formulating directional hypotheses. Based on previous studies, we assume that

3.1 Increasing age increases the probability of refusal.

3.2 Higher educational attainment lowers the probability of refusal.

3.3 Homeowners have a higher probability of refusal.

3.4 Those with lower satisfaction with their current housing situation are more likely to refuse to participate.

3.5 Lower perceived collective efficacy in the neighborhood leads to a higher propensity to refuse.

Finally, we control for previous participation status, as we assume that:

3.6 The more frequently a respondent has already participated in the survey, the lower the probability of refusal.

Effects of Nonresponse in the Dwelling Sample

While the results of the analyses on the individual level allow for conclusions regarding residents' nonresponse mechanisms, they only have limited informative value for the evaluation of possible bias in the case of a dwelling panel. Given that the correct depiction of population change in a certain area depends on an unbiased dwelling sample, it should be examined whether there is *selective*

unit nonresponse *on the level of the dwellings*. Therefore, in the second part of the analysis, we use features related to both dwellings and neighborhoods to predict the probability of data being collected in a dwelling in subsequent waves.

In particular, we assess the effects of household change (when a new household moved in between waves), apartment size, and location (dummy variable: whether an apartment is located in the districts Deutz or Mülheim of the city of Cologne) on the dwelling's probability of participation in subsequent waves. These effects can be interpreted in two ways: Methodologically, they can be used to assess whether nonresponse in the dwelling sample is systematic, implying possible bias. Conceptually, it needs to be considered that, even when the focus is shifted to the dwelling level, the actual decision to participate still takes place at the level of individual respondents. As such, dwelling size can be interpreted as a proxy for household size, with smaller households lowering the likelihood of a residents' availability to be surveyed (de Leeuw & de Heer, 2002; Nicoletti & Peracchi, 2005). The dwellings' location is indicative of both contextual and socio-structural composition effects, which have been shown to influence the nonresponse rate in face-to-face-surveys (Brick & Williams, 2013). Couper and Groves (1996) argue that survey cooperation is lower in "urban, densely populated, high crime rate areas". The two districts in our study differ, for example, in terms of social heterogeneity and the share of residents receiving welfare benefits (see data section for more details on the neighborhoods).

From the literature on panel nonresponse, we expect the likelihood of participation to be higher in dwellings where residents stayed the same, as there has been at least one successful interview, and familiarity with study procedures has been established. If this is true, however, long-term residents might become over-represented over time, leading to an underestimation of socio-structural change in the research area.

Taking into account that the decision to take part in the survey is made by the individuals, we differentiate between the outcomes "participation", "non-contact", and "refusal" in the case of dwellings. While the response "non-contact" and "refusal" both result in missing data for the dwelling, we are interested in the question as to whether the probability of these two statuses differs between staying and new households. Significant differences could inform fieldwork practice; if new households are more likely to refuse, for instance, interviewers that are particularly adept at refusal conversion could be allocated to these dwellings. The state of research regarding dwelling-level effects is not as advanced as the one regarding individual mechanisms, but still, we formulate assumptions regarding the direction of effects:

4. Non-contact hypotheses

4.1 Smaller dwellings have a higher probability of non-contact.

4.2 In an area with higher socio-economic status, the propensity for non-contact is lower.

5. Refusal hypotheses

5.1 Dwellings where residents stayed the same have a lower propensity for refusal.

5.2 In an area with higher socio-economic status, the propensity for refusal is lower.

Data and Methods

Data

Beginning in 2010, the Cologne Dwelling Panel was designed to measure neighborhood change in urban residential areas where gentrification processes are expected to take place (Blasius & Barth, 2025; Friedrichs & Blasius, 2015, 2020). To this end, dwellings (mostly apartments) were defined as the primary sampling units that are followed over the panel waves. Within each dwelling, one inhabitant is interviewed, making one individual resident per dwelling the secondary sampling unit. In the case of household moves, a new resident of the same dwelling is approached and asked to participate in the study[2]. The main idea behind this design is the dwelling panel's capacity to assess socio-structural change in specific research areas by tracing individual moves in and out of the area, as well as intra-individual attitude change in residents (as opposed to using data aggregated on a higher level, or repeated cross-sectional surveys). The panel design using dwellings in specified neighborhoods or districts as primary sampling units and dwellings' residents as secondary sampling units, is—to our knowledge—unique. Other studies assessing neighborhood change define individuals or households as sampling units (e.g., Mood, 2010; Moore et al., 2016; Schnake-Mahl et al., 2020), albeit an interviewer may visit the same address and interview the current occupants, regardless of tenant change (Coulton et al., 2012). Usually, studies assessing neighborhood change do not focus on a small number of predefined areas, but instead use geo-coded data from general population surveys, often in combination with aggregate spatial data (e.g., Freeman et al., 2016; Hirsch et al., 2016; Sui et al., 2023).

The Cologne Dwelling Panel focuses on two residential neighborhoods in Cologne. The research areas were initially chosen based on their location close to the city center, the characteristics of their buildings (predominantly residential buildings built around 1900), and the social structure (predominantly work-

[2] There are few cases in which the entire household has not moved out, but the previous individual respondent is not available anymore, e.g., because they moved out separately, are chronically ill, or are absent for the entire fieldwork period. In these cases, another household member is asked to respond.

ing and lower middle class at the beginning of the study), as the combination of these characteristics suggests a high susceptibility to gentrification processes (Hamnett, 1991). Despite these shared features, the districts in which the two neighborhoods are located also differ in some respects: Traditionally, and from the beginning of the study in 2010, Deutz has had a comparatively low share of both welfare recipients (7.2% in 2022) and residents of foreign nationality (18.9%; 35.1% of residents with any migration background in 2022). Mülheim, in contrast, is a more socially deprived and ethnically heterogeneous district, with almost a quarter of residents receiving welfare benefits in 2022 and a strong ethnic mix (33.6% with foreign nationality and 56.1% with any migration background; Leßke & Blasius, 2021; Stadt Köln, 2023).

Due to the non-availability of a comprehensive grid of dwellings in the selected research areas, the first wave of the Cologne Dwelling Panel started with an address-based random sampling of individuals ($N = 2{,}372$). Names and addresses of current residents in the selected areas were obtained from the Cologne Office for Urban Development and Statistics.

From the net sample of 2,209 persons[3], 18.5% could not be contacted, and 35.9% refused to be interviewed, resulting in a response rate of 45.7%, or 1,009 completed face-to-face interviews, during the first wave's field period in June to October 2010. During the first wave, interviewers noted the dwelling's address, as well as the position of each respondent's name on the respective housing unit's bell-board in multi-family buildings: The bell-board, which can usually be found next to the entrance of a residential building, lists the names of residents, with an individual bell-button for each apartment. In the case of multi-family buildings, a specific apartment's location was documented by noting its position on the bell-board, so that the exact dwelling could be found again in subsequent waves.

Subsequently, the dwellings (address, apartment location within housing unit) were recorded as the primary sample units and re-approached for each new wave of data collection. The 1,009 dwellings "interviewed" in Wave 1 henceforth constituted the sample for Waves 2 (2011), 3 (2013), and 4 (2014). Data for the fifth wave was collected, after a prolonged hiatus, from June to December 2022. Response rates based on the original sample of 1,009 dwellings are displayed in Table 1. Here, we differentiate between staying households and new households; in staying households, the same person as in the last wave was approached for an interview, while in households that newly moved in, one new eligible household member was asked to participate. In a few cases (fewer than 15 dwellings per wave), only the target person moved out, but not the entire household; here, a new target person was approached by the interviewer. These dwellings are counted as staying households in Table 1.

[3] In cases where two or more sampled persons belonged to the same household, only one resident per dwelling was kept in the sample; the others count as neutral loss.

Between each wave of Waves 1 to 4, between 11–16% of households moved. Moves were primarily identified by on-site inspections of the names on the bell-boards of all dwellings in the sample prior to each wave's field period. In the case of participation, respondents' information, such as when they moved in, was compared against the records of the previous wave. While Waves 1 to 4 were conducted in approximately one-year intervals between 2010 and 2015, in 2022 on-site inspections of all buildings in the sample—carried out before the interview fieldwork—revealed that household moves had occurred in more than half of the sample. In addition, 56 dwellings went out of sample, as the respective buildings had been demolished or transformed into office space, a hotel, or business facilities[4].

Refusals comprise all individual residents who were personally contacted by an interviewer and explicitly declined to participate, mainly due to lack of interest or time. "Non-contact" are those dwellings where interviewers were not able to contact a current resident (on average, eight to ten contact attempts were made at different times and days of the week) or where residents were reached, but not able to participate in the survey due to illness, language barriers, or other reasons[5]. If possible, interviewers were instructed to try to contact a proxy respondent residing in the same dwelling if the initial target person was not available for an interview. In Table 1, dwellings where an interview was conducted are counted as successful, irrespective of a within-household change in the target person. Cases in which the dwelling was temporarily unoccupied in the field period, that is, there was no name on the bell-board and the interviewers were not able to contact a current resident, were also counted as "non-contact".

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[4] In order to achieve a sufficiently large number of interviews and to integrate new buildings (in total, 65 apartments built since 2014 were identified in the research areas), in 2022, a refreshment sample of n = 1,030 additional dwellings in the research areas was drawn. The cases of the refreshment sample are not included in the present analysis, as we do not yet have information on their response status in the forthcoming wave of data collection.

[5] Strictly speaking, cases in which a current resident was contacted, but was not able to take part in the interview due to various reasons are not to be counted as "non-contact", but rather constitute a separate category such as "other non-interview" or "ineligible". It is a peculiarity of the dwelling panel design that ineligible respondents are not completely excluded from the study as neutral loss; instead, the dwelling's address is visited again in subsequent waves to check whether an eligible person has moved in. While in principle, nonresponse mechanisms differ for non-contact and non-interview due to ineligibility, there is no fieldwork documentation available for the Waves 1–4 (2010 to 2014) that allows for a separation of ineligible respondents and genuine non-contact. In Wave 5, for about 7% of those registered as "non-contact", an interview was not possible due to lack of language skills; another 7% were too ill. In total, we estimate that "other non-interview" makes up for less than 3% as a response status in Wave 5. While it would be preferrable to set these cases to missing values, we chose to keep these cases in the category "non-contact" for the sake of consistency with the first four waves.

Table 1 Rates of successful interview, refusal, and non-contact based on the original sample of 1,009 dwellings

	Staying household		New household	
	N	%	*N*	%
Wave 2				
Sample	892	88.4	117	11.6
Interviews	784	87.9	94	80.3
Refusals	57	6.4	11	9.4
Non-contact	51	5.7	12	10.3
Wave 3				
Sample	843	83.6	166	16.4
Interviews	689	81.7	121	72.9
Refusals	104	12.3	11	6.6
Non-contact	50	5.9	34	20.5
Wave 4				
Sample	848	84.1	161	15.9
Interviews	659	77.7	88	54.7
Refusals	125	14.7	19	11.8
Non-contact	64	7.5	54	33.5
Wave 5[a]				
Sample	460	48.3	493	51.7
Interviews	234	50.9	249	50.5
Refusals	127	27.6	120	24.3
Non-contact	99	21.5	124	25.1

Notes: In the "sample" rows, row percentages are given that differentiate between staying and new households at the base of the 1,009 dwellings in the original sample. The differentiation between interviews, refusals, and non-contact are column percentages, based on the number of staying and new households in each wave.

[a] Excluding 56 dwelling units not traceable in 2022 (due to demolition or substantial architectural changes).

Table 1 shows that, as expected, the response rate of staying residents is continuously higher compared to new residents, except for Wave 5. Here, the gap between the waves was eight years, so that the effect of familiarity with the study seems to have worn off. While there are no remarkable differences concerning refusal rates between staying and new residents, non-contact of new residents is notably higher in Waves 2 to 4. However, some cases of non-contact in new households may be due to temporarily unoccupied apartments.

Methods

Nonresponse of Individuals

In total, there are 1,522 individuals who took part at least once in any of the Waves 1 to 4. Due to the high share of individuals who newly enter the panel in each wave (residents of households that moved in), we chose to analyze the data in the form of a pooled dataset of wave-to-wave transitions of individuals (characteristics in Wave t-1 predict response status in Wave t). Therefore, many individuals are present several times in the pooled dataset. Statistically, we account for this by using cluster robust standard errors with person ID as a cluster variable.

To examine associations between individual characteristics and nonresponse, we apply multinomial logistic regression with response status (participation, non-contact, refusal, moved out) in Wave t as the dependent variable. "Moved out" applies to the cases where the entire household moved out. Cases in which the target person within a household changed are treated as missing values, as the response status of the previous target person is unknown in Wave t.

As explanatory variables, we use information from the previous Wave t-1: respondents' age and age squared, gender, highest educational attainment, whether children up to 14 years are living in the household, household size, satisfaction with current housing situation (5-point Likert scale, see Appendix A1 for the wording of the item), duration of residence (three categories), dwelling ownership, and a unit value index on perception of collective efficacy in the neighborhood (five Likert-scaled items, see Appendix A2 for the wording of the item battery). The index ranges from 1 to 4, with higher numbers meaning more perceived collective efficacy in the neighborhood. Summary statistics of the variables are listed in Table 2. For each wave, the predictors are listed column-wise, with the individuals' status in the next wave at the bottom of the table (e.g., explanatory variables in Wave 1 (t-1) are used to estimate status in Wave 2 (t)). Control variables are the respondents' number of previous participations in the panel study and wave dummies. Due to listwise deletion of missing values in the explanatory variables or unknown status in Wave t, the number of individuals in the sample is reduced to 1,291, with a total of 3,121 wave-to-wave transitions. Table 2 reports summary statistics only for those cases that are part of the regression model later on.

Nonresponse in Dwellings

In the analysis of nonresponse on the dwelling level, the dataset is structured differently: The cases (units) are dwellings that "participate" (or not) in each wave. An analysis on the dwelling level enables us to model the difference between staying and new households with regard to the likelihood of being able to obtain data on a dwelling. First, we visualize the dwellings' wave-to-wave

Table 2 Summary statistics of explanatory variables

		Wave 1 *N* = 957	Wave 2 *N* = 839	Wave 3 *N* = 726	Wave 4 *N* = 599
Age	*M* (*SD*)	46.7 (17.6)	47.0 (17.4)	48.5 (17.2)	48.1 (17.1)
Gender (in %)	Female	48.1	49.5	49.4	50.2
	Male	51.9	50.5	50.6	49.8
Education (in %)	None or basic secondary	19.6	18.2	18.0	15.9
	Intermediate secondary	17.7	16.6	15.3	17.2
	Upper secondary	24.8	25.3	25.9	25.2
	Tertiary	37.9	39.9	40.8	41.7
Children (up to 14 years old; in %)	No	84.0	82.8	82.2	82.0
	Yes	16.0	17.2	17.8	18.0
Household size	*M* (*SD*)	2.1 (1.0)	2.0 (0.9)	2.0 (0.9)	2.0 (0.9)
Satisfaction with housing (in %)	Not at all	1.2	1.9	0.7	1.5
	Not much	1.7	1.7	1.9	2.3
	Moderately	14.9	13.8	11.2	13.9
	Mostly	48.3	49.9	51.9	47.7
	Fully	33.9	32.7	34.3	34.6
Duration of residence (in %)	Up to 5 years	47.2	46.6	42.4	42.4
	6 to 15 years	26.5	26.8	30.0	28.7
	16 years and more	26.3	26.6	27.6	28.9
Ownership (in %)	Renter	83.1	83.0	82.9	81.8
	Owner	16.9	17.0	17.1	18.2
Collective efficacy	*M* (*SD*)	3.0 (0.5)	3.0 (0.5)	3.1 (0.5)	3.0 (0.5)
Status next wave (t; in %)		Wave 2	Wave 3	Wave 4	Wave 5
	Moved	12.1	15.9	11.6	49.6
	Interview	77.0	74.8	77.1	29.9
	Refusal	5.1	6.0	8.0	11.2
	Non-contact	5.7	3.3	3.3	9.3

transitions between the response statuses “successful interview”, “non-contact”, and “refusal” (differentiated by new and staying households), in a hammock plot (Schonlau, 2003). The width of the lines between categories is proportional to the number of cases that transition to the status from one wave to the next. This enables initial insights into the patterns of participation on the level of dwellings. Second, we run a multinomial logistic regression with the three outcome categories for the dwellings in each wave, considering move status (staying vs. new household), apartment size (five categories), and neighborhood (Deutz vs. Mülheim) as explanatory variables (see Table 3).

Table 3 Dwelling characteristics as reported in Wave 1

	%
Location	
Mülheim	40.3
Deutz	59.7
Dwelling size (n = 1,006)[a]	
Up to 50 m^2	15.4
51 to 65 m^2	25.1
66 to 80 m^2	25.1
81 to 95 m^2	15.1
96 m^2 and more	19.4

[a] In 3 units, there is no information available on dwelling size.

"Wave" is added as a dummy variable to control for changing patterns of participation over time; we also control for the dwellings' response status in Wave t-1 (interview, refusal, or non-contact). All statistical analyses were conducted with Stata, Version 18.

Results

Nonresponse of Individuals

We first present the results of multinomial logistic regression on the outcomes "participation" (reference), "moved", "refusal", and "non-contact" for individuals (Table 4). The pooled dataset of individuals' wave-to-wave transitions comprises 3,121 observations. The model explains a moderate amount of variance with a Pseudo R^2 (McFadden) of .146.

For the outcome "moved", which refers to the entire household having moved out of the dwelling, and consequently, of the panel, we observe clear trends: In line with our hypotheses (H1.1–H1.3), the probability of moving out is predicted by age, educational attainment, and satisfaction with current housing situation. The effect of age is curvilinear: The probability of moving out decreases up to about 60 years of age, after which it increases again (see plot of predictive margins for age, Appendix A3). Compared to no or basic secondary education, respondents with tertiary education are more likely to move. Lower satisfaction with the current housing situation in the previous wave entails a higher probability of moving. In addition, a longer duration of residence and being the owner of the dwelling (H1.5) lead to a significant decrease in the probability of moving. Contrary to our assumption, perceived collective efficacy (H1.4) has no effect on

the probability of moving. Further, indicators on household composition, such as children in household and household size, show no significant effect.

Regarding the propensities for nonresponse (refusal and non-contact), only the variable satisfaction with the current housing situation shows a consistent and strong effect, with higher satisfaction lowering the probability of both refusal (H3.4) and non-contact (no previous hypothesis). Unsurprisingly, the wave dummies are significant as well, confirming that nonresponse increases in later waves. Neither the presence of children in the household (H 2.1), nor age (H2.2), household size (H2.3), home ownership (H2.4), or duration of residence (H2.5) have significant effects on non-contact. The hypothesized effects of age (H3.1), education (H3.2), home ownership (H3.3), and collective efficacy in the neighborhood (H3.5) are also not confirmed by the model.

Table 4 Multinomial logistic models of nonresponse at individual level

	Moved	Refusal	Non-contact
Male (ref.: female)	−.046 (.105)	.104 (.147)	.162 (.168)
Age	−.163*** (.017)	−.031 (.028)	−.048 (.031)
Age squared	.001*** (.000)	.000 (.000)	.001 (.000)
No and basic secondary education (reference)			
Intermediate secondary education	.062 (.216)	−.185 (.229)	−.230 (.278)
Upper secondary education	.284 (.207)	−.518* (.252)	−.481 (.316)
Tertiary education	.663** (.200)	−.438 (.233)	−.371 (.288)
Children in household (ref.: no children)	.072 (.179)	.0325 (.229)	−.144 (.320)
Household size	−.031 (.073)	.011 (.094)	.092 (.111)
Satisfaction with housing	−.325*** (.071)	−.300** (.092)	−.310** (.105)

Table 4 (continued)

	Moved	Refusal	Non-contact
Duration of residence: 0–5 years (reference)			
6–15 years	−.433**	.303	.032
	(.162)	(.208)	(.260)
More than 15 years	−.762***	.104	−.045
	(.210)	(.259)	(.310)
Dwelling ownership (ref.: renter)	−.779***	−.209	−.261
	(.183)	(.203)	(.234)
Collective efficacy	.075	−.249	.018
	(.116)	(.150)	(.161)
Number of participations	−.025	−.231*	−.220
	(.082)	(.116)	(.149)
Waves 1–2 (reference)			
Waves 2–3	.350*	.399	−.310
	(.158)	(.235)	(.277)
Waves 3–4	.097	.877**	−.161
	(.194)	(.274)	(.339)
Waves 4–5	2.820***	2.376***	2.034***
	(.218)	(.323)	(.406)
Constant	3.237***	−.531	.203
	(.612)	(.868)	(1.036)

Notes: Pseudo R^2 (McFadden) = .146, Log pseudolikelihood = −2483.332, $\chi^2(48) = 690.02$, $p < .001$, $N = 3{,}121$. Reference: Completed interview, cluster robust standard errors in parentheses. *$p < .05$, **$p < .01$, ***$p < .001$.

Considering the substantial hiatus between Waves 4 and 5, we estimated the same model separately for transitions from Waves 1 to 4 and for transitions from Waves 4 to 5 (see Appendix A4 for robustness checks). The results indicate that the effects shown in Table 4 are mostly stable; due to the high number of moves between Waves 4 and 5 and the lower N, some coefficients fail to reach significance in the separate models, but there are no striking differences that would suggest different processes over time. When looking at the model with one-year intervals between Waves 1 to 4 (left panel in A4), a negative effect of perceived collective efficacy on the probability to refuse in the upcoming wave is visible, as hypothesized in H3.5.

Nonresponse in Dwellings

For the analysis on the level of dwellings, we first visualize transitions in the response status of dwellings using a hammock plot (Figure 1). We differentiate between staying and new households on the one hand[6], and the three outcomes non-contact (n/a), refused (ref), and successfully interviewed (int)[7], on the other. Between waves two to four, by far the largest group consists of dwellings where households stayed the same and continued to be interviewed in the next wave of the panel (stay int to stay int). This group remains substantial in Wave 5; however, due to the longer gap between waves, we can also observe a large number of dwellings with new residents being interviewed in this last wave (see the line from stay int in Wave 4 to new int in Wave 5). In contrast, there are very few dwellings (thin to non-existent lines between categories) where a new household refused participation or was not available, but a member of the same household took part in the next wave (new ref and new n/a to stay int).

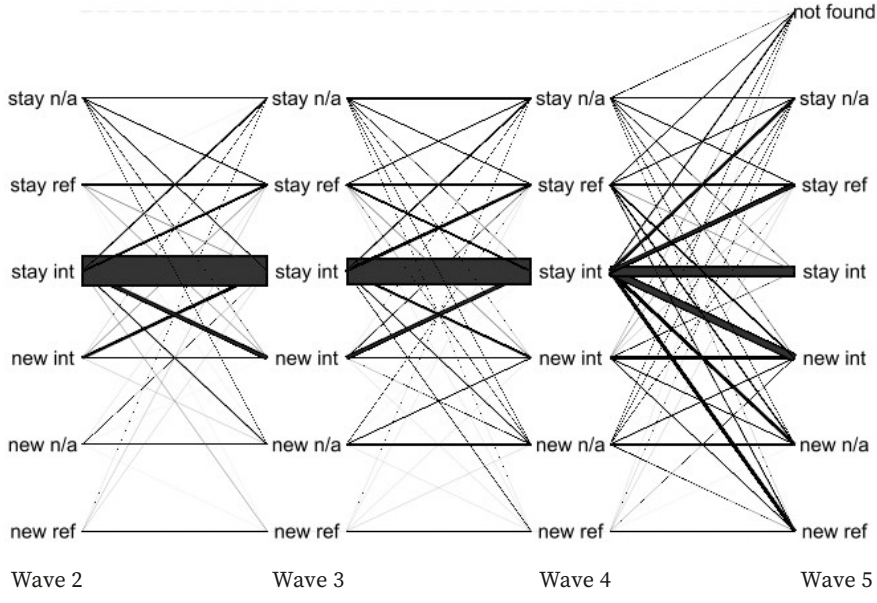

Figure 1 Hammock plot of wave-to-wave transitions of dwellings, Waves 2 to 5

[6] This differentiation applies to each wave, that is, a new household who moved into the dwelling in Wave 2 will be counted as staying one in Wave 3 when no move occurred between Waves 2 and 3.

[7] Between Waves 4 and 5, 56 dwellings were demolished, transformed into office space, or completely rebuilt so the original apartments were no longer identifiable, constituting the category "not found" (see also Table 1).

In general, Figure 1 demonstrates that transitions to different states happen in all directions: In some dwellings, residents who were previously interviewed go on to refuse or cannot be contacted in the following wave (stay int to stay n/a or stay ref), but there are also (thin) lines from non-responders (stay n/a and stay ref) to dwellings where an interview was obtained again in the next wave (stay int). A substantial share of incoming residents become loyal participants, which can be seen by the moderately thick lines going from "new int" into "stay int" between Waves 2 and 4. This shows that new residents are often successfully recruited into the panel, enabling the continuous observation of dwellings across resident changes. We also observe that dwellings where residents refused or were not able to be contacted can be converted into successfully interviewed ones once the dwellings' resident changes (see the lines from "stay n/a" and "stay ref" leading to "new int"). Due to the time gap between Waves 4 and 5, which potentially induced a loss of familiarity effects, there is a higher share of non-contact and refusal in staying residents from Waves 4 to 5 (lines between "stay int" and "stay ref" or "stay n/a" are thicker compared to Waves 2, 3, and 4).

Delving deeper into the question of potential attrition bias with respect to dwellings, in Table 5 we show a multinomial logistic regression which models (non)response with the outcomes participation (reference), refusal, and non-contact on the level of dwellings. Again, the data are pooled as wave-to-wave transitions, yielding a total of 3,968 observations on the dwelling level[8].

The model provides further insights regarding both dwelling and contextual (i.e., neighborhood) characteristics. First, we see that, contrary to our hypothesis 5.1, a new household does not have a significant effect on the probability of refusal, but it does increase the chance of a dwelling non-contact (no previous hypothesis). The dwelling's location also shows a significant effect: Dwellings located in Deutz, the neighborhood with a higher-socio-economic status, have a lower probability of refusal (H5.2). Our expectation that dwellings in Deutz will also have a lower probability of non-contact (H4.2), however, cannot be confirmed, as the location shows no significant effects here.

Regarding dwelling size, we see that the smallest dwellings (up to 50 m^2) have a higher propensity for nonresponse compared to nearly all other dwelling sizes. This confirms our assumption that smaller dwellings would be more difficult to (re-)contact (H4.1). Further, the model confirms the tendency that was already visible in the hammock plot: Despite the fluctuations due to new residents, a dwelling's participation status in the wave before is a strong predictor of its status in the current wave.

[8] In theory, there are 4*1,009 wave-to-wave transitions of dwellings; however, information on size is permanently missing from 3 dwellings, and 56 dwellings went out of sample between Wave 4 and Wave 5. Thus, the number of wave-to-wave transitions is reduced to 3,968.

Table 5 Multinomial logistic models of nonresponse at dwelling level

	Refusal	Non-contact
New household (ref.: staying)	−.245	.596***
	(.132)	(.130)
Deutz (ref.: Mülheim)	−.474***	−.001
	(.102)	(.111)
Up to 50 m² (reference)		
51 to 65 m²	−.444**	−.214
	(.160)	(.154)
66 to 80 m²	−.472**	−.485**
	(.163)	(.166)
81 to 95 m²	−.504**	−.777***
	(.177)	(.196)
96 m² and more	−.597***	−.668***
	(.170)	(.181)
Wave t-1 interview (reference)		
Wave t-1 refusal	1.647***	1.353***
	(.162)	(.181)
Wave t-1 non-contact	1.322***	1.810***
	(.191)	(.170)
Wave 2 (reference)		
Wave 3	.427**	−.045
	(.152)	(.176)
Wave 4	.619***	.276
	(.164)	(.161)
Wave 5	1.750***	1.194***
	(.165)	(.170)
Constant	−1.939***	−2.269***
	(.195)	(.187)

Notes: Pseudo R^2 (McFadden) = .123, Log pseudolikelihood = −2652.962, $\chi^2(22) = 700.41$, $p < .001$, N = 3,968, standard errors robust for 1,006 clusters. Reference: Completed interview, cluster robust standard errors in parentheses.
**$p < .01$, ***$p < .001$.

To confirm these results despite the larger gap between Waves 4 and 5, we estimated the same model separately for transitions from Waves 1 to 4 and for transitions from Wave 4 to 5 (see Appendix A5 for details). The results indicate that none of the effects change direction, but some coefficients fail to reach significance when looking at transitions from Wave 4 to 5 only. Given the long hiatus between Waves 4 and 5, and the high number of moves in the meantime, this result does not invalidate our general findings. We also tested whether the results

remain stable when excluding those dwellings in which only the responding person changed, but no move of the entire household was recorded (as opposed to being counted as "staying household" in Table 5; see Appendix A6 for details). In this model, the negative effect of new households on the probability of refusal becomes marginally stronger and thus reaches the 5% level of significance. All other predictors show comparable results.

Discussion

In this paper, we analyzed unit nonresponse in a panel survey where the primary sampling units are dwellings, and where data are collected from one of each dwelling's current residents, making individuals in dwellings the secondary sampling units. We argued that while the decision to take part in the study is made by individuals, systematic missingness associated with dwelling characteristics could hinder a dwelling panel's capacity to estimate actual socio-structural change in the neighborhoods that are the focus of the research. Drawing on an adjusted framework of nonresponse mechanisms in face-to-face panel surveys, we assessed how socio-demographic and housing-related characteristics are related to individuals' and dwellings' response status in the subsequent panel wave, using data from the Cologne Dwelling Panel 2010–2022.

On the individual level, we found that when respondents express lower levels of satisfaction with their current housing situation, this is a significant predictor of nonresponse (both non-contact and refusal) in the following wave. This effect may partly be related to the survey topic, as taking part in a survey on housing characteristics and attitudes towards one's neighborhood is likely to be a more pleasant experience if one is satisfied with one's current living situation. In addition, it may reflect a general condition of face-to-face surveys, as respondents who are dissatisfied with their current housing situation may be more reluctant to allow an interviewer to enter their private home. This finding is potentially valuable for fieldwork in other panel surveys as well, as respondents who express low satisfaction with (or low interest in) a topic that is relevant for the survey could be especially targeted (e.g., by using incentives; Schoeni et al., 2013) in order to prevent attrition in subsequent waves. A number of socio-demographic characteristics that were found to influence nonresponse in previous research on longitudinal panel studies did not exhibit significant effects in our study. This supports the argument of Haunberger (2011, pp. 108–109), who concludes from an extensive literature review that the effects of socio-demographic variables on nonresponse vary widely between panel surveys.

Nonresponse with regard to dwellings as sample units has, to our knowledge, not yet been analyzed in previous studies. We find that when if a dwelling is occupied by a new household between waves, the probability of refusal is not

affected, and in some cases actually decreases (see model for Waves 1–4 in A.4), whereas the probability of non-contact rises with a new household. While for panel studies that follow persons or households, a move on the part of the target means an elevated risk of losing track of the respondent, in a dwelling panel the challenge is to contact a current resident of the new household and convince them to take part in the study. The higher probability of non-contact in new households may—besides prospective participants simply not being at home—reflect other possible issues, e.g., the fact that some apartments were temporarily unoccupied during a tenant change.

Looking at the neighborhood in which dwellings are located, we found that refusal rates were higher in the district of Mülheim as compared to Deutz. While the use of neighborhood as a dummy variable does not allow for a disentangling of contextual effects, previous research suggests that a heterogenous neighborhood composition and a higher number of people who receive welfare benefits might be characteristics related to unit nonresponse. Effects of socio-environmental contexts on nonresponse have hitherto been demonstrated in cross-sectional surveys (Brick & Williams, 2013; Couper & Groves, 1996); our analysis shows that the effect is not restricted to the first contact, but also affects nonresponse rates in subsequent panel waves. Therefore, in future studies that aim to compare different neighborhoods or areas, it could be advisable to draw a higher gross sample in specific areas in order to account for this effect.

We also found dwelling size to be a significant predictor of unit nonresponse in subsequent waves, with residents of small apartments being more likely to refuse or not be contacted. There are several possible reasons for this effect: On the one hand, dwelling size may be seen as a proxy for household size, where bigger households increase the probability of someone being at home when the interviewer rings the bell (but note that household size did not have an effect on nonresponse rates at the individual level in our analysis). On the other hand, small apartments in our study are more likely to have a high turnover of residents, and we know from the fieldwork that small apartments are frequently sub-let or on the short-term rental market (e.g., as holiday apartments; Mindl & Arentz, 2020), leading to a lower propensity of residents to take part in the survey. Furthermore, satisfaction with housing is slightly lower in small apartments (Peter & Bierwirth, 2021; see Appendix A7 for data on the Cologne Dwelling Panel), reflecting an interaction between dwelling characteristics and residents' attitudes. In total, though, change in the Cologne Dwelling Panel's sample composition in terms of dwelling size and area is moderate, with 15.2% of dwellings up to 50 m^2 in Wave 1 compared to 12.8% in Wave 5 and the proportion of interviews in Mülheim, the more heterogeneous and socially deprived neighborhood, ranging between 40.3% (Wave 1) and 36.8% (Wave 3). In the light of these findings, longitudinal weights do not seem crucial, but the potential over-representation of satisfied residents should be kept in mind.

While the analysis of nonresponse in a dwelling panel generated a number of interesting insights, the study also has some notable limitations. In general, it is an advantage of panel studies that there is information from previous waves that can be used to assess nonresponse probabilities; conversely, the restriction to units that took part at least once means that nonresponse bias may already be present in the original sample of first-wave respondents. More specifically for the dwelling panel, respondents who move out of their apartment are lost by design, as it is the dwellings that are "re-contacted" in each wave. While we accounted for "moved out" as a separate status in our analyses, there is no way of knowing the probability that these outmovers would have participated in the study again had they not moved out: That is to say, while we deem the choice of analysis the best possible solution considering the specific design of the dwelling panel, it is not entirely possible to disentangle the effects of these individuals' characteristics on the likelihood of moving and on the likelihood of participating, respectively. In terms of variables, it is a limitation that the Cologne Dwelling Panel does not have indicators on respondents' subjective ratings of the survey experience and interviewers' ratings of respondents' performance, both of which might be indicative of the likelihood of individuals participating in future. In addition, the long gap between Wave 4 and Wave 5 of the Cologne Dwelling Panel has to be kept in mind when it comes to the generalizability of the results; however, we conducted robustness checks in the form of separate analyses, which indicated that the results are broadly stable.

In general terms, the approach implemented in the Cologne Dwelling Panel allows for a detailed assessment of the effect of household moves on nonresponse, as the information on whether a household has moved away is determined simply by the interviewer examining the building's bell-board, and is not contingent on a dwelling's "participation" in the upcoming wave. However, this fieldwork strategy also bears the risk that the study, which is specifically designed to measure change in residential neighborhoods, may be increasingly challenged by the very transformations it aims to document: In the case of substantial changes to the building stock, the re-identification of dwellings via their position on a housing unit's bell-board can become increasingly difficult, or even impossible. Moreover, modernization works—such as replacing traditional doorbells with coded entry systems—introduce additional challenges, and vaguely announced visits (receiving a letter announcing that "an interviewer is going to ring your bell within the next weeks") are becoming less socially acceptable, especially in light of the near-ubiquity nowadays of digital communication. Therefore, like all longitudinal studies, the Cologne Dwelling Panel is performing a constant balancing act between adaptation to new circumstances and ensuring comparability of results over time.

In conclusion, our study contributes to the literature on nonresponse in panel surveys by providing an example of a small-area dwelling panel study with face-to-face interviews. The relevance of respondents' satisfaction with their current

housing situation and the effect of the neighborhood environment on the probability of nonresponse underline the fact that survey (non)participation is a complex and context-specific problem with implications that are not likely to be correctable by solely applying socio-demographic weights (Peytcheva & Groves, 2009).

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Appendix

Table A1 Satisfaction with housing

German original wording	English translation
Wenn Sie jetzt alles zusammennehmen, wie zufrieden sind Sie mit Ihrer Wohnsituation?	Taking everything into account, how satisfied are you with your housing situation?

Table A2 Perception of collective efficacy in the neighborhood

German original wording	English translation
Die Leute hier helfen sich gegenseitig	People around here help each other
Hier kennen sich die Leute gut	People around here know each other well
Man kann den Leuten in der Nachbarschaft vertrauen	People in this neighborhood can be trusted
Die Leute hier kommen gut miteinander aus	People in this neighborhood generally get along with each other
Die Leute hier haben nur wenig Respekt vor Gesetz und Ordnung	People in this neighborhood have little respect for law and order

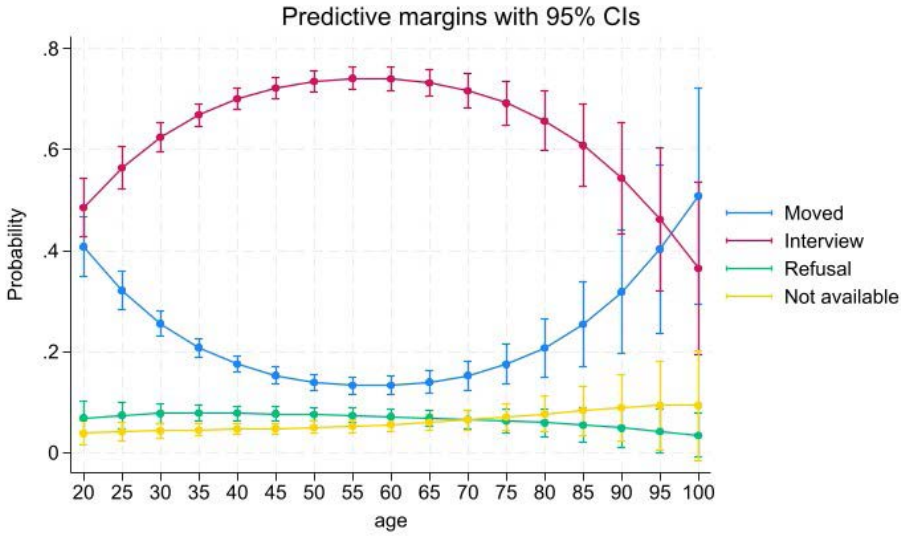

Figure A3 Marginsplot of the effect of age on nonresponse categories

Table A4 Multinomial logistic models of nonresponse at individual level, separated for Waves 1–4 and Waves 4–5

	Waves 1 to 4			Waves 4 to 5		
	Moved	Refusal	Non-contact	Moved	Refusal	Non-contact
Male (ref.: female)	−.152 (.124)	.322 (.177)	.081 (.204)	−.133 (.213)	−.335 (.302)	.362 (.316)
Age	−.147*** (.024)	−.057 (.033)	−.036 (.036)	−.246*** (.045)	.008 (.072)	−.147* (.068)
Age squared	.001*** (.000)	.000 (.000)	.000 (.000)	.002*** (.000)	−.000 (.001)	.001* (.001)
No and basic secondary education (reference)						
Intermediate secondary education	.242 (.295)	−.260 (.281)	−.228 (.317)	−.057 (.389)	−.100 (.484)	−.087 (.530)
Upper secondary education	.611* (.269)	−.644* (.300)	−.715 (.380)	−.115 (.409)	−.441 (.522)	.014 (.557)
Tertiary education	.936*** (.262)	−.381 (.269)	−.635 (.342)	.258 (.391)	−.714 (.534)	−.091 (.484)

Table A4 (continued)

	Waves 1 to 4			Waves 4 to 5		
	Moved	Refusal	Non-contact	Moved	Refusal	Non-contact
Children in household (ref.: no children)	.042 (.203)	−.003 (.278)	−.051 (.377)	.182 (.363)	−.007 (.483)	.168 (.501)
Household size	.001 (.086)	−.098 (.113)	.097 (.124)	−.037 (.147)	.350 (.206)	.093 (.230)
Satisfaction with housing	−.301** (.087)	−.310** (.114)	−.381** (.116)	−.311* (.136)	−.315 (.181)	−.118 (.238)
Duration of residence: 0–5 years (reference)						
6–15 years	−.334* (.168)	.396 (.235)	−.106 (.284)	−.296 (.355)	.431 (.495)	.689 (.730)
More than 15 years	−1.032*** (.268)	.029 (.319)	−.239 (.333)	.034 (.402)	.624 (.579)	1.089 (.855)
Dwelling ownership (ref.: renter)	−.968*** (.257)	−.261 (.261)	.337 (.295)	−.488 (.289)	−.003 (.379)	−.097 (.420)
Collective efficacy	.187 (.143)	−.407* (.174)	−.070 (.377)	−.070 (.238)	.178 (.312)	.281 (.338)
Number of participations	.374* (.147)	−.449* (.178)	.068 (.311)	−.297* (.145)	−.368 (.189)	−.496 (.242)
Waves 1–2 (reference)				n.a.	n.a.	n.a.
Waves 2–3	.014 (.186)	.588* (.263)	−.572 (.375)	n.a.	n.a.	n.a.
Waves 3–4	−.497 (.277)	1.199*** (.319)	−.618 (.590)	n.a.	n.a.	n.a.
Waves 4–5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Constant	1.929* (.794)	1.527 (1.025)	−.089 (1.280)	9.396*** (1.407)	.673 (2.242)	2.552 (2.210)
	Pseudo R^2 (McFadden) = .076, Log pseudolikelihood = −1817.912, $\chi^2(45) = 257.64$, $p < .001$, $N = 2{,}522$			Pseudo R^2 (McFadden) = .108, Log pseudolikelihood = −627.738, $\chi^2(39) = 131.92$, $p < .001$, $N = 599$		

*$p < .05$, **$p < .01$, ***$p < .001$.

Table A5 Multinomial logistic models of nonresponse at dwelling level, Waves 4 to 5 separate

	Waves 1 to 4		Waves 4 to 5	
	Refusal	Non-contact	Refusal	Non-contact
New household (ref.: staying)	−.385 (.237)	1.102*** (.163)	−.210 (.160)	−.205 (.171)
Deutz (ref.: Mülheim)	−.585*** (.135)	.000 (.148)	−.219 (.162)	.081 (.175)
Up to 50 m² (reference)				
51 to 65 m²	−.743*** (.195)	−.284 (.203)	.116 (.267)	.022 (.253)
66 to 80 m²	−.678*** (.192)	−.281 (.212)	−.137 (.265)	−.699** (.266)
81 to 95 m²	−.649** (.220)	−.712** (.265)	−.202 (.294)	−.785* (.307)
96 m² and more	−.866*** (.214)	−.754** (.263)	−.115 (.279)	−.495 (.279)
Wave t-1 interview (reference)				
Wave t-1 refusal	2.237*** (.206)	1.535*** (.257)	.716** (.237)	.949*** (.238)
Wave t-1 non-contact	1.891*** (.242)	2.333*** (.259)	.503 (.264)	.919*** (.253)
Wave 2 (reference)			n.a.	n.a.
Wave 3	.292 (.167)	−.157 (.192)	n.a.	n.a.
Wave 4	.457** (.176)	.145 (.168)	n.a.	n.a.
Wave 5	n.a.	n.a.	n.a.	n.a.
Constant	−1.690*** (.203)		−.515 (.264)	
	Pseudo R^2 (McFadden) = .128, Log pseudolikelihood = −1649.252, $\chi^2(20) = 468.10$, $p < .001$, $N = 3{,}018$		Pseudo R^2 (McFadden) = .0262, Log pseudolikelihood = −956.386, $\chi^2(16) = 50.08$, $p < .001$, $N = 950$	

*$p < .05$, **$p < .01$, ***$p < .001$.

Table A6 Multinomial logistic models of nonresponse at dwelling level, Waves 1 to 5, excluding wave-to-wave transitions when responding person changed (but no move for the entire household was recorded)

	Refusal	Non-contact
In-mover (ref.: stayer)	−.295*	.545***
	(.134)	(.133)
Deutz (ref.: Mülheim)	−.466***	.004
	(.103)	(.113)
Up to 50 m² (reference)		
51 to 65 m²	−.424**	−.170
	(.160)	(.158)
66 to 80 m²	−.468**	−.482**
	(.164)	(.169)
81 to 95 m²	−.491**	−.737***
	(.179)	(.198)
96 m² and more	−.618***	−.681***
	(.170)	(.184)
Wave t-1 interview (reference)		
Wave t-1 refusal	1.697***	1.428***
	(.168)	(.185)
Wave t-1 non-contact	1.410***	1.887***
	(.195)	(.194)
Wave 2 (reference)		
Wave 3	.425*	−.072
	(.153)	(.176)
Wave 4	.607***	.259
	(.166)	(.161)
Wave 5	1.772***	1.197***
	(.167)	(.171)
Constant	−1.690***	−2.251***
	(.203)	(.189)
	Pseudo R^2 (McFadden) = .126, Log pseudolikelihood = −2595.553, $\chi^2(22) = 695.02$, $p < .001$, $N = 3{,}867$	

*$p < .05$, **$p < .01$, ***$p < .001$.

Table A7 Satisfaction with housing by dwelling size, M (*SD*)

		Wave 1	Wave 2	Wave 3	Wave 4
Dwelling size	Up to 50 m^2	3.9 (0.9)	4.0 (0.9)	4.0 (0.8)	3.9 (0.9)
	51 to 65 m^2	4.1 (0.8)	3.9 (0.9)	4.1 (0.8)	3.9 (0.9)
	66 to 80 m^2	4.1 (0.8)	4.1 (0.8)	4.2 (0.7)	4.1 (0.8)
	81 to 95 m^2	4.2 (0.7)	4.1 (0.9)	4.2 (0.7)	4.2 (0.7)
	96 m^2 and more	4.2 (0.8)	4.3 (0.8)	4.3 (0.7)	4.3 (0.7)

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