Title: Sociodemographic predictors of residents worry about contaminated sites

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Abstract

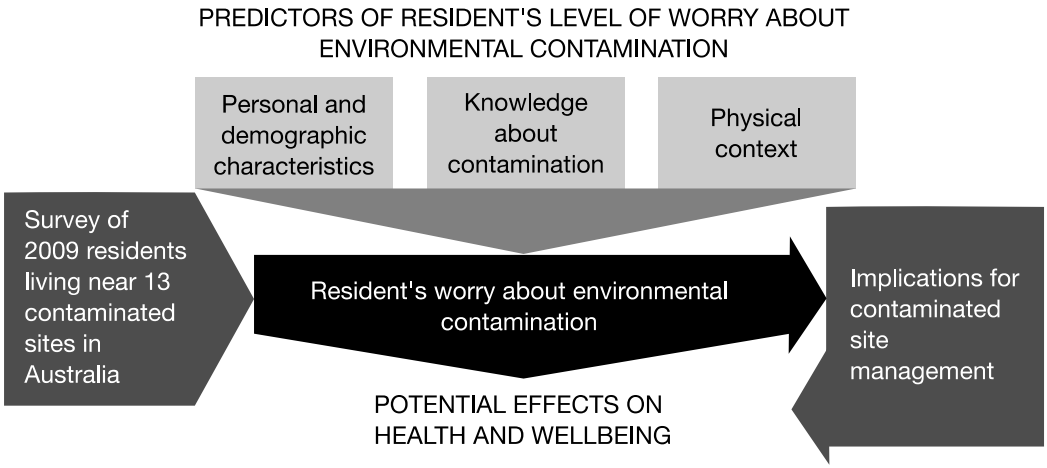
The management and remediation of contaminated environments increasingly involves engagement with affected local residents. Of late, risk communication tools and guidelines have drawn attention to the stress and concern of residents as a result of heightened awareness of localised contamination and the need to address these less visible impacts of contamination when engaging with affected communities. Despite this emerging focus, there is an absence of research exploring the factors that predict resident worry about neighbourhood contamination. This paper aims to address this shortcoming by drawing on data from a cross-sectional survey of 2,009 adult residents in neighbourhoods near 13 contaminated sites across Australia. Analyses used ordered logistic regression to determine the sociodemographic, environmental, and knowledge-based factors that influence residents' degree of worry. The findings suggest age, gender and income significantly affect residents' degree of worry. Being knowledgeable about the contaminant was associated with lower degrees of worry. Conversely, having a stronger sense of place within a neighbourhood predicted higher degrees of worry. Type of contaminant also impacted resident worry, with residents being less likely to worry about hydrocarbon, asbestos and waste than other types of contaminants. Our analyses suggest resident worry can be

reduced through improving access to accurate information and the development of specific risk reduction strategies tailored to each neighbourhood and aimed at the heterogeneous distribution of worry amongst residential populations.

Keywords

Worry, residents, contaminated land and groundwater, policy and practice, engagement

Graphic Abstract



Highlights (max 85 characters for each highlight including spaces):

- Framework for understanding residents' worry about neighbourhood contamination
- Details diverse factors, including contaminant types, which affect residents' worry
- Provides insights through a survey of 2,009 residents living near 13 contaminated sites
- Details how residents' worries can be used to enhance contaminated site management

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1. Introduction

Environmental contamination in residential communities is widespread and presents significant risks to public health (Fazzo et al., 2017; Norris et al., 2002). Research shows that exposure to acute environmental hazards, such as natural disasters, can have significant effects on mental health, cause significant stress and trauma, and lead to feelings of fear and helplessness (Evans, 2003). In recent years these effects on mental health have been increasingly acknowledged within environmental contamination health policy, as the Australian EnHealth Environmental Health Risk Assessment guidelines state "high levels of stress, concern … are bound to make the already complex task of risk communication more difficult" (EnHealth, 2012 , p. 88-89). Such policy concerns have been recognised in broader remediation engagement and guidelines acknowledging that 'heightened stress and anxiety to the point of dread' may be observed in groups affected by living in or near contaminated sites, (Heath et al., 2010). It has been argued that contaminated site management and remediation approaches need to recognize the value of engaging diverse stakeholder experiences, including those of affected residents, in their efforts to produce more holistic, sustainable approaches to contaminated sites (Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, 2014; EnHealth, 2012 ; National Environment Protection Council, 1999).

Residents living near contaminated sites are required to navigate a range of complex issues in their day-to-day lives, such as: having reduced access to neighbourhood spaces, increased costs and inconvenience associated with managing their exposure to contaminants, management of known health problems, prevention of unknown future health problems, litigation processes, communication with government organisations and industry related to the contamination, and impacts from remediation of the contaminated site (Couch and Coles, 2011; Cuthbertson et al., 2016; Peek et al., 2009a; Prior et al., 2017; Shusterman et al., 1991; Takebayashi et al., 2017; Wakefield and Elliott, 2000). Having to manage these issues contributes to existing "daily hassles" (e.g. financial management, traffic, household conflict) leading to stress proliferation (Couch and Coles, 2011), which can manifest as a chronic type of stress (Couch and Coles, 2011) that can increase levels of worry (Zlomke and Jeter, 2014). In the case of neighbourhood contamination, the proliferation of stress can persist for long periods of time, due to the lengthy processes involved in remediation of contaminated sites and a range of complex factors (Couch and Coles, 2011; Matthies et al., 2000; Prior et al., 2017). Consequently, it is critical to have a comprehensive understanding of worry in the context of chronic neighbourhood environmental contamination.

Worry is a cognitive state of repetitive thinking related to stress, and a characteristic feature of anxiety (Hirsch and Mathews, 2012; Watkins, 2008). Worry is commonly defined as "a chain of thoughts and images, negatively affect-laden, and relatively uncontrollable" (Brosschot et al., 2006 113). Worry focuses on potential future negative events, and is related to fear, which differs from (although related to) rumination which is a form of repetitive thinking focused on the past (Watkins, 2008; Zoccola and Dickerson, 2012). When it is brief and controllable worry can serve as a constructive process that assists in problem solving and preparation for managing potential threats (Brosschot et al., 2006; Watkins, 2008). However, worry is more often studied in the context of being chronic and pathological, as it is involved in most anxiety disorders and associated with depression (McLean et al., 2011; Newman et al., 2013; Watkins, 2008). In this context, worry is considered a problematic perseverative cognition (Brosschot et al., 2006), and is involved in the development and maintenance of generalised anxiety disorder (Newman et al., 2013) and physical health problems such as cardiovascular disease (Brosschot, 2010; Brosschot et al., 2006), and can cause negative effects on the immune system and increase inflammatory responses (Peek et al., 2009b).

In the context of chronic environmental contamination, worry is also related to a person's perceived uncertainty about a potential risk. Having uncertainty about the future is influenced by a perceived lack of knowledge about a situation (Lima, 2004; Powell et al., 2007). Studies have found that residents affected by neighbourhood contamination report worrying (or having "concerns") about future uncertainty of health impacts, financial security, community acceptance, and remediation technologies (Cuthbertson et al., 2016; Prior et al., 2017; Shusterman et al., 1991; Wakefield and Elliott, 2000). In addition, uncertainty is considered to be an important contributor to psychological stress associated with chronic environmental contamination (Couch and Coles, 2011; Lima, 2004; Matthies et al., 2000).

The psychological impact of exposure to chronic technological disasters (human-caused environmental hazards) can be greater than the physical health effects (Cline et al., 2014; Norris et al., 2002). Yet, despite the increasing emphasis on psychological impacts in contaminated site policy, research on the health effects of contamination in residential environments remains primarily focused on direct "objective" risks related to physical and mental health (Brender et al., 2011; Norris et al., 2002; Weems et al., 2018). This comes at the expense of examining the indirect "subjective" mental health and wellbeing of people

living in neighbourhoods affected by environmental contamination (Couch and Coles, 2011; Cuthbertson et al., 2016; Norris et al., 2002). Specifically, there is a dearth of research exploring the cognitive factors related to the stress of living with exposure to chronic environmental contamination that influence mental health and wellbeing, such as persistent long-term worry. This paper addresses this significant gap by reporting the results of a study that explored the predictors of resident's worry about neighbourhood contamination. The study provides insights to help consider how to better integrate the indirect "subjective" psychological experiences of residents into the development of more holistic and sustainable approaches to contaminated site management and remediation.

In this paper we present a conceptual framework of worry about neighbourhood contamination. Following this we describe a survey designed to determine the sociodemographic and environmental determinants of a person's level of worry about contamination in their neighbourhood. The paper concludes with a discussion of the primary factors involved in the development of high amounts of worry about neighbourhood contamination, and the health implications of high levels of chronic worry. Strategies to mitigate this health risk are suggested.

2. A conceptual framework for understanding worry related to neighbourhood environmental contamination

Here we present a conceptual framework—developed from the broader literature on worry and perceptions of environmental risk (Auyero and Swistun, 2008; Brosschot, 2010; Brosschot et al., 2006; Powell et al., 2007; Sjoberg, 1998; Vaughan, 1993)—that seeks to explain the primary determinants of residents' worry about environmental contamination.

While worry as a cognitive process can play a positive role in decision-making more generally, it also has the potential to cause significant distress if it is uncontrollable and persistent (Brosschot et al., 2006). Living in a neighbourhood affected by contamination has the potential to cause residents long-term persistent worry related to stress, as the contamination can be present for unknown periods of time and the remediation process can be slow and have unknown consequences (Prior et al., 2017). A consequence of having unknown risks when living near contaminated sites is uncertainty about the future. This may lead to long-term worry causing distress and posing a risk to mental health and wellbeing, even becoming pathological in some cases (Brosschot, 2010). Worry is considered pathological when its severity and duration is disproportionate to what would normally be expected in a specific circumstance (Cuthbertson et al., 2016). Whether or not worry causes

psychological stress and develops into more serious mental health problems is dependent on interacting individual psychosocial and environmental factors.

The framework developed to inform our study identifies three discrete but interacting dimensions that influence residents' level of worry about neighbourhood contamination. The first dimension in our framework reflects the personal and demographic features that influence resident's level of worry about contamination. For example, females have been found to be more likely to worry about environmental concerns compared to men (Powell et al., 2007), and mothers with children at home may be at greater risk of worry due to concerns about the future health impacts of chronic environmental contamination for their family (Couch and Coles, 2011; Takebayashi et al., 2017). Demographic variables also influence risk perception, which is related to worry, with higher levels of education and financial security associated with less concern about environmental risks (Slimak and Dietz, 2006). The literature also suggests that vulnerable populations (e.g. low socioeconomic status, specific cultural groups) may be at risk of higher levels of worry about contamination (Powell et al., 2007), as they experience a greater number of daily stressors leading to greater stress proliferation (Couch and Coles, 2011).

The second dimension in our framework constitutes a person's level of knowledge about the contamination in their neighbourhood. A person's perceived lack of knowledge about contamination influences their level of worry about the contamination (Powell et al., 2007). Perceived uncertainty about the future is influenced by a lack of knowledge regarding a specific situation, which can also lead to worry (Powell et al., 2007).

Physical context is the third dimension in our framework, which includes contaminant type, tenure of home ownership, physical proximity to the contaminated site, and resident's sense of place within their neighbourhood environment. The concept of sense of place refers to how a specific physical location can have significant strong socially constructed meanings for people developed through familiarity and interaction over time (Venables et al., 2012). Having a sense of place is an important determinant of resilience where there is environmental risk (e.g. contamination) in a neighbourhood (Venables et al., 2012). A number of studies suggest people with a strong sense of place tend to have less concern for potential environmental risks in their area (Venables et al., 2012). Previous studies examining the impact of physical proximity to environmental contaminants suggest that in relation to long-term contamination rather than new developments involving hazardous substances, physical proximity is associated with lower levels of concern and greater

acceptance of risk (Burningham and Thrush, 2004; Venables et al., 2012). Home ownership is related to a person's sense of place; people who own their homes may have stronger emotional connections to their neighbourhood, and a greater sense of security and control over their environment that influences their attachment to place (Easthope, 2004; Venables et al., 2012). There is scant research on the relation between worry about environmental contamination and home ownership; however, recent research found no relation between home ownership and worry about contamination remediation (Prior et al., 2017). Finally, the type of environmental contaminant may also be related to worry. Research on contamination remediation strategies has found that the type of contaminant in a neighbourhood environment is a predictor of degree of worry about remediation (Prior et al., 2017).

In relation to living with environmental contamination associated with technological hazards there are few published studies exploring the long-term impacts on mental health and wellbeing, or the processes that contribute to psychopathology, such as worry (Cuthbertson et al., 2016; Israel et al., 2006; Ochodo et al., 2014). Consideration of both the subjective and objective dimensions of environmental risk is needed to understand how people make sense of living with environmental contamination and subsequently adapt to such circumstances. Research in this field has demonstrated that perceived health risks are as important as known risks in influencing health and wellbeing (Aldred and Jungnickel, 2013; Alessa et al., 2008; Bickerstaff and Walker, 2003; Davis, 2005; Kushinskaya, 2013; Segrott and Doel, 2004; Slovic et al., 2004).

To contribute to the body of research in this area and to address existing gaps in knowledge our study posed the following research question:

RQ. What are the demographic and environmental predictors of resident's level of worry about contamination in their neighborhood?

3. Methods

This was a cross-sectional study that collected survey responses from 2,009 adults (18 years and over) residing near 13 contaminated sites across Australia, in New South Wales, South Australia, the Australian Capital Territory, Tasmania, Queensland and Victoria. A mixed-methods sampling strategy was used which aligned with the research aims. Purposive sampling was used to select the sites. Following site selection probability sampling was used to ensure a representative sample across the sites. Suitable sites were identified through an

212 extensive consultation process with the Australian remediation industry, state
213 environmental protection agencies, and the Australian Land and Ground Water Association.

214 Each site had a range of recognised environmental contaminants present – chlorinated
215 solvents, hydrocarbons, heavy metals, asbestos and putrescible waste. All sites included in
216 the study were located in urban areas and varied with regards to type and number of
217 contaminants located at the site, and background of the site (e.g., age and history of site).
218 These ranged from small sites, such as petrol stations with a short period of history (e.g., 1
219 year) through to large sites with multiple industrial uses spanning many decades where
220 remediation will continue over many years. To protect the confidentiality of survey
221 respondents and sites, only generic information is provided.

222 ### 3.1 Questionnaire and measures

223 A structured questionnaire was deployed to collect the data. Within the questionnaire the
224 respondent was read a brief outline of a contaminant that had been found at a site near to
225 their place of residence. The description provided to residents included: the type of
226 contaminant (e.g., mercury), the location of the contaminant, how the contamination
227 occurred, and how it behaved (e.g., groundwater). No potential consequences (e.g. health
228 risks) related to the presence of the contaminant were described, as this would have
229 influenced the responses to the questionnaire. Given the vast range of contaminants within
230 the environment, the study focused on five key types of contaminants within the Australian
231 context including: heavy metals (i.e. lead, cadmium, mercury and arsenic), hydrocarbons (i.e.
232 hydrocarbon compounds derived from petroleum sources, including petrol, diesel and
233 kerosene and lubricating oils/greases), chlorinated solvents (i.e. chlorinated hydrocarbons
234 used in dry cleaning and industry), waste (i.e. which can include liquids, solids and gases),
235 and asbestos.

236 The respondents were then asked the question “How worried are you about the
237 contamination at the [site]?” with respondents rating their degree of worry on an 11-point
238 Likert type scale, where 0 is *not at all worried*, and 10 is *extremely worried*. Higher values
239 indicate higher levels of worry. This question was used to operationalise the dependent
240 variable “worry” in the regression analysis.

241 The questionnaire also sought information about a range of basic sociodemographic
242 variables, such as gender, age, household income, university education, primary language
243 spoken, home tenure, and number of children living in the home. Each of these variables are

described in detail in Appendix 1. Two items were included that reflected a resident's sense of place: "I feel like I belong to the community where I live" and "For me, this is the ideal place to live". Each of these items were measured on an 11-point scale (0 = *strongly disagree* to 10 = *strongly agree*).

Location data in the form of latitude and longitude coordinates for the home of each respondent was also collected. Polygons were created for the boundaries of each contamination site using geographic information system (GIS) software. The minimum Cartesian distance (that is, the minimum distance between the respondent's home and the contaminated site boundary) was used as a measure of physical distance between each respondent and the contaminated site. The questions included in the questionnaire were developed as part of a larger study exploring resident perceptions and experiences of contamination and associated remediation technologies (see Prior et al., 2017).

3.2 Procedure

Ethical approval for this study was provided by the University of Technology Sydney Human Research Ethics Committee. Participants were randomly selected from a residential telephone database for the neighbourhoods surrounding the 13 contaminates sites. The survey was conducted using computer-assisted telephone interviewing (CATI) technologies. The data was collected anonymously with results reported as aggregated data to protect the privacy of participants. The survey response rate was 19%. Surveys were completed between 24 March and 30 September 2014 by a team of 12 researchers who would call residents between Mondays and Thursdays from 15:30 to 20:00. If calls initially went unanswered or were diverted to answering machines, repeat attempts (up to five further occasions) were made to contact each resident. Survey completion time varied from 10 to 38 minutes, with an average of 20.4 minutes.

3.3 Regression analysis

IBM SPSS and R statistical software were used to analyse the data. As the dependant variable worry is ordinal, ordered logistic regression was used to determine the likelihood of a range of sociodemographic, geographic and belief factors on the degree of worry about contamination. The two items "I feel like I belong to the community where I live" and "For me, this is the ideal place to live" were highly correlated (α = .87). As there can be no multicollinearity between independent variables in logistic regression (Stoltzfus, 2011), these items were combined to create one variable that reflected the construct sense of

place. Continuous variables were recoded into categorical dummy variables prior to entering into the regression model if necessary to ensure linearity of the logit for continuous and ordinal independent variables (Stoltzfus, 2011). See Appendix 1 for detailed descriptions of each variable.

The independent variables were chosen for inclusion in the model based on the conceptual framework developed in section 2, which was constructed on feasible predictors found in broader environmental hazards and health research.

4. Results

4.1 Sample characteristics

Of the 2,009 respondents, the majority were female (58.5%). The largest age range represented was between 35 and 54 years (28.8%), with those between 18 and 34 being the least represented age range (7.2%). The age distribution was from 18 to 89 years. See Table 1 for a summary of the demographic characteristics. Of the 2,009 surveys completed, four were excluded due to data-entry errors at the analysis stage, leaving a total of 2,005 respondents.

Table 1

Participant sociodemographic characteristics presented as frequencies and percentages.

Characteristic	n (%)
Gender	
Female	1175(58.5)[a]
Male	834 (41.5)[a]
Age range	
Under 35	144 (7.2) [b]
35-54	579(28.8) [b]
55-74	1006 (50.1) [b]
75+	280(13.9) [b]
Income	
Zero to $40k	377 (18.7)[c]
$40k to $80k	405 (20.1)[c]
$80k to $120k	361 (18.0)[c]
$120k and over	460(22.9)[c]
University education (yes)	1153 (57.4)[d]
Children in household (yes)	361 (18.0)
Own or purchasing home (yes)	1652 (82.2)
Language other than English	304 (15.1)[e]

Notes: [a] One respondent did not report their gender; [b]One respondent did not report age; [c] 404 respondents declined to report income, one respondent did not report income; [d] Two respondents did not report education level; [e] 46 languages other than English were spoken, the most common being Italian, Greek and French.

4.2 Predictors of worry about contamination

The results of the ordered logistic regression are shown in Table 2. Males were highly significantly less likely to be worried about contaminants compared to females (see Gender [male] in Table 2 and Appendix A). Age had a significant effect on worry about contamination; with those under 35, and 75 and over being less likely to worry (see Age in Table 2 and Appendix A). There was also a highly significant effect for household income, with all income groups being more likely to worry about contamination compared to those in the highest income bracket (120k +) (see Income in Table 2 and Appendix A). Those who owned or were purchasing their home were significantly less worried about contamination

compared to those who were renting (see Tenure owner or purchasing (yes) in Table 2 and Appendix A).

Participants who reported hearing of the contaminant in their suburb were highly significantly less likely to be worried about the contaminant compared to those who had not (see Heard of Contaminant (yes) in Table 2 and Appendix A).

Contaminant types were found to have a highly significant effect on the degree to which respondents worry about contamination in their neighbourhood (see Contaminant Type in Table 2 and Appendix A). Respondents were significantly less likely to worry about asbestos, hydrocarbon and waste then they were about metals.

Those who spoke a language other than English at home were highly significantly more likely to be worried about contaminants at the site compared to those who did speak English at home (see Language other than English in Table 2 and Appendix A). People with children at home were significantly more likely to be worried about contaminants than those without (see Children in Home in Table 2 and Appendix A).

Finally, people identifying as having a sense of place within their community were significantly more likely to worry about contamination in their neighbourhood compared to those without a connection to place (see Sense of Place in Table 2 and Appendix A).

Table 2

Ordered logistic regression coefficients, with the dependent variable being the degree to which respondents are worried about contaminants at a nearby site. Positive coefficients indicate variables are associated with higher levels of worry.

Characteristic	Value
Gender (male)	-0.726***
Contamination type	
Waste	-0.565***
Asbestos	-0.894***
Chlorinated solvent	0.064
Hydrocarbon	-0.424***
Metal	0
Tenure own or purchasing (yes)	-0.197*
Language other than English	0.515***
University education	-0.084
Children in household	0.261**
Age	
Under 35	-0.476***
35-54	0
55-74	0.008
75 +	-0.328**
Income	
Unspecified	0.633***
Zero to 40k	0.894***
40k to 80k	0.518***
80k to 120k	0.529***
120K+	0
Heard of contaminant (yes)	-0.29***
Sense of place	0.054**
Distance to site	0.075

Note: *** denotes p<0.001; ** denotes p<0.01; * denotes p<0.05.

5. Discussion and conclusion

This paper is the first to develop a conceptual framework seeking to explain the factors involved in residents' worry about neighbourhood contamination, which was informed by the broader worry and risk perception literature. This framework provides a first step in understanding the factors that may lead to pathological worry in the context of a resident living in an area affected by environmental contamination. This conceptual framework may be expanded upon through future research. This is also the first study to explore the

sociodemographic and environmental factors that affect resident's level of worry about neighbourhood contamination in a large Australian sample. Each of the three dimensions within our conceptual framework contain attributes that our study identified as significant predictors of worry.

5.1 Demographic predictors of level of worry about contamination

We found a number of demographic variables were significant predictors of residents' level of worry about contamination in their neighborhood; specifically, age, language spoken at home, gender, income, and having children in the household.

Consistent with previous research our study found females were more likely to worry about contamination compared to males. An increased level of worry in females may be related to perceived exposure to contamination and environmental risk, as women have consistently been found to have a greater amount of concern about environmental risk compared to men (Davidson and Freudenburg, 1996; McCright and Xiao, 2014; Powell et al., 2007). This finding may partly be explained by women being at greater risk of developing pathological worry (e.g., generalised anxiety disorder) compared to men (McLean et al., 2011). Women are also more likely to worry about health risks more generally compared to men, and health risks have been associated with perceived environmental risk in studies examining resident perceptions of risk associated with living in environments affected by contamination (Couch and Coles, 2011).

Both the youngest (<35) and oldest residents were less likely to worry about contamination compared to other age groups in our study. This is consistent with another Australian study finding that older residents (75 and over) were less likely to worry about the remediation of contamination compared to other age groups (Prior et al., 2017). In contrast, the same study found that residents under 35 were also more likely to worry about the remediation of contaminated sites compared to other age groups (Prior et al., 2017). These findings are consistent with the broader literature on age and worry. Older adults are less likely to worry in general compared to other age groups (Gonçalves and Byrne, 2013); however, this can vary depending on the content of their worry. For example, older adults have been found to be more likely to worry about the health and welfare of friends and family (Gonçalves and Byrne, 2013).

Consistent with previous research (Cutchin et al., 2008; Cuthbertson et al., 2016), we found that certain demographics related to vulnerable populations predicted worry about

contamination. Specifically, people who spoke a language other than English at home were more likely to be worried about contaminants compared to English speakers. This lends support to studies suggesting that the mental health impacts of environmental contamination are greater for certain vulnerable populations, including ethnic minorities (Cuthbertson et al., 2016). In addition, all income groups being more likely to worry about contamination compared to those in the highest income bracket. This indicates that people of a lower socio-economic status may also be more vulnerable to the mental health impacts associated with environmental contamination. (Cuthbertson et al., 2016).

Our findings suggest that certain demographic factors may increase a person's risk of pathological worry and need consideration when developing strategies for communicating with residents about contamination. These findings are particularly concerning as people from low socioeconomic backgrounds are at increased risk of anxiety disorders and cardiovascular disease, which both have strong associations with pathological worry (Thurston et al., 2013). Therefore, those on lower incomes, as well as those who speak a language other than English at home, may need additional support to cope with managing environmental contamination in their neighbourhood.

5.2 The influence of knowledge on degree of worry about contamination

Our study found that residents who reported previously hearing about the contamination in their neighbourhood were less likely to be worried about the contaminant compared to those who had not. This is consistent with the hypothesis that perceived uncertainty about the future is influenced by lack of knowledge about a specific situation, which can also lead to worry (Powell et al., 2007). It is possible that residents who had previous knowledge of the contamination may have had the opportunity to manage their exposure to contamination and have a better understanding of how it might impact them. Consequently, they may have less uncertainty related to the contamination compared to residents who were previously unaware of its presence. It is therefore critical that residents are provided with the information they need about contaminants in their neighbourhood in a timely and accessible manner to reduce unnecessary uncertainty and worry.

5.3 Impact of physical context on worry about contamination

Certain attributes of residents' physical context appear to influence levels of worry more than others. We found that people who identified as having a strong sense of place within their neighbourhood were more likely to worry about contamination compared to those

400 with a weaker sense of place. This association was also found in another study related to
401 residents worry about contamination remediation technologies (Prior et al., 2017), and is
402 consistent with studies finding that people tend to have less concern about environmental
403 risks in their neighborhood if they have a strong sense of place (Bonaiuto et al., 2016;
404 Venables et al., 2012). In contrast, residents who owned or mortgaged their home were less
405 likely to worry about contamination. These findings are somewhat contradictory as it could
406 be suggested that those who own their own homes would be more likely to have a strong
407 sense of place, as they may perceive a greater sense of security and stability in their living
408 environment (Easthope, 2004).

409 The type of contaminant at the site was also found to be an important predictor of worry,
410 which is consistent with previous research (Prior et al., 2017). However, in our study certain
411 types of contaminants (i.e. waste, asbestos, hydrocarbon) predicted worry about
412 contamination, compared to other types of contaminants (i.e. metal, chlorinated solvents)
413 that did not. It is possible that people may have more knowledge about certain types of
414 contaminants which reduces their uncertainty about contamination risk. However, more
415 research is needed to confirm this assertion.

416 The study revealed that physical proximity to the contaminated site did not influence worry
417 about contamination. Our findings lend support to studies that suggest that proximity tends
418 to be associated with lower levels of worry and greater acceptance of risk (Burningham and
419 Thrush, 2004; Freudenburg and Davidson, 2009). The reasons for this are not fully
420 understood, but one possible explanation is that in the absence of major accidents,
421 increased familiarity by those living closest to a contaminated site leads to lower levels of
422 concern (Greenberg, 2009).

423 ### 5.4 Implications

424 The conceptual framework developed in this paper is significant as it provides a starting
425 point for generating awareness and understanding of how worry is influenced by a range of
426 factors by highlighting the key predictors and categorising them into three primary
427 dimensions. Future research undertaken within this area can build on the framework by
428 exploring whether additional factors feature in impacting upon resident worry levels.

429 Worry has the potential to have a negative impact on health and wellbeing (Cuthbertson et
430 al., 2016), which has previously been described by residents affected by worry about
431 remediation technologies used for contaminated sites using (Prior et al., 2017). Residents of

Flint, Michigan reported stress and anxiety they perceived was caused by the unknown health impacts of water contamination in their neighbourhood (Cuthbertson et al., 2016). They also reported stress was increased by concerns about the financial costs associated with the contamination (i.e. access to clean water and health care costs) and perceived inability to control the situation were factors that influenced worry.

Within the context of contaminated site management and remediation it is critical that strategies are put in place to assist residents to better manage their worry about contamination. This paper has revealed that levels of worry held by residential populations about contamination from nearby contaminated sites is not evenly distributed amongst those populations due to a range of factors related to demographics, knowledge, and physical context. Awareness of these factors that contribute to worry about contamination are important when developing strategies within the context of contaminated site management and remediation.

Strategies and interventions developed on the basis of our findings should include improving access to accurate information to reduce uncertainty related to perceived contamination risk. Having knowledge about health risks can reduce uncertainty about the future (Lima, 2004; Powell et al., 2007), better equip people to feel more in control over their situation, and consequently reduce worry. Worry reduction strategies should be developed for residents that are specific to the context of the technological hazard in their neighbourhood. For example, both mindfulness-based training and relaxation training programs have been shown as effective in reducing self-reported worry, anxiety, depression and some physiological symptoms in non-pathological high worriers (Delgado et al., 2010). More research is needed to determine the effectiveness of these type of interventions in residents affected by environmental technological hazards.

Personal resilience may be a protective factor that can reduce the negative effects of worry and prevent the onset of mental health disorders (Beesdo et al., 2010). In this context resilience is defined as “the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress” (American Psychological Association, 2018), and is a critical factor in how people respond to environmental hazard (Cutter, 2008; Foudi et al., 2017). Consequently, it is important to recognise that people have different levels of psychological resilience and ways of coping with environmental hazards due to individual differences (Bonanno et al., 2010), and some people will need more targeted support to manage living with environmental contamination. This paper highlights the varying levels of

resilience that residents have to worry about contamination based on a range of factors. For example, our findings suggest that males have significantly lower levels of worry than females. Therefore, strategies aimed at managing and developing individual resilience in addition to community resilience are needed (Liu et al., 2017). This is particularly important for women, as they are more likely to develop anxiety as a consequence of worry (Ryum et al., 2017), and have been found to have a lower level of resilience compared to males in the context of environmental disasters (Rodriguez-Llanes et al., 2013).

5.5 Limitations

A strength of this study was the large sample size; however, generalisations to the broader Australian population need to be made cautiously. There was a high proportion of home ownership reported in this study (82.2%) compared to the general population (65%; Australian Bureau of Statistics, 2017); consequently, the responses may not represent all residents affected by contamination. Regional cultural differences may affect the factors that influence worry about contamination; consequently, the findings from this study should be applied cautiously to populations in other regions or countries. Furthermore, in this study worry was not measured using a previously validated tool; however, as argued in this paper, the subjective experience of worry is a critical consideration. There may be other variables that influence worry, such as social capital and ethnicity. These factors have previously been found to influence distress caused by natural disaster (Cuthbertson et al., 2016). Health-related variables may also influence the level of worry experienced by residents. Including these variables may improve the validly of the model; therefore, future research should consider exploring these factors in relation to environmental contamination. In addition, future research should seek to understand resident's self-reported reasons for their level of worry about contamination, as this will assist to identify issues relevant to communities.

5.6 Future research

Future research could further develop the conceptual framework presented in this paper by identifying additional predictors of worry. Another important area for future research is to determine the individual psychological characteristics (e.g. personality traits and cognitive styles) that influence a person's level of resilience and risk of developing unhealthy "worry" that may lead to poor mental health and wellbeing. Research could seek to characterise those who are more vulnerable to the negative effects of worry related to neighbourhood contamination. Higher levels of worry are associated with certain personality traits, such as neuroticism (Vollrath et al., 1999) and intolerance to uncertainty (Zlomke and Jeter, 2014).

Being able to identify people high in these personality traits is important to enable more targeted interventions to support people to manage worry. Longitudinal research is needed to determine the incidence of pathological worry and associated mental health disorders, and whether or not worry about neighbourhood contamination is persistent over time.

As we found that people with a primary language other than English were more likely to worry about contamination, future research should consider the impact of ethnicity to determine whether there are additional cultural factors that influence worry in addition to language. Future research also needs to focus on community engagement to support residents to determine the best way to reduce their levels of worry and increase resilience. Adoption of sustainable remediation strategies that encourage public participation may assist to reduce residents worry about contamination, as resident's knowledge of contamination and remediation would increase (Hou and Al-Tabbaa, 2014). Participation in the process is likely to help residents feel more control over the perceived risks. Therefore, future research should aim to develop effective ways of engaging communities in remediation decision-making to facilitate social sustainability in remediation practices (Hou et al., 2014).

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Appendix 1: Data

Independent Variables

Language other than English (yes): 0/1 dummy variable, which is 1 if the household speaks a language other than English in the home.

University education: 0/1 dummy with value 1 if the respondent had a university degree.

Gender: 0/1 dummy with value 1 if the respondent is male.

Tenure own or purchasing: 0/1 dummy with value 1 if the respondent owns or is purchasing their home. Other tenures are renting (private), renting (public/social), and other.

Children in household: 0/1 dummy with value 1 if children younger than 14 are in the household.

Age under 35: 0/1 dummy with value 1 if the respondent is under 35.

Age 35-54: 0/1 dummy for respondents aged 25-54.

Age 55-74: 0/1 dummy for respondents aged 55-74.

Age 75+: 0/1 dummy for respondents aged 75+.

Income unspecified: 0/1 dummy for respondents who did not specify income.

Income 0 to 40k: 0/1 dummy for household income between $0-$40k p.a.

Income 40k to 80k: 0/1 dummy for household income between $40-$80k p.a.

Income 80k to 120k: 0/1 dummy for household income between $80-$120k p.a.

Income 120k+: 0/1 dummy for household income over $120k p.a.

Sense of place: A single continuous variable was created by summing the scores of the two items *"I feel like I belong to the community where I live"* and *"For me, this is the ideal place to live"*. Higher scores reflected having a greater sense of place.

Proximity to contaminated site: The minimum Cartesian distance (that is, the minimum distance between the respondent's home and contamination site boundary) was used as a measure of physical distance between each respondent and the contamination site.

Heard of contaminant (yes): 0/1 dummy with value 1 if the respondent had heard of the contaminant in their local area.

Hydrocarbon: 0/1 dummy with value 1 if the contaminant discussed with the respondent was classified as a hydrocarbon.

Heavy Metal: 0/1 dummy with value 1 if the contaminant discussed with the respondent was classified as a metal.

Chlorinated solvent: 0/1 dummy with value 1 if the contaminant discussed with the respondent was classified as a solvent.

Waste: 0/1 dummy with value 1 if the contaminant discussed with the respondent was classified as a waste.

Asbestos: 0/1 dummy with value 1 if the contaminant discussed with the respondent was classified as a waste.