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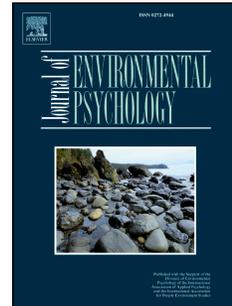
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# The impact of earthquakes on the intention to move: Fight or flight?

Sylvia J.T. Jansen\*, Joris S.C.M. Hoekstra, Harry J.F.M. Boumeester

Department of OTB – Research for the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Delft, The Netherlands

\* Corresponding author.

*E-mail addresses:* [s.j.t.jansen@tudelft.nl](mailto:s.j.t.jansen@tudelft.nl) (S.J.T. Jansen), [j.s.c.m.hoekstra@tudelft.nl](mailto:j.s.c.m.hoekstra@tudelft.nl) (J.S.C.M. Hoekstra), [h.j.f.m.boumeester@tudelft.nl](mailto:h.j.f.m.boumeester@tudelft.nl) (H.J.F.M. Boumeester)

1 The impact of earthquakes on the intention to move:

2 Fight or flight?

3

4

5

6 ABSTRACT

7 The extraction of natural gas in the north of the Netherlands has led to soil subsidence and the occurrence of  
8 earthquakes. Residents worry about the safety of their families and the saleability of their dwelling and might want to  
9 move. The goal is to examine whether the earthquakes are related to the intention to move. A survey among residents  
10 in the area was carried out in 2015. The results show that the intention to move is influenced by age, education,  
11 household size, length of residence and attachment to the region. In addition, there is an effect of experience of  
12 earthquakes, which is mediated by psychological distress (anxiety, insecurity and concern). We conclude that the  
13 way in which residents handle the earthquake experience determines their intention to move, not the experience in  
14 itself. This provides opportunities to prevent out-migration by supporting residents and by providing them  
15 psychological care and security regarding the value and saleability of their dwellings.

16

17 Keywords: intention to move, residential satisfaction, risk perception, coping, earthquakes, multinomial logistic  
18 regression analysis

19

## 1 **1. Introduction**

### 3 *1.1. Description of the problem*

5 Natural gas has been extracted in the province of Groningen, the Netherlands, since 1963. The production  
6 of natural gas can have a number of negative consequences, such as noise and air pollution, ground water  
7 contamination and soil subsidence. The latter can have an impact on seismic activity and in Groningen this  
8 had led to an increase in the number of earthquakes recorded in the last two decades. Up to and including  
9 2013, 579 earthquakes with a magnitude of at least 1 on the Richter scale were recorded; 21 of these had a  
10 magnitude of at least 2.5 (Koster & van Ommeren, 2015). On 16 August, 2012, an earthquake with a  
11 magnitude of 3.6 was recorded. Furthermore, in January 2013, a report was published that showed that  
12 earthquakes with a magnitude of up to 5 on the Richter scale could be expected in the future (Dost,  
13 Caccavale, van Eck, & Kraaijpoel, 2013). This was the starting point for the recognition of earthquake-  
14 induced problems in the region. While an earthquake of such magnitude might seem rather weak, the  
15 present soil conditions and the shallow depth of 3,000 meters at which the earthquakes are triggered can  
16 cause serious damage to properties (Koster & van Ommeren, 2015). To provide an impression of the size  
17 of the problem: 28,680 damage claims related to gas-induced earthquakes were recorded in 2015. Over the  
18 years, about 20% of damage claims have not been successful, 35% were deemed to be minor damage (<  
19 €3,000), 41% of medium size (€3,000 to €25,000) and 24% were deemed to be major damage (> €25,000).<sup>1</sup>

20 The physical damage to dwellings is (partly) compensated for by NAM, the company that exploits  
21 the gas. In addition, home-owners who sell their dwelling can apply for compensation to cover losses due  
22 to the depreciation of housing prices that results from the negative effect of the earthquakes on the housing  
23 market. However, determining the amount of such compensation is difficult because there are other  
24 factors that may influence housing prices, such as population decline and the economic crisis (Jansen &  
25 Boelhouwer, 2016). Furthermore, there are other negative consequences of the earthquakes, which seem to  
26 be fairly similar to those brought on by environmental hazards. These consequences include: the threat of  
27 physical harm, financial ruin, disruption of social networks and loss of personal control (Rich, Edelstein,  
28 Hallman, & Wandersman, 1995; Ruiz & Hernandez, 2014). People exposed to uncontrollable events often  
29 experience traumatic stress and psychological distress (Nolen-Hoeksema & Morrow, 1991; Sumer,  
30 Karanci, Berument, & Gunes, 2005). Tas, Cosgun and Tas (2007) argued that earthquakes do not only  
31 destroy buildings but can also lead to social and economic ruin. Residents in the region at risk in  
32 Groningen are concerned about issues such as their own safety and that of their loved ones, the saleability  
33 of their dwelling and the uncertainty of future damage or even collapse of the dwelling. In addition, people

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<sup>1</sup> [www.nam.nl/feiten-en-cijfers.html](http://www.nam.nl/feiten-en-cijfers.html)

1 in such circumstances may have a feeling of powerlessness because neither fight nor flight is possible  
2 (Rich, Edelstein, Hallman, & Wandersman, 1995). Residents might even view their own home as a source  
3 of danger because it increases the risk of being exposed to the hazard, something they cannot fight against.  
4 Moreover, selling their home might be impossible because of a lack of demand. Selling prices might be so  
5 low that residents with mortgage commitments cannot buy or rent a place somewhere else. This leads  
6 people to feel trapped and helpless and they are disappointed because they feel that the national  
7 government has let them down.

8 The problem outlined here has many similarities to climate change-induced migration caused, for  
9 example, by frequent storms, occasional flooding and droughts. People in such situations can mitigate the  
10 effects, do nothing and accept a lower quality of life or leave the affected areas (Reuveny, 2007). Out-  
11 migration has negative consequences for both the residents and the region. Residents living in the region  
12 studied here are relatively old. Elderly residents are often strongly attached to their neighbourhood  
13 because of limited mobility, the loss of close family members and friends, retirement from work and a  
14 decrease in social contacts later in life (Oh, 2003). Older people are therefore more dependent upon their  
15 neighbourhood for social interaction and social support (Oh, 2003). Other “transaction costs” include the  
16 loss of information networks, the psychological costs and the direct costs of moving (Böheim & Taylor,  
17 2002), the loss of their own place (Ruiz & Hernandez, 2014) and problems related to adjusting to the new  
18 living location (Speare, 1974). It should be noted that this region in north-east Groningen had already been  
19 experiencing serious population decline (Haartsen & Venhorst, 2010). An intensified out-migration of  
20 residents as a result of the earthquakes might lead to even more serious problems, such as further housing  
21 price depreciation (Glaeser & Gyourko, 2005), uninhabited houses, a decrease in the supply of facilities  
22 and services and decreasing liveability of the area (Haartsen & Venhorst, 2010).

23 The goal of the current paper is to examine whether there is a relationship between the  
24 earthquakes and people’s intention to move. In doing so, we must take into account known predictors of  
25 residential mobility, such as personal characteristics (age, income) and residential satisfaction. In the  
26 following section, the most important general predictors of residential mobility are described. This is  
27 followed by a description of personal factors that might apply more specifically to the situation in  
28 Groningen. Furthermore, the role of residential satisfaction is clarified. The introduction ends with the  
29 formulation of the research questions.

## 1 *1.2. Predictors of residential mobility*

### 3 **Life-cycle/life-course/life-stage models**

4 One of the most important groups of motives for migration relates to the life-cycle/life-course/life-stage  
5 models. The work by Rossi (1955) is often seen as the starting point for research on this topic. According  
6 to Rossi's family life-cycle model, different stages of nuclear family formation (cohabitation/marriage),  
7 expansion (birth of children), contraction (children moving out) and dissolution (divorce or death of a  
8 spouse) lead to changes in the size and composition of households. A transition to a new stage in the cycle  
9 may lead to residential dissatisfaction because characteristics of the dwelling or the residential  
10 environment might no longer meet the needs or preferences of the family. For example, a change in  
11 marital status or the birth of a child might create the need for greater housing consumption (Clark &  
12 Huang, 2003). At an older age, when the children have left home and/or when one of the spouses has died,  
13 less space is required (Winstanley, Thorns, & Perkins, 2002). If a dwelling cannot be adapted to present  
14 needs, this might eventually lead to residential mobility. Socio-demographic characteristics, such as age,  
15 household type and number of children are important indicators within these models. Studies have shown  
16 that mobility can be predicted on the basis of younger age (Clark & Dieleman, 1996; Böheim & Taylor,  
17 2002; Clark, Deurloo & Dieleman, 2003; Clark & Huang, 2003) and being a single-person household  
18 (Böheim & Taylor, 2002).

### 20 **The housing career**

21 The housing career assumes upward career progression and associated improvements in housing  
22 situations. Clark, Deurloo and Dieleman (2003) defined the housing career as a sequence of housing states  
23 distinguished in terms of tenure and the quality/price of the dwellings that households occupy while they  
24 make parallel careers in family status and the job market. According to the theoretical housing career  
25 model, new households move into the private rental sector before they access the homeowner housing  
26 market and then move up to larger and more expensive owner-occupation (Winstanley, Thorns, & Perkins,  
27 2002; Clark & Huang, 2003). The important socio-demographic characteristics underlying these models  
28 are income and tenure. Being a renter (Clark & Dieleman, 1996; Böheim & Taylor, 2002; Clark, Deurloo,  
29 & Dieleman, 2003) and having a higher income (Clark & Dieleman, 1996; Böheim & Taylor, 2002; Clark  
30 & Huang, 2003) are both related to a higher probability of moving.

### 32 **Push factors in the current location**

33 Push factors are those life situations that give a person reason to be dissatisfied with the present location  
34 (Dorigo & Tobler, 1983). Lee (1966) described these factors as being associated with the area of origin.

1 Some of the factors will be unattractive to almost everyone, for example a bad climate, whereas other  
2 factors might only be unattractive to some people (Lee, 1966). Examples of push factors are high  
3 unemployment and economic decline (Reuveny, 2007). In the current study, the experience of earthquakes  
4 might fuel the intention to move. We also include population decline as a potential push factor associated  
5 with the current location.

### 7 **Place attachment**

8 Place attachment can be seen as the bonding that occurs between individuals and their meaningful  
9 environments and that can vary in terms of spatial level, degree of specificity and social or physical  
10 features of the place (Scannell & Gifford, 2010). With regard to spatial level, one can think of the  
11 attachment to one's own room, the dwelling, the neighbourhood or a higher level. Place attachment is  
12 manifested through affective, cognitive and behavioural psychological processes (Scannell & Gifford,  
13 2010; Bonaiuto & Fornara, 2017). The behavioural aspects include use, personalisation and upkeep of the  
14 place and developing routines while spending time there (Brown et al., 2016). Place attachment has been  
15 shown to have a positive relationship with risk-coping behaviour when one stays in a risky place and takes  
16 action to improve or protect it (Bonaiuto, Alves, De Dominicis, & Petruccelli, 2016). Examples of such  
17 behaviour, as described in Bonaiuto, Alves, De Dominicis, & Petruccelli (2016), are using mitigation  
18 measures for wildfire prevention, cleaning up beaches and collecting litter after oil spills, and planting  
19 trees after a tornado has hit the region. Place attachment is also a factor that might reduce the willingness  
20 to move because people are reluctant to leave surroundings with which they have strong bonds.  
21 Attachment to a place can even be so strong that residents are less willing to relocate when a place is  
22 threatened by a natural hazard, or are more willing to return to post-disaster environments (Ruiz &  
23 Hernandez, 2014; Bonaiuto, Alves, De Dominicis, & Petruccelli, 2016).

### 27 *1.3. The role of residential satisfaction*

29 Residential satisfaction can be defined as: "The experience of pleasure or gratification deriving from  
30 living in a specific place, that is, the global evaluations that inhabitants give of their housing that can be  
31 considered at various levels of scale (e.g., house, building, neighborhood)." (Bonaiuto & Fornara, 2017,  
32 page 1). Residential (dis)satisfaction plays an important role in the intention to move; it is the link  
33 between the factors mentioned above and the intention to move. For example, according to the lifecycle  
34 model the birth of another child might increase the intention to move. However, this will only occur when

1 the objective housing circumstances (number of rooms, size of the dwelling, etc.) no longer match the  
2 needs of the family. If there is a discrepancy between actual and preferred housing characteristics (a “gap”  
3 or “mismatch”), this leads to dissatisfaction and, eventually, to the intention to move. Speare (1974)  
4 argued that - apart from forced moves - mobility can be viewed as resulting from the increase in  
5 dissatisfaction beyond a person’s threshold or tolerance level. Many researchers agree that residential  
6 satisfaction is not influenced by the objective characteristics of the dwelling and the dwelling environment  
7 per se, but by the subjective evaluation of these attributes (e.g., Campbell, Converse, & Rodgers, 1976;  
8 Galster & Hesser, 1981; Christensen & Carp, 1987; Amérigo & Aragonés, 1997; Lu, 1999; Sirgy, Rahtz,  
9 Cicic, & Underwood, 2000; Marans, 2003; Winkel, Saegert, & Evans, 2009; Vemuri, Grove, Wilson, &  
10 Burch, 2011; Bonaiuto & Fornara, 2017). Marans (2003) argued that the objective condition of a setting  
11 does not convey its true quality. Rather, it is the meaning of those conditions to the occupants that  
12 determines the quality. Campbell, Converse & Rodgers (1976) argued that objective attributes within a  
13 specific domain are first perceived and then evaluated by individuals. This leads to (dis)satisfaction with  
14 the specific domain which ultimately influences life satisfaction. Life satisfaction then influences coping  
15 and adaptive behaviour (such as moving house). The subjective evaluation of objective characteristics is  
16 influenced by personal characteristics and a normative element of comparison between the current and  
17 ideal residential situation. The latter concept – also called standard of residential quality - considers issues  
18 such as expectations, level of aspiration, degree of equity, reference groups, need and values (Speare,  
19 1974; Amérigo & Aragonés, 1997). Examples of factors that could cause a change in internal standards  
20 are social mobility (aspirations) and the receipt of information about opportunities elsewhere, such as  
21 higher wages for the same job (Speare, 1974).

22

#### 23 **1.4 Potentially mediating personal factors**

24 In the case of Groningen, the occurrence of (future) earthquakes generates stress. Stress can be defined as  
25 the relationship between the person and the environment that is appraised as personally significant and as  
26 taxing or receding resources for coping (Folkman, 2013). Coping relates to a person’s cognitive and  
27 behavioural efforts to manage the demands of a stressful person-environment relationship (Folkman,  
28 Lazarus, Gruen, & DeLongis, 1986). Moving house, or the intention to move, can be seen as one out of a  
29 number of potential coping strategies to handle the threat of earthquakes. Other coping strategies include  
30 cognitions such as accepting the situation or blaming others and actions such as making the dwelling  
31 earthquake resistant. Which coping strategie(s) will be applied depends upon the situation, personal  
32 characteristics and other complex processes, such as risk perception (Lopez-Vasquez, 2001). It is  
33 important to recognise that a stimulus only produces stress when it is appraised as exceeding individual  
34 resources and therefore threatens the person’s psychological well-being (Lazarus, DeLongis, Folkman &

1 Gruen, 1985). In other words, ecologically hazardous features become stressful only if the individual  
2 interprets these features as a threat (Kiecolt & Nigg 1982). And, as Lazarus, DeLongis, Folkman and  
3 Gruen (1985, page 776) pointed out: “No environmental event can be identified as a stressor  
4 independently of its appraisal by the person.” Appraisal has two steps, the primary appraisal concerns the  
5 person’s evaluation of personal significance and the secondary appraisal considers the options for coping  
6 (Folkman, 2013). Appraisals generate emotions, for example, threat-appraisals are often accompanied by  
7 fear, anxiety and worry and harm/loss-appraisals often coincide with emotions of anger, sadness, or guilt  
8 (Folkman, 2013). As explained above, coping is influenced by the perception of risk. Risk perception can  
9 be defined as the process of collecting, selecting and interpreting signals about uncertain impacts of  
10 events, activities or technologies (Wachinger, Renn, Begg, & Kuhlicke, 2013). Risk perception is  
11 subjective and can be influenced by the situation people face, individual characteristics (Lopez-Vazquez  
12 & Marvan, 2003) and previous experience (Tversky & Kahneman, 1973; Whitmarsh, 2008; Peters,  
13 Kunreuther, Sagara, Slovic, & Schley, 2012). Risk perception has three logically distinct, but overlapping,  
14 aspects: a sense of vulnerability to a threatening event, the likelihood of being harmed by the event and the  
15 extent of harm the event would cause (de Boer, Botzen, & Terpstra, 2015). Lopez Vasquez (2001) also  
16 added that it is important whether the risk is accepted voluntarily or not.

17  
18

### 19 *1.5. The research questions*

20  
21 Our research goal is to determine the impact of earthquakes (a push factor) on the intention to move. In  
22 examining this relationship we must take into account the factors described above, including residential  
23 satisfaction. We are specifically interested in the role of personal factors (cognitions, risk perception and  
24 emotions) in mediating the relationship between the experience of earthquakes and the intention to move.  
25 The research questions are:

- 26 1. Is there a relationship between the experience of earthquakes and the intention to move, taking into  
27 account life-cycle/life-course/life-stage variables, housing career variables, population decline, place  
28 attachment and residential satisfaction?
- 29 2. Is the relationship between the experience of earthquakes and the intention to move, as analysed  
30 according to research question 1, mediated by personal factors, i.e., cognitions, emotions and risk  
31 perception?

32

## 2. *Methods*

### 2.1. *The respondents*

Data for the study presented in this paper were collected in nine “risk municipalities” in the province of Groningen, the Netherlands, in June 2015. These municipalities combined have about 96,500 inhabitants aged 18 years or older and almost 53,000 households. In total, more than 19,000 residents were invited by letter to take part in an internet survey (note that - if preferred - they could also fill in a written questionnaire). Two groups could be distinguished. First, all 811 participants of the “Groninger Panel” who lived within the area were invited. The “Groninger Panel” is a representative sample of the inhabitants of the province of Groningen. The other 18,436 potential respondents were selected by having the nine municipalities take a random sample from their registry based on the following criteria: age  $\geq 18$ , one person per household, not part of the “Groninger Panel” and not living in an institution. The selection was partly stratified to obtain a sufficient number of respondents from smaller villages within the municipalities. More specifically, in four municipalities a stratified sample was taken (based on the criteria described above), and the chance of inclusion varied from 100% in small villages to less than 20% in regions with many more inhabitants. The mean chance of being included in the sample was 38%. In the other five municipalities an aselect sample was taken (based on the criteria described above) and the chance of being included in the sample was 33% (Hoekstra 2016). The response rate was 65% ( $n = 529$ ) for participants from the “Groninger Panel” and 21% ( $n = 3,834$ ) for the randomly selected residents (total = 4,363) (Hoekstra, 2016). Some of the questionnaires were not usable, leading to a total of 4,260 valid responses.

### 2.2. *The outcome variable and predictors*

The outcome variable and the predictors are summarised in Table 1. The outcome variable concerns the intention to move. This was examined using the question: “Do you intend to move within two years?”. The answering categories were: “yes, definitely”, “yes, maybe” and “no”. Data on the following aspects related to life-cycle/life-course/ life-stage were collected and used in the analyses: age, gender, household type and number of persons in the household. For the aspects related to housing career, information on education, monthly net household income and tenure was collected. Both the occurrence of earthquakes and population decline were assumed to act as push factors. We asked whether the respondent had personally experienced one or more earthquakes in Groningen and whether the respondent had personal

1 experience of damage to the dwelling. The indicator for population decline was based on an administrative  
2 distinction made by the national government. Five of the nine municipalities in the risk region are  
3 currently classified as experiencing population decline, while the other four are not (yet).

4 Place attachment was operationalized with the use of three questions. The first question asked  
5 whether the respondent had been born and raised in the province of Groningen and the second concerned  
6 the level to which the respondent felt attached to the region in which he/she currently lives. The third  
7 question concerned the length of residence, as this has been shown to be positively correlated with place  
8 attachment (von Wirth, Grêt-Regamey, Moser, & Stauffacher, 2016).

9 Following Amérigo and Aragonés (1997), residential satisfaction was explored using three  
10 different domains of satisfaction: 1) the dwelling, 2) the dwelling environment and 3) social contacts in  
11 the neighbourhood. Satisfaction with the dwelling was investigated using a composite measure that asked  
12 respondents to indicate their satisfaction with seven different dwelling aspects on a scale ranging from 1  
13 (very satisfied) to 5 (very dissatisfied). These aspects were: size of the dwelling, affordability,  
14 maintenance, attractiveness, access to the internet, energy efficiency and the house price development ( $\alpha =$   
15  $0.69$ ,  $n = 3,689$ ). The reliability of the scale was enhanced by omitting the items on house price  
16 development and internet accessibility, resulting in an alpha coefficient of  $0.74$  ( $n = 4,112$ ; 5 items). The  
17 mean score on this scale was calculated for those who responded to at least 3 of the 5 items ( $n = 4,245$ ).  
18 Note that in the analysis the coding was reversed, such that a higher value indicated more residential  
19 satisfaction. Satisfaction with the residential environment was measured by two items: one that asked  
20 about satisfaction with the current residential environment on a scale ranging from 1 (very satisfied) to 5  
21 (very dissatisfied) and one item that measured the satisfaction with liveability in the residential  
22 environment on a scale ranging from 1 to 10 (the higher, the better). The coding of the first item was  
23 reversed so that a higher value indicated more residential satisfaction. Finally, satisfaction with social  
24 contacts in the neighbourhood was investigated using a composite measure that asked respondents to rate  
25 six different statements on a 5-point Likert scale. These statements were: “I have a lot of contact with my  
26 direct neighbours”, “In this neighbourhood people get on with each other in a pleasant way”, “I live in a  
27 pleasant neighbourhood with a lot of togetherness”, “I feel at home with the people in this  
28 neighbourhood“, “It is unpleasant to live in this neighbourhood” (coding reversed) and “People hardly  
29 know each other in this neighbourhood” (coding reversed) ( $\alpha = 0.83$ ,  $n = 3,699$ ). The mean score on this  
30 scale was calculated for those who responded to at least three of the six items ( $n = 4,238$ ). The scores were  
31 reversed, such that a higher score indicated more satisfaction.

32 The potentially mediating personal factors (cognitions, emotions, risk perception) were  
33 determined with the use of seven different statements that were rated on a 5-point Likert scale (entirely  
34 agree to entirely disagree). Respondents could also indicate: “I don’t know / not applicable”, which was

1 coded as a missing answer. The statements were: “I have psychological problems as a consequence of the  
2 earthquakes”, “I am worried about the safety of my family”, “I feel anxious as a consequence of the  
3 earthquakes”, “I feel unsafe as a consequence of the earthquakes”, “I feel less happy as a consequence of  
4 the earthquakes”, “The threat of future earthquakes makes me insecure” and “I feel that my worries about  
5 the earthquakes are not taken seriously”. We used a Principal components analysis with Varimax rotation  
6 to examine whether the separate items could be combined into one or more underlying dimensions. The  
7 results showed that the seven items reflect one underlying dimension (71% variance explained). A  
8 subsequent Cronbach’s Alpha analysis yielded a value of 0.93, which is quite satisfactory ( $n = 3,211$ ). We  
9 therefore combined the items into one scale, which will be referred to as reflecting “Psychological  
10 distress”. The mean score on the scale was calculated for respondents who had no missing or inconclusive  
11 answers on at least four of the items ( $n = 3,887$ ). Higher scores indicate more psychological distress (more  
12 anxiety, concerns, etc.). Apart from this scale, there was also an item that asked respondents about their  
13 expectations of (further) damage to their dwelling as a consequence of future earthquakes.

14  
15

1 Table 1. Outcome variable and predictors

Outcome variable

Do you intend to move within two years? (yes; maybe; no)

Predictors*Life-cycle/life-course/life-stage related aspects*

Age (< 46; 46-55; 56-65; > 65)

Gender (male; female)

Household type (single; couple; couple with children; single parent)

Number of persons in the household (1; 2; 3; 4; > 4)

*Housing-career related aspects*

Education (low; middle; high; unknown)

Monthly net household income (low; middle; high; unknown)

Tenure (owner-occupied; rental)

*Push factors*

Personal experience of earthquakes in Groningen (yes, once; yes, more than once; no)

Personal experience of damage to the dwelling (no; slight damage; heavy damage; unknown/NA)

Municipality experiencing population decline (yes; no)

*Place attachment*

Born and raised in the province of Groningen? (yes, always; yes, some of the time; no)

Do you feel an attachment to the region in which you live? (very strong; strong; moderate; weak or none)

Length of residence (< 6 years; 6-10 years; > 10 years)

*Residential satisfaction (higher indicates more satisfied)*

Satisfaction with the dwelling (range 1 – 5)

Satisfaction with the current residential environment (range 1 – 5)

Satisfaction with the liveability of the residential environment (1 – 10)

Satisfaction with social contacts in the neighbourhood (1 – 5)

Potentially mediating personal factors

Psychological distress due to earthquakes (range 1 – 5; higher indicates more distress)

Expectation of (further) damage to the dwelling as a consequence of future earthquakes (I don't know; yes; maybe; no)

### 1 2.3. *Statistical methods*

2  
3 The first research question explored whether there is a relationship between the experience of earthquakes  
4 and the intention to move, taking into account life-cycle/life-course/life-stage variables, housing career  
5 variables, push factors (experience of earthquakes and population decline), place attachment and  
6 residential satisfaction. A multinomial logistic regression analysis was performed with “no intention to  
7 move” as the reference category (against “yes, definitely” and “yes, maybe”). To obtain a parsimonious  
8 model, a backward elimination-by-hand procedure was used. This means that initially all predictors were  
9 entered into the analysis and the method “enter” was used. Next, the indicator with the highest, non-  
10 significant, p-value was omitted from the analysis. This process was repeated until only statistically  
11 significant predictors remained ( $p \leq 0.05$ ). Almost all of the variables were categorical and were included  
12 as dummy variables. The indicator contrast method was used. A test of multicollinearity among predictors  
13 indicated no problematic levels of multicollinearity (all condition indices below 10). A correlation matrix  
14 for the numerical variables showed that the highest correlation was found between satisfaction with the  
15 residential environment and satisfaction with the liveability of the residential environment ( $r = 0.48$ ,  $p <$   
16  $0.01$ ,  $n = 4,247$ ). This result also indicates that there is no multicollinearity.

17 The second research question explored whether the relationship between the experience of  
18 earthquakes (independent variable) and the intention to move (dependent variable), as described above, is  
19 mediated by personal factors, in our case measured by psychological distress and the expectation of  
20 (further) damage to the dwelling as a consequence of future earthquakes (hereafter referred to as  
21 “expectation of damage”). In statistical terms, a mediator accounts for the relationship between the  
22 independent variable and the dependent variable (Baron & Kenny 1986). Baron and Kenny (1986) advise  
23 testing for a mediation effect with the use of three regression equations. The first regresses the mediator  
24 on the independent variable, and there should be a statistically significant relationship between both. In  
25 our case, this means predicting psychological distress and/or the expectation of damage on the basis of  
26 experience of earthquakes. The second analysis regresses the dependent variable on the independent  
27 variable. This is the regression described for the first research question (intention to move predicted by  
28 experience of earthquakes). There should be a relationship between both. The third analysis regresses the  
29 dependent variable (the intention to move) on the independent variable (experience of earthquakes) and  
30 either one of the potential mediators (psychological distress or the expectation of damage). In order for  
31 these aspects to have a mediating effect, the relationship of the independent variable with the dependent  
32 variable should in that case be weaker.

### 3. Results

#### 3.1. A short description of the respondents

The total dataset consisted of 4,260 respondents. The appendix includes a table with an overview of frequencies and percentages of nominal variables and a table with means and standard deviations of numerical variables. One third of the sample (33%) was older than 65 years of age and 17% of respondents were aged between 18 and 45. The group was close to equally distributed with regard to gender, education (lower, middle, higher) and monthly household income (low, middle, high and unknown). About half of the respondents (52%) lived as a couple, while 30% of respondents had children living at home. The large majority of respondents were owner-occupiers (87%), lived in a municipality that was experiencing population decline (60%), had been born and raised in the province of Groningen (57%) and lived more than ten years in the current dwelling (74%). Of the respondents, 68% felt a very strong (30%) or strong (38%) attachment to the region. Only 7% reported none or only a weak attachment to the region. Of the respondents, 70% had experienced an earthquake more than once and 79% reported to have experienced damage to the dwelling (62% slight damage and 17% heavy damage). Of the total respondents, 430 (10%) indicated that they intended to move within two years; 1,097 (26%) responded “maybe” and 2,732 (64%) did not intend to move.

We have information on age (18-45: 38%; 46-55: 20%; 56-65: 19%; >65: 23%) and household composition (single: 31%; couple: 34%; couple with children: 28%; single-parent: 7%) of all inhabitants of the nine risk municipalities (the population). This information was calculated from data obtained from Statistics Netherlands for 2014. By comparing our respondent group to the population, we found that older respondents and couples without children were overrepresented and singles were underrepresented.

#### 3.2. Is there a relationship between the experience of earthquakes and the intention to move, taking into account life-cycle/life-course/life-stage variables, housing career variables, population decline, place attachment and residential satisfaction?

A multinomial regression analysis was performed with “no intention to move” as the reference category. Using the backward-elimination-by-hand method the non-statistically significant indicators were eliminated in the following order: income ( $p = 0.73$ ), population decline ( $p = 0.22$ ), gender ( $p = 0.22$ ), tenure ( $p = 0.14$ ), household type ( $p = 0.10$ ) and personal experience of damage to the dwelling ( $p = 0.08$ ). The final model resulted in a statistically superior fit compared to the null model, with the -2 Log

1 Likelihood values decreasing from 7077.50 to 6368.40,  $\chi^2(46) = 709.10$ ,  $p < 0.01$ . The final model  
2 included 11 predictors and had a value of 0.19 for Nagelkerke  $R^2$ . The results are presented in Table 2.  
3 The results show that the respondents who had experienced an earthquake once were not more likely to  
4 have the intention to move than respondents who had no personal experience of earthquakes. However,  
5 respondents who had experienced earthquakes more than once were about 1.6 times (definitely want to  
6 move) and 1.5 times (probably want to move) more likely to have the intention to move than respondents  
7 without personal experience of earthquakes. Thus, in answer to the first research question, it is highly  
8 likely that there is a relationship between the personal experience of earthquakes and the intention to  
9 move. However, this only seems to be the case for respondents who have experienced earthquakes more  
10 than once.

11 The results also show that in addition to personal experience of earthquakes, the intention to move  
12 can be predicted on the basis of life-cycle variables (age and number of persons in the household), a  
13 housing career variable (education), place attachment (all variables) and residential satisfaction (all  
14 variables). Compared to younger respondents ( $\leq 45$ ), older respondents were less likely to have the  
15 intention to move. Furthermore, when compared to single-person households, respondents with larger  
16 households were less willing to move. This effect is somewhat stronger in the group that probably wants  
17 to move. Respondents with a higher education were more willing to move than those with lower  
18 education. Respondents who were born in Groningen, but who had also lived elsewhere, were more likely  
19 to have the intention to move than respondents who had never lived outside Groningen. Furthermore,  
20 respondents with weak or no attachment to the region were more willing to move than respondents with a  
21 moderate, strong or very strong attachment to the region. Respondents with a longer length of residence  
22 were more likely to have the intention to move than respondents who lived up to six years in their current  
23 dwelling. Finally, all four of the indicators of residential satisfaction were statistically significant,  
24 demonstrating that higher residential satisfaction is related to less willingness to move.

25  
26

Table 2. Statistically significant predictors of the intention to move: model without moderators (n = 4,112)

	Definite versus no intention to move						Probable versus no intention to move					
	b	SE	p	OR	Lower	Upper	b	SE	p	OR	Lower	Upper
Constant	6.04	0.55					4.62	0.41				
Personal exp. earthquakes**												
No	---	---	---	---	---	---	---	---	---	---	---	---
Yes, once	0.05	0.24	0.84	1.05	0.65	1.68	0.19	0.15	0.21	1.21	0.90	1.61
Yes, more than once	0.47	0.20	<b>0.02</b>	1.60	1.08	2.37	0.38	0.13	<b>&lt;0.01</b>	1.46	1.14	1.87
Age**												
≤ 45	---	---	---	---	---	---	---	---	---	---	---	---
46 - 55	-0.59	0.19	<b>&lt;0.01</b>	0.55	0.38	0.80	-0.24	0.13	0.07	0.79	0.61	1.02
56 - 65	-0.44	0.20	<b>0.02</b>	0.64	0.44	0.95	-0.41	0.14	<b>&lt;0.01</b>	0.66	0.50	0.87
> 65	-0.70	0.21	<b>&lt;0.01</b>	0.50	0.33	0.75	-0.28	0.15	0.06	0.75	0.56	1.01
Nr of persons in household**												
1	---	---	---	---	---	---	---	---	---	---	---	---
2	-0.09	0.16	0.58	0.92	0.67	1.25	-0.32	0.10	<b>&lt;0.01</b>	0.73	0.59	0.89
3	-0.14	0.21	0.52	0.87	0.57	1.33	-0.35	0.15	<b>0.02</b>	0.71	0.52	0.95
4	-1.24	0.27	<b>&lt;0.01</b>	0.29	0.17	0.49	-0.53	0.16	<b>&lt;0.01</b>	0.59	0.43	0.80
5 or more	-0.60	0.30	<b>0.05</b>	0.55	0.30	0.99	-0.52	0.21	<b>0.01</b>	0.59	0.39	0.89
Education**												
Unknown	-0.46	0.36	0.20	0.63	0.31	1.27	-0.29	0.25	0.24	0.74	0.46	1.21
Lower education	-0.67	0.16	<b>&lt;0.01</b>	0.51	0.38	0.70	-0.27	0.10	<b>&lt;0.01</b>	0.76	0.62	0.93
Middle education	-0.35	0.14	<b>0.01</b>	0.71	0.54	0.93	-0.18	0.10	0.07	0.84	0.69	1.01
Higher education	---	---	---	---	---	---	---	---	---	---	---	---

	Definite versus no intention to move						Probable versus no intention to move					
	b	SE	p	OR	Lower	Upper	b	SE	p	OR	Lower	Upper
Born and raised in Gron.*												
Yes, always lived here	---	---	---	---	---	---	---	---	---	---	---	---
Yes, but also elsewhere	0.33	0.17	<b>0.05</b>	1.39	1.00	1.93	0.28	0.12	<b>0.02</b>	1.32	1.05	1.66
No	-0.06	0.14	0.65	0.94	0.71	1.23	-0.05	0.09	0.61	0.95	0.79	1.15
Attachment to the region**												
Very strong	-1.49	0.21	<b>&lt;0.01</b>	0.23	0.15	0.34	-1.05	0.17	<b>&lt;0.01</b>	0.35	0.25	0.49
Strong	-1.36	0.20	<b>&lt;0.01</b>	0.26	0.17	0.38	-0.82	0.16	<b>&lt;0.01</b>	0.44	0.32	0.60
Moderate	-0.99	0.20	<b>&lt;0.01</b>	0.37	0.25	0.55	-0.47	0.16	<b>&lt;0.01</b>	0.63	0.46	0.86
Weak or no attachment	---	---	---	---	---	---	---	---	---	---	---	---
Length of residence**												
< 6 years	---	---	---	---	---	---	---	---	---	---	---	---
6 – 10 years	0.47	0.21	<b>0.03</b>	1.60	1.05	2.43	0.25	0.16	0.10	1.30	0.95	1.77
> 10 years	0.39	0.19	<b>0.04</b>	1.47	1.02	2.12	0.56	0.13	<b>&lt;0.01</b>	1.76	1.36	2.27
Satisfaction dwelling**												
Satisfaction dwelling**	-0.53	0.10	<b>&lt;0.01</b>	0.59	0.48	0.71	-0.44	0.07	<b>&lt;0.01</b>	0.65	0.56	0.74
Satisfaction res. environm.**												
Satisfaction res. environm.**	-0.29	0.07	<b>&lt;0.01</b>	0.75	0.66	0.85	-0.16	0.05	<b>&lt;0.01</b>	0.85	0.78	0.93
Satisfaction liveability**												
Satisfaction liveability**	-0.35	0.04	<b>&lt;0.01</b>	0.70	0.65	0.77	-0.23	0.03	<b>&lt;0.01</b>	0.79	0.74	0.84
Satisfaction social contacts**												
Satisfaction social contacts**	-0.23	0.09	<b>0.01</b>	0.79	0.66	0.95	-0.22	0.06	<b>&lt;0.01</b>	0.80	0.70	0.90

Note: \* =  $p < 0.05$ , \*\* =  $p < 0.01$

1 3.3. *Is the relationship between the experience of earthquakes and the intention to move, as analysed*  
 2 *according to research question 1, mediated by personal factors?*

3  
 4 For the second research question the mediating effect of personal factors (psychological distress and the  
 5 expectation of future damage) on the relationship between the experience of earthquakes and the intention  
 6 to move is examined, following the method proposed by Baron and Kenny (1986) (see also Section 2.3).

7 The first criterion implies that the mediator should be statistically significantly predicted by the  
 8 independent variable (the experience of earthquakes). To explore this relationship for the expectation of  
 9 damage, a simple  $\chi^2$  analysis was used. The results show that there is a statistically significant  
 10 relationship between the level of personal experience of earthquakes and the expectation of damage ( $\chi^2(6)$   
 11 = 357.33,  $p < 0.01$ ). Table 3 shows that the expectation of damage increases with increasing personal  
 12 experience of earthquakes.

13  
 14 Table 3 Relationship between earthquake experience and expectation of (further) damage to the dwelling  
 15 as a consequence of future earthquakes (n = 4,247)

	Expectation of damage to the dwelling								
	Yes		Maybe		No		I don't know		Total
Experience of earthquakes									
No experience	167	33%	204	40%	23	4%	116	23%	100%
Yes, once	343	44%	302	39%	15	2%	119	15%	100%
Yes, more than once	1985	67%	751	25%	24	1%	198	7%	100%

16  
 17  
 18 To test the relationship between psychological distress and earthquake experience, an ordinary  
 19 least squares (OLS) regression analysis was performed with psychological distress (range 1 to 5) as the  
 20 dependent variable and experience of earthquakes as the independent variable (using dummy variables).  
 21 The results show that the regression analysis is statistically significant ( $F = 153.24$ ,  $p < 0.01$ ,  $n = 3,884$ )  
 22 and that 7% of the variance in psychological distress is explained by experience of earthquakes. Compared  
 23 to respondents without experience of earthquakes, those who have experienced an earthquake once have,  
 24 on average, a 0.21 higher level of psychological distress ( $t = 3.40$ ,  $p < 0.01$ ) and those who have

1 experienced an earthquake more than once have on average a 0.74 higher level of psychological distress ( $t$   
2 = 14.05,  $p < 0.01$ ). Based on the results, we can conclude that the first criterion for being a moderator is  
3 met for both psychological distress and the expectation of damage.

4 The second criterion argues that there should be a statistically significant relationship between the  
5 dependent variable (the intention to move) and the independent variable (experience of earthquakes). The  
6 results examined under research question 1 showed that this was the case.

7 To test for the third criterion, an analysis that regresses the dependent variable (the intention to  
8 move) on the independent variable (experience of earthquakes) and either one of the mediators  
9 (psychological distress or the expectation of damage) is performed. The effect of the independent variable  
10 (experience of earthquakes) on the outcome (intention to move) should be weaker than when the mediator  
11 (either the expectation of damage or psychological distress) is not included.

12 A multinomial regression analysis was performed in the same manner as described under research  
13 question 1, but now the expectation of damage was also included. Using the backward-elimination-by-  
14 hand method, the indicators were eliminated in the following order: income ( $p = 0.70$ ), personal  
15 experience of damage to the dwelling ( $p = 0.28$ ), tenure ( $p = 0.29$ ), gender ( $p = 0.21$ ), population decline  
16 ( $p = 0.23$ ) and household type ( $p = 0.08$ ). The final model resulted in a statistically superior fit compared  
17 to the null model, with the -2 Log Likelihood values decreasing from 7083.10 to 6348.70,  $\chi^2(52) =$   
18 734.40,  $p < 0.01$ . The final model included 12 predictors (the same 11 as for research question 1, plus the  
19 expectation of damage) and had a value of 0.20 for Nagelkerke  $R^2$ . The results show that the personal  
20 experience of earthquakes is still a statistically significant predictor of the intention to move ( $p = 0.02$ ).  
21 However, its influence has decreased and a statistically significant effect ( $p = 0.02$ ) is observed only in the  
22 group that probably intends to move. When compared to respondents without experience, those who have  
23 experienced an earthquake more than once are 1.3 times more likely to intend to move (95% CI: 1.04 -  
24 1.70). Furthermore, the effect of the expectation of damage, although highly statistically significant in the  
25 overall model ( $p < 0.01$ ), did not reach statistical significance in the separate models when both groups  
26 (maybe and definitely intend to move) are compared against the no intention to move group. This result  
27 indicates that the expectation of damage plays only a small role in mediating the relationship between the  
28 personal experience of earthquakes and the intention to move.

29 Subsequently, a multinomial regression analysis was performed in the manner described above,  
30 but now psychological distress was included to determine its influence as a mediator. Using the backward-  
31 elimination-by-hand method the indicators were eliminated in the following order: tenure ( $p = 0.64$ ),  
32 personal experience of damage to the dwelling ( $p = 0.53$ ), population decline ( $p = 0.49$ ), income ( $p =$   
33 0.35), gender ( $p = 0.17$ ), household type ( $p = 0.10$ ) and born and raised in Groningen ( $p = 0.07$ ). The final  
34 model resulted in a statistically superior fit compared to the null model, with the -2 Log Likelihood values

1 decreasing from 6579.65 to 5748.97,  $\chi^2(44) = 830.69$ ,  $p < 0.01$ . The final model included 11 predictors  
2 and had a value of 0.24 for Nagelkerke  $R^2$ . The predictors are the same as those for research question 1,  
3 except for “Born and raised in Groningen”. This variable just reached statistical significance in the first  
4 analysis ( $p = 0.049$ ), but just failed to reach significance in the second analysis ( $p = 0.067$ ). The results of  
5 the analysis are presented in Table 4. The results show that the personal experience of earthquakes is no  
6 longer a statistically significant predictor of the intention to move ( $p = 0.72$ ). Instead, a one-point increase  
7 in psychological distress (on a five-point scale) was related to being 1.8 times more likely to intend to  
8 move in the group that definitely wants to move and 1.6 times more likely to move in the group that  
9 probably wants to move. The results for the other predictors were similar to those described above.

10 In summary, there is strong evidence that psychological distress is a mediator of the relationship  
11 between personal earthquake experience and the intention to move. Such evidence is not prevalent for the  
12 expectation of damage to the dwelling.

13

Table 4. Statistically significant predictors of the intention to move: model with both earthquake experience and psychological distress (n = 3782)

	Definite versus no intention to move						Probable versus no intention to move					
	b	SE	p	OR	Lower	Upper	b	SE	p	OR	Lower	Upper
Constant	4.37	0.62					3.16	0.46				
Personal exp. earthquakes												
No	---	---	---	---	---	---	---	---	---	---	---	---
Yes, once	-0.10	0.27	0.69	0.90	0.53	1.52	0.12	0.16	0.46	1.13	0.82	1.56
Yes, more than once	0.09	0.22	0.69	1.09	0.70	1.70	0.07	0.14	0.62	1.07	0.81	1.42
Psychological distress**	0.59	0.07	<b>&lt;0.01</b>	1.81	1.58	2.07	0.47	0.04	<b>&lt;0.01</b>	1.60	1.46	1.75
Age**												
≤ 45	---	---	---	---	---	---	---	---	---	---	---	---
46 - 55	-0.60	0.20	<b>&lt;0.01</b>	0.55	0.37	0.81	-0.24	0.14	0.08	0.79	0.60	1.02
56 - 65	-0.50	0.20	<b>0.01</b>	0.61	0.41	0.90	-0.44	0.15	<b>&lt;0.01</b>	0.64	0.48	0.86
> 65	-0.67	0.22	<b>&lt;0.01</b>	0.51	0.33	0.79	-0.21	0.15	0.18	0.81	0.60	1.10
Nr of persons in household**												
1	---	---	---	---	---	---	---	---	---	---	---	---
2	-0.06	0.17	0.73	0.94	0.67	1.32	-0.35	0.11	<b>&lt;0.01</b>	0.70	0.56	0.87
3	-0.13	0.23	0.57	0.88	0.56	1.37	-0.41	0.16	<b>0.01</b>	0.66	0.49	0.91
4	-1.27	0.28	<b>&lt;0.01</b>	0.28	0.16	0.48	-0.59	0.16	<b>&lt;0.01</b>	0.55	0.40	0.76
5 or more	-0.70	0.31	<b>0.03</b>	0.50	0.27	0.92	-0.66	0.22	<b>&lt;0.01</b>	0.51	0.33	0.79

	Definite versus no intention to move						Probable versus no intention to move					
	b	SE	p	OR	Lower	Upper	b	SE	p	OR	Lower	Upper
Education**												
Unknown	-0.85	0.43	<0.05	0.43	0.18	0.99	-0.24	0.26	0.36	0.79	0.47	1.31
Lower education	-0.68	0.16	<0.01	0.51	0.37	0.69	-0.27	0.10	<b>0.01</b>	0.76	0.62	0.94
Middle education	-0.40	0.14	<0.01	0.67	0.51	0.89	-0.18	0.10	0.07	0.84	0.69	1.02
Higher education	---	---	---	---	---	---	---	---	---	---	---	---
Attachment to the region**												
Very strong	-1.86	0.23	<0.01	0.16	0.10	0.24	-1.22	0.18	<0.01	0.29	0.21	0.42
Strong	-1.55	0.21	<0.01	0.21	0.14	0.32	-0.92	0.17	<0.01	0.40	0.28	0.56
Moderate	-1.09	0.21	<0.01	0.34	0.22	0.51	-0.48	0.18	<0.01	0.62	0.44	0.88
Weak or no attachment	---	---	---	---	---	---	---	---	---	---	---	---
Length of residence**												
< 6 years	---	---	---	---	---	---	---	---	---	---	---	---
6 – 10 years	0.41	0.22	0.06	1.51	0.97	2.34	0.23	0.16	0.16	1.26	0.91	1.74
> 10 years	0.32	0.19	0.10	1.38	0.94	2.02	0.51	0.14	<0.01	1.67	1.28	2.19
Satisfaction dwelling**												
Satisfaction dwelling**	-0.54	0.10	<0.01	0.58	0.47	0.71	-0.45	0.08	<0.01	0.64	0.55	0.74
Satisfaction res. environm.**												
Satisfaction res. environm.**	-0.31	0.07	<0.01	0.73	0.64	0.84	-0.14	0.05	<0.01	0.87	0.78	0.96
Satisfaction liveability**												
Satisfaction liveability**	-0.23	0.05	<0.01	0.80	0.73	0.87	-0.14	0.04	<0.01	0.87	0.81	0.93
Satisfaction social contacts**												
Satisfaction social contacts**	-0.28	0.10	<0.01	0.76	0.62	0.92	-0.26	0.07	<0.01	0.77	0.68	0.88

Note: \*\* =  $p < 0.01$

#### 4. Discussion and conclusion

The goal of this paper was to determine whether there is a relationship between the earthquakes that are occurring in the region of Groningen and the intention to move. Our results show that this seems to be the case, but that this relationship is mediated by the level of psychological distress that the residents experience. This means that it is not the experience of earthquakes as such that determines the intention to move, but the way in which residents handle the threat of earthquakes.

Our results show that respondents of a younger age, with higher education and single-person households are more likely to intend to move, which is consistent with the literature (Clark & Dieleman, 1996; Böheim & Taylor, 2002; Clark, Deurloo, & Dieleman, 2003; Clark & Huang, 2003). We found no relationship between tenure and the intention to move. Usually, renters are more likely to move than home-owners, because the costs of moving are higher for home-owners and because home-owners take more pride in their own home (Speare, 1974; Clark & Dieleman, 1996; Böheim & Taylor, 2002; Clark, Deurloo, & Dieleman, 2003). That this is not the case in our study might be due to the fact that owner-occupiers might worry more about (future) damage to their dwelling and house price depreciation, which might make them more eager to move. Research has shown that, in the case of flooding, homeowners are more risk aware than renters (Burningham, Fielding, & Thrush, 2008). We also found no effect for income. Other studies, for example Clark and Dieleman (1996), Böheim and Taylor (2002) and Clark and Huang (2003), found that wealthier households were more mobile because they had more opportunities to realise their housing preferences. Apparently, money plays no role in the willingness to move in our study. Perhaps it is as difficult for people with lower and higher incomes to sell their current dwelling (most of the residents are owner-occupiers) for a reasonable price. Both groups have mortgage commitments and cannot easily buy or rent a place somewhere else.

We found a weak effect of length of residence, which suggested that respondents who have lived in their dwelling for a relatively long period are more likely to be willing to move. This result contradicts the literature as length of residence has been shown to be positively correlated with place attachment (von Wirth, Grêt-Regamey, Moser, & Stauffacher, 2016). The shorter the length of stay in a specific place, the less someone has invested in and becomes attached to that locality (Speare, 1974; Böheim & Taylor, 2002). At the same time, it could also be argued that residents with a shorter period of residence do not intend to move because they did so relatively recently, thereby investing time, money and other moving costs. Clark and Dieleman (1996) found that the relationship between duration and mobility is more complicated. Not only was duration since the last move important but also the total number of moves and their order of occurrence, both of which can have an influence on the probability of moving. One possible reason for the positive relationship between length of residence and the willingness to move in our study

could be that residents with a longer period of residence live in older dwellings that have experienced more damage and might be relatively vulnerable to future damage. More recent residents could live in more recently built (and stronger) dwellings. Furthermore, they might have been aware of the earthquake threat and for that reason have bought qualitatively better dwellings or might have renovated their dwelling directly after buying. Unfortunately, we have no information on the age of the respondents' dwellings or of their maintenance level to verify this hypothesis. However, a crosstable shows that respondents residing in the dwelling for a period of less than six years have indeed less frequently reported damage to their dwelling than respondents with a longer period of residence.

Furthermore, the relationship between length of residence and the intention to move may be influenced by place attachment, which was also present in our models. With regard to place attachment, a more general item on how attached to the region residents felt, proved to be more important than the item on whether or not the residents had been born and raised in Groningen. The results show that respondents with weak or no attachment were more willing to move than respondents with a stronger attachment to the region. This result agrees with studies that consider place attachment to be reflected in behavioural terms by the desire to remain close to a place (Scannell & Gifford, 2010). An elaborate review by Bonaiuto, Alves, De Dominicis and Petruccelli (2016) has shown that residents who experience high place attachment are generally unwilling to relocate in the case of a risk of environmental hazard. The authors argued that place attachment seems to undermine the potential of coping with risk, such as planning to relocate. De Dominicis et al. (2015) have empirically shown that place attachment might hamper preventive behaviours to cope with an environmental risk (in their case flooding), when the perceived risk is high. One of the possible explanations for this finding could be a spatial optimistic bias (De Dominicis et al. 2015, Bonaiuto, Alves, De Dominicis, & Petruccelli, 2016), also known as optimistic comparable perceptual bias (Sarabia-Sanchez & Rodriguez-Sanchez, 2016). For our study this would mean that residents with strong place attachment might accept the probability of future earthquakes in the region in general but might underestimate the individual risk that it poses to them, as they perceive their home as a safe haven in times of threat and risk. It would be interesting for a future study to explore the role of place attachment as a moderator in the relationship between risk perception and preventive behaviour, and for different levels of actual risk. Research by De Dominicis et al. (2015), for example, showed that the influence of place attachment on hampering preventive behaviours seems to be stronger in situations of high risk than in situations of lower risk. In addition, it would be interesting to explore the role of psychological distress in the relationship between place attachment, risk perception and preventive behaviours as well as the role of socio-demographic characteristics. Research by Burningham, Fielding and Thrush (2008) has shown that risk perception is higher with increasing age (up to 65), length of residence (longer than one year), being an owner-occupier and higher social class. Nevertheless, another

explanation for the strong relationship between place attachment and the intention to move could lie in a the negative result of the trade-off between moving away to a secure, but less valued, place and facing the risks of the current, highly valued, location (Wachinger, Renn, Begg, & Kuhlicke, 2013; Bonaiuto, Alves, De Dominicis, & Petruccelli, 2016).

All four indicators of residential satisfaction were statistically significant, demonstrating that more satisfaction is related to a lower likelihood of intending to move. This agrees with the literature, for example the studies by Speare (1974), Amérgo and Aragonés (1997) and Lu (1999). It is interesting to note that the three domains (dwelling, dwelling environment and social contacts) independently showed a relationship with the intention to move. This indicates that the three domains are indeed different, but related, aspects of residential satisfaction as suggested by Amérgo and Aragonés (1997). The findings also agree with the notion of a residential environment as having a dual layer that is composed of physical and social dimensions (Shin, 2016).

Our results showed that the expectation of (further) damage to the dwelling increased with increasing personal experience of earthquakes. This result might partly be due to the “availability heuristic”, which argues that images of the future are shaped by the experience of the past (Tversky & Kahneman, 1973). Having experienced a striking event, such as an earthquake, increases the subjective probability of such an event. A similar result was found in a study by Whitmarsh (2008), who showed that direct experience of flooding increases the likelihood of accepting that flooding poses a genuine personal risk. Moreover, Barnett and Breakwell (2001) showed that the experience of negative involuntary activities was related to a greater risk concern. Peters, Kunreuther, Sagara, Slovic and Schley (2012) argued that negative personal experiences influence self-protective behaviours by increasing affect. They showed, among other findings, that previously burgled people worried more about being burgled and were more likely to buy a second lock as a precaution than people who had no such experience.

This study has a number of limitations. First, it is important to note that, just like any actual move, the intention to move is influenced by the policy and housing market context in which they develop. This context determines the choices that households have with regard to moving. Constraints, such as low demand and house price depreciation in the current location and relatively high house prices in the desired location, might negatively affect the residents’ sense of having a choice. Residents might feel trapped in their current dwelling and see no possibility to move. A second limitation concerns the cross-sectional design of our study, which means that we can only explore relationships, but not causal connections. We assume that psychological distress is a concern that influences the intention to move but we cannot prove that this is the case. A third point that should be mentioned is that all respondents lived in the risk community and therefore there is no reference group of unexposed residents. However, within the risk community there are regions with more damage to dwellings and regions with less damage, as officially

registered by NAM (the company that financially compensates for the damage). Hoekstra (2016) showed that respondents living in a region that has experienced more damage also report more earthquake experience than those living in a region with less damage. This provides some face validity to the notion that personal experience of earthquakes is related to actual damage, and probably to the severity and frequency of past earthquakes. Fourth, the composition of the respondent group was not entirely representative of the population of the nine risk municipalities. Residents of some smaller villages were oversampled because we wanted to present reliable results on the level of individual (small) villages in the final research report. Furthermore, our results showed that older respondents and couples without children were overrepresented and single households were underrepresented. This is probably due to the fact that older people are more often owner-occupiers. Owner-occupiers, as described above, might be concerned about (further) damage to their dwelling and they might therefore be more eager to participate in the survey. The overrepresentation of older respondents and couples might have led to a lower intention to move as research has shown that younger people and single-person households are more likely to have the intention to move (Clark & Dieleman, 1996; Böheim & Taylor, 2002; Clark, Deurloo, & Dieleman, 2003; Clark & Huang, 2003). Nevertheless, we do not expect this to have an effect on the final conclusions of our study regarding the relationships between the experience of earthquakes, psychological distress and the intention to move as age, household composition and tenure were included in the statistical analyses and thus were corrected for. A fifth limitation concerns the Psychological distress scale, which consisted of a mix of items reflecting cognitions, emotions and risk perception issues. Unfortunately, we were not able to further refine the scale to make a distinction between items reflecting cognitions, items reflecting emotions and risk perception issues. A sixth point concerns the fact that the survey was filled out by an individual member of the household and consequently does not necessarily reflect the household's opinion. Nevertheless, the impact of the earthquakes on residential satisfaction and the intention to move is an important topic in the municipalities at risk and it can be assumed that family members have discussed these topics with each other. A seventh limitation concerns the limited number of predictors in the analysis. The pseudo  $R^2$  of the multinomial regression analysis including psychological distress was 0.24, which indicates that almost a quarter of the variation is explained by the predictors. We were clearly not able to capture all of the relevant predictors of the intention to move in the survey. We were limited in the number of questions that we could include by the fact that the survey also covered other topics. A final limitation that we would like to mention is that we studied only one aspect of coping, namely the intention to move. There are many other coping strategies. For example, a group of 127 residents blames NAM and has recently won a case against NAM to obtain compensation for immaterial damage (decrease in housing pleasure and increased psychological distress). Other ways of coping include merely accepting the situation, seeking information or social support and becoming depressed.

In conclusion, our results support the statement that ecologically hazardous features cause stress only when the individual interprets these features of the environment as a threat (Kiecolt & Nigg, 1982). This finding could be the starting point for preventing out-migration by improving the quality of life and residential satisfaction of residents living in the region. This would entail actions such as recognition of the problems by the national government, providing residents with psychological support in handling their concerns and fears, better communication and giving residents some sense of security with regard to the value and saleability of their dwellings. Helping residents fight might prevent them from flight.

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## Appendix I Overview of nominal predictors

Intention to move	Yes		Maybe		No		Total	
	n	%	n	%	n	%	n	%
<i>Life-cycle variables</i>								
Age (n = 4221)								
18 - 45	101	24%	201	18%	422	16%	724	17%
46 - 55	82	19%	239	22%	553	20%	874	21%
56 - 65	132	31%	283	26%	814	30%	1229	29%
> 65	111	26%	365	33%	918	34%	1394	33%
Gender (n = 4259)								
Male	224	52%	555	51%	1359	50%	2138	50%
Female	206	48%	542	49%	1373	50%	2121	50%
Household type (n = 4231)								
Single	76	18%	227	21%	457	17%	760	18%
Couple	230	54%	540	49%	1446	53%	2216	52%
Couple with kids	101	24%	285	26%	741	27%	1127	27%
Single-parent	21	5%	38	3%	69	2%	128	3%
Number of persons in household (n = 4242)								
1	76	18%	224	20%	453	17%	753	18%
2	237	55%	561	51%	1520	56%	2318	55%
3	61	14%	124	11%	276	10%	461	11%
4	29	7%	131	12%	340	12%	500	12%
> 4	25	6%	54	5%	131	5%	210	5%
<i>Housing career variables</i>								
Education (n = 4259)								
Lower education	99	23%	322	29%	871	32%	1292	30%
Middle education	136	32%	346	31%	864	32%	1346	32%
Higher education	181	42%	393	36%	909	33%	1483	35%
Unknown	14	3%	36	3%	88	3%	138	3%

Intention to move	Yes		Maybe		No		Total	
	n	%	n	%	n	%	n	%
Net monthly household income (n = 4259)								
Low ( $\leq$ € 2000)	105	24%	283	26%	638	23%	1026	24%
Middle (€ 2001 - € 3000)	96	22%	260	24%	634	23%	990	23%
High ( $>$ € 3000)	107	25%	248	23%	694	25%	1049	25%
Unknown	122	28%	306	28%	766	28%	1194	28%
Tenure (n = 4259)								
Owner-occupied	364	85%	962	88%	2395	88%	3721	87%
Rental	66	15%	135	12%	337	12%	538	13%
<i>Push factors</i>								
Has experienced earthquakes (n = 4250)								
No	36	8%	107	10%	368	13%	511	12%
Yes, once	56	13%	186	17%	539	20%	781	18%
Yes, more than once	335	78%	803	73%	1820	67%	2958	70%
Has experienced damage to dwelling (n = 4259)								
No	30	7%	87	8%	316	12%	433	10%
Yes, slight damage	251	58%	668	61%	1734	63%	2653	62%
Yes, heavy damage	105	24%	217	20%	404	15%	726	17%
Unknown/not applicable	44	10%	125	11%	278	10%	447	10%
Population decline (n = 4258)								
Yes	287	67%	678	62%	1585	58%	2550	60%
No	142	33%	419	38%	1147	42%	1708	40%

Intention to move	Yes		Maybe		No		Total	
	n	%	n	%	n	%	n	%
<i>Personal factors</i>								
Risk perception: expectation of damage to dwelling (n = 4253)								
Yes	299	70%	704	64%	1491	55%	2494	59%
Maybe	82	19%	283	26%	896	33%	1261	30%
No	6	1%	8	1%	49	2%	63	1%
I don't know	42	10%	102	9%	291	11%	435	10%
<i>Place attachment</i>								
Born and raised in Groningen (n = 4237)								
Yes, always lived here	220	51%	604	55%	1592	59%	2416	57%
Yes, but also elsewhere	70	16%	167	15%	314	12%	551	13%
No	139	32%	323	29%	808	30%	1270	30%
Attachment to the region (n = 4199)								
Very strong	95	22%	246	23%	903	33%	1244	30%
Strong	129	31%	390	36%	1084	40%	1603	38%
Moderate	120	28%	336	31%	596	22%	1052	25%
Weak or no attachment	78	18%	113	10%	109	4%	300	7%
Length of residence (n = 4224)								
< 6 years	58	14%	120	11%	383	14%	561	13%
6 – 10 years	71	17%	131	12%	340	12%	542	13%
> 10 years	298	70%	835	77%	1988	73%	3121	74%

## Appendix II Overview of numerical predictors

Intention to move	Yes			Maybe			No			Total		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
<i>Personal factors</i>												
Earthquake-related psychological distress (n = 3930)	403	3.22	0.93	1028	3.02	0.87	2499	2.60	0.82	3930	2.77	0.88
<i>Residential satisfaction</i>												
Satisfaction with dwelling (n = 4244)	428	3.64	0.73	1094	3.73	0.61	2722	3.96	0.54	4244	3.87	0.59
Satisfaction with current residential environment (n = 4249)	429	3.37	1.08	1091	3.65	0.93	2729	4.01	0.89	4249	3.85	0.95
Satisfaction with liveability in residential environment (n = 4254)	427	6.53	1.91	1096	7.04	1.40	2731	7.72	1.20	4254	7.43	1.40
Satisfaction with social contacts in neighbourhood (n = 4237)	425	3.46	0.77	1094	3.54	0.65	2718	3.79	0.63	4237	3.69	0.67

- The impact of earthquakes on moving intention is mediated by psychological distress
- Being young, high educated or single is related to a higher intention to move
- Having weak or no attachment to the region is related to a higher intention to move
- Higher residential satisfaction is related to a lower intention to move
- Experience of earthquakes increases expectation of future damage to the dwelling

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