STUDY TO EVALUATE THE EFFECTIVENESS OF INTERVENTIONS INTENDED TO REDUCE EXPOSURE TO LEAD FROM DRINKING WATER WITHIN THE VULNERABLE GROUP

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1 EXECUTIVE SUMMARY

1.1 BACKGROUND

The Water Safety Plan\(^1\), a World Health Organization framework, encompasses all steps in water supply from catchment to consumer. United Utilities (UU), the water utility company in the north west of England, have identified risks to drinking water quality within customers’ homes due to increased exposure to lead arising from the lead plumbing on the premises. Although lead plumbing replacement is the most effective control measure, previous experience has shown that customers’ uptake is very low. The current study explored the potential for improved uptake of other practices such as, flushing taps or using bottled water, as inexpensive but effective interim measures.

In order to develop customer-orientated approaches, as supported by Drinking Water Inspectorate\(^2\), research was needed to understand the factors affecting customers’ knowledge, attitudes and practices regarding lead in drinking water. The vulnerable group are pregnant women and families with children under six years old, therefore health interventions should be specifically targeted to this group. Focus groups with members of this group investigated lifestyle values. A number of health promotion messages had been designed and the focus groups were asked which messages particularly resonated. This qualitative data was used to develop a health intervention leaflet and website. A questionnaire was developed to generate quantitative data from a larger sample, which was then used as an outcome measure for a randomised control trial of the health intervention.

The aim of these qualitative and quantitative studies is to inform United Utilities’ communication strategy with the objective of increasing the proportion of customers who adopt and maintain measures to reduce their exposure to lead which may be present in drinking water. Although this research is targeted to the local population, some conclusions may be applicable nationally. Furthermore, the conclusions may support the work of other health professionals, to define and deliver effective health promotion programmes.
1.2 INTRODUCTION

The hazard of lead in tap water has been studied for many years. Tap water is one of many environmental sources of lead, all of which, through technological improvement and legislative control, have now been greatly reduced. For some environmental sources the impact of legislative changes occurred rapidly, for example banning lead fuel additives. Whereas for drinking water there is a long legacy issue due to the large number of installed lead service pipes. Because the part of the service pipe within the property boundary (the supply pipe) is owned by the owner of the property, this is beyond the control of the water company. Therefore, to reduce exposure further among the general population requires action by members of the public.

Although mathematical models are available to compute overall lead dose, given data on multiple sources, it would be very difficult to assess risk on a regional or national scale. From a clinical perspective, acute, high exposure is likely to be the focus of attention, although the number of people affected is likely to be small. However, from a public health perspective chronic low level exposure, although generally causing small effects in individuals, could be the priority due to the high numbers of people at risk. Examples of high exposure sources include imported toys and cosmetics along with old lead-based paint. Examples of chronic low level exposure are contaminated dust and soil, and tap water in a house with lead plumbing.

Exposure patterns and groups at risk differ greatly between the different sources of lead. Correspondingly, the most appropriate approaches to controlling exposure, and importantly, the health professionals involved, will also differ greatly. For the case of lead in water, the approach has traditionally focused on technical measures. Control measures employed by the water utility companies through water treatment have been successful at reducing lead concentrations, and extensive monitoring indicates a high proportion of residences now meet water quality regulations\(^3\). Further improvement by this means is expected to be limited and the water industry is shifting the emphasis towards encouraging members of the public to take action. However this raises an important question - which health professionals should be involved in this new approach? Although this hazard traditionally falls within the remit of environmental health officers, considering the most vulnerable group are pregnant women and young children, the professionals with the greatest opportunity to bring about change may be GPs, midwives and health visitors.

The current study focused on examining perceptions and raising awareness of the risks of lead in tap water amongst the vulnerable group. The key message of the study is that delivery of targeted health promotion by water companies may be of limited effect without similar messages coming from other relevant health sectors. Data from this study indicates that this population group place trust in the health professionals that they have contact with. For maximum benefit, the issue should be promoted amongst health professionals, as well as members of the public. The next step in developing this approach may be to test the effectiveness of different modes of delivery of the leaflet, for example delivery in GP’s pregnancy packs, as part of midwives’ information or from other community settings such as children’s centres.
1.3 SUMMARY OF FINDINGS

1.3.1 AWARENESS
The study clearly shows a lack of awareness of the risks of exposure to lead in drinking water amongst the vulnerable group. The data indicate that although there was some awareness of lead toxicity, and also that infants may be most sensitive, there was little knowledge about the current risk caused by lead plumbing. This may be due to a lack of appropriate information which is readily accessible to the vulnerable group (people expecting a baby or caring for young children). However, participants did appear keen to learn about the hazard, so that they can take action to protect their children from potential harm.

To improve awareness of the current risk it would help to have more detailed information about the current distribution of the risk. Current risk levels are based on estimates of the distribution of lead supply pipes. Conducting a survey of properties, or building a database from existing data, would raise awareness of the current situation, in turn strengthening the case for professionals to take action. With this greater knowledge health promotion can be improved, by specific targeting, but also using a ‘social norms’ approach; encouraging people to take action because the majority of local people have already taken action.

1.3.2 FAMILY HISTORY, FRIENDS AND NEIGHBOURS
Parents who remember older family members flushing taps in the morning were more likely to practice this behaviour before the intervention. Health promotion could build on this pre-existing knowledge.

1.3.3 PRACTICES OF WATER USE AND WATER METERING
The primary practice promoted in this study was to run the taps in the morning in order to flush water which has been standing overnight in the supply pipe. This is an effective way of reducing potential exposure to lead, however it may conflict with other messages about water conservation. Participants who had a water meter were less likely to run the taps in the morning. Participants were also aware of the need to conserve water for sustainability of the natural environment, which may mean that they are less keen to run the taps. In the short term, health promotion should emphasise the insignificance of the volume flushed (and suggest other uses for it). However in the long term the water conservation message could be used to encourage replacement of lead plumbing, which is the ultimate solution.

1.3.4 WILLINGNESS TO CHANGE PRACTICE
From participants’ reported practice it seems that they were willing to change their practice to reduce their potential exposure to lead in drinking water. It is important that these findings are fed-back to national organisations, in order that policy makers are aware that people are prepared to take action that is immediate and requires no investment. This contrasts markedly with a programme of lead pipe replacement, which would require large investment and long timescale at a national level.

1.3.5 EFFECTIVENESS OF PRACTICE
To maintain behaviour, people should be reassured that their practices are effective. A selection of participants (n=23) were asked to take water samples for lead content analysis. They were asked to take one sample first thing in the morning and the second when they filled the kettle or made a drink. The aim was to check that lead levels decreased between samples. Of twelve participants with initial lead levels greater than 1μg/l, nine showed a
decrease in the second sample. Although the data is not robust enough to link specific practices with exposure levels, and this was not an outcome measure for the study, it indicates that exposure is amenable to participant’s action.

Health promotion aimed at publicising the effectiveness of flushing taps could support people’s continued practice, for example by estimating the difference that running the tap every morning can make to the cumulative level of exposure of a 6 year old child, previously fed formula milk. Obviously, these are very difficult messages to design, in order to avoid being either too technical or too alarmist.

1.3.6 BARRIERS TO BEHAVIOUR CHANGE

There are very limited sources of information about health risks of exposure to lead from drinking water in UK media. The historical background of the widespread use of lead in the domestic environment means that it is perceived as a familiar household metal. Furthermore, a common perception is that legislation for health and safety controls, or at least warns, of any health risks that the public may face. Together, these factors are likely to have strong influences on people’s risk perception and will be a barrier to effective behaviour change through health promotion.

There is some evidence from this study that there may be an aspect of denial, which allowed participants to ignore the issue. Approaches to tackle this barrier to action include giving further information about the hazard, or further support to make taking action appear easier. Personalisation of information is a key aim of Social marketing framework, and a tool to help people evaluate their personal risk, based on detailed information on family, property and geography, may empower action. Further messages indicating the insignificant cost or inconvenience of taking action (running the tap in the morning) may encourage action and hence reduce the denial reaction.

1.3.7 MESSAGE DELIVERY AND ENDORSEMENT

The target population is defined by two very different factors. The first is the distribution of the hazard of lead in water, defined by the presence of lead plumbing and characteristics of the water supply. The second is whether people have young children or are planning to start a family. To specifically target media to people defined by either factor is possible, but defining a population by the combination of both factors, and designing media specifically, is potentially very difficult. This study selected people on the basis of both criteria by visiting pre-1970 houses during the day, when parents and carers were likely to be home with children. However this targeting procedure would not be possible for health promotion. The follow-up questionnaire asked several questions about the setting and timing for delivery of media. These questions were concerned with the second factor; how to target people expecting or caring for young children. Responses indicated that the most popular settings for delivery of information were home and the GP surgery, whereas the most popular timing was before birth. Due to difficulties targeting people at home, the next stage of developing health interventions may be to pilot the GP delivering the intervention at one of the first consultations during pregnancy.

Linked to the delivery location is endorsement and branding of the information. Some responses from the focus groups indicated that information published by the water utility company may be treated with cynicism and distrust. Therefore it may be more appropriate for information to be endorsed by a health agency or organisation. This would also be
appropriate if the message was being delivered in a healthcare setting. In common with most health promotion media messages, the difficulty is to convince the at-risk population to attend to the messages whilst not raising unnecessary concerns amongst the population who do not have lead plumbing. A simple question from a health practitioner may be able to select members of the at-risk population whilst also effectively raising awareness. Given appropriate media this could be a simple intervention which could be delivered by any member of staff with patient contact, for example surgery receptionist or health trainer.

1.3.8 AREA VARIATION AND DEMOGRAPHICS
The four areas covered by the present study represent quite different housing styles and demographics. Lead plumbing was common in all houses built before 1970, therefore the risk factor is likely to have a similar distribution amongst houses irrespective of size. As some pipes may have been replaced since fitting, the distribution may have changed. It is possible that affluent homeowners are more likely to have replaced their pipes, which may cause a slight bias in the distribution, thereby decreasing the risk factor for more affluent households. However, information from United Utilities indicates that the number of customers who have replaced pipes is so low that this effect would be small\(^3\).

For the purposes of social marketing it is important to design messages for specific target groups. In this case the vulnerable group are carers of infants or young children, however they may be of diverse socioeconomic status. One important aspect is tenure; from this study, householders who rent are more likely to have a lower income than homeowners. Also homeowners are more likely to know some information about their plumbing system and are able to invest in pipe replacement, whereas tenants have less power to act. This implies that different media should be designed for homeowners and tenants.

1.4 CONCLUSIONS
To the authors’ knowledge this is the first study of people's perceptions and attitudes towards the risks of lead in drinking water. As such it has yielded important findings including the low level of awareness about the issue. The randomised control trial did not show significant benefit of the leaflet and website developed compared with the control UU leaflet. Overall however, the study showed that participant’s knowledge increased and practices were modified. It could be that both experimental and control interventions were equally effective. On the other hand the improvement could have been due to the process of gaining informed consent and also of interviewing, raising awareness, which may have a greater effect than the leaflet intervention. The positive aspect is the indication that people are willing to take action, and that face-to-face delivery of health promotion may be effective and should be explored further.
1.5 Recommendations

Based on the findings from this study, as well as the literature search and discussions with stakeholders, the following three communication strategies are recommended. These are justified in more depth at the end of the full report (8.Conclusions). The first recommendation has long-term aims and could be labelled ambitious whereas the last is short-term and is pragmatic. Some of the potential benefits (✓) and barriers (■) are listed for each:

- **build a database of properties with lead plumbing**
  - ✓ will be required to achieve long term aim of replacing all lead plumbing
  - ✓ health promotion can be targeted very specifically
  - ✓ residents of these properties can start taking action immediately (with no investment needed) by flushing the taps
  - ✓ concurrently raise awareness of the scale of the issue amongst health professionals involved in the database
    - ■ will require multi-sector coordination
    - ■ confidentiality of residents
    - ■ ownership and maintenance

- **coordinated programme of raising awareness**
  - ✓ using media developed in this study, but also developing media for other target populations and other formats (eg posters)
  - ✓ campaign involving regions of the country most affected.
  - ✓ target services visited by the vulnerable group, such as children’s centres and GP surgeries
    - ■ training of health professionals involved in the campaign
    - ■ multi-sector approach
    - ■ substantial investment required

- **develop a web-based tool so that members of the public can assess level of risk**
  - ✓ individual assessment of risk is likely to encourage people to take action
  - ✓ technical aspects of the tool may improve knowledge of level of risk amongst health professionals
    - ■ to reach significant population information in other media (eg posters and leaflets) will be needed to raise awareness of the website
    - ■ promotion or training required for health professionals, who are best placed to ensure such a tool reaches the vulnerable group, including those without internet access
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2.3 ABBREVIATIONS AND DEFINITIONS
UU - United Utilities
μg/l – unit of measurement of total lead (dissolved and suspended) in water
μg/dl – unit of measurement of lead in blood – note different unit is used to water
BK - Birkenhead
WL - Wallasey
EP - Ellesmere Port
SK - Skelmersdale
SP - Southport
GP – General practitioner or family doctor
NHS – National Health Service, England and Wales
χ² – Pearson’s Chi-squared statistical significance test
p – statistical probability (of difference being due to chance alone)
OR – Odds ratio
CI – Confidence interval
RCT – Randomised control trial
Plumbosolvency – tendency to dissolve lead
3 INTRODUCTION

3.1 AIM OF THE STUDY
The aim of the research was to develop and test suitable material that can be used as part of a health promotion campaign to improve awareness of and attitudes to the hazard of exposure to lead in water. The media should encourage people to change their behaviour and protect themselves and their families from the health risks associated with exposure to lead that may be present in household water supplies.

3.2 OBJECTIVES

- conduct a review of the literature about health risks from exposure to lead in drinking water
- use focus groups to explore perceptions of those at risk to discover what they want and value in life and to develop health promotion materials
- develop a questionnaire to investigate current awareness and attitudes towards the risk, and current avoidance practice, in a representative sample of the vulnerable group
- deliver the health promotion intervention to this sample to investigate if it changes knowledge, attitudes or practices in relation to the risk
- disseminate findings to local and national stakeholders

This report begins with a literature review of the toxicity and sources of lead. To tackle these issues, social theories of health promotion will be explored. Next the methodology of the two stages of the study is described. The findings of the two stages are described, followed by a discussion of conclusions drawn from the results.

4 LITERATURE REVIEW

4.1 THE HEALTH RISKS AND ENVIRONMENTAL SOURCES OF LEAD
Lead is a toxic heavy metal that has many environmental sources. Over the last 30 years the levels of lead in the environment have decreased substantially, owing to increasing control in many different legislative areas (Figure 1).
Lead fuel additives for road transport used to be the largest contributor to air pollution and soil contamination, but have been banned from petrol since 2000 (Figure 2). However, residual contamination can still be present in soil close to busy roads. Due to improvements in this and many other forms of lead pollution, the priority of tackling exposure to lead in drinking water has risen relative to other sources. Drinking water can contain lead because water can accumulate lead (either dissolved or suspended) from the supply pipe, especially after water has been left standing in the pipe overnight. This is a particular problem in areas with soft water.
4.1.1 TOXICITY OF LEAD FOR FOETUS AND INFANT

The developing foetus, infant and child are the life-stages which are the most vulnerable to lead toxicity. The increased vulnerability is for two reasons; a greater relative exposure and the sensitivity of developmental processes. Whereas adults have an uptake rate of 10-15% of ingested lead, in infants and children this increases to 50-60%. Lead is compartmentalised and stored in the bone. Due to this lead remains in the body for a considerable time after initial ingestion; the biological half-life of lead is 30 years.

Toxicity of lead has many diverse mechanisms; however, the developing brain is a particularly sensitive target. At the low level doses considered in this study, this is the most important effect. In the developing central nervous system (brain and spinal cord) toxicity due to lead is thought to be cumulative and irreversible. This would suggest that exposure in the womb, during pregnancy, could have effects throughout adult life. Uptake of lead can limit or slow brain development. At low exposure levels, these effects are likely to manifest as social rather than medical (or mental health) problems. The most recent correlational (cohort) studies have shown that low level lead exposure during infancy (estimated from blood lead measurement at 2½ years of age) are significantly linked to poorer reading and writing outcomes (Standard Assessment Tests, SATs) at 7 or 8 years of age. Children with slightly higher lead exposure were also found to have worse scores in assessments of antisocial behaviour and hyperactivity.

It is important to bear in mind the nature of the impact of exposure to lead in drinking water. As mentioned above, the likely range of doses of lead from drinking water during gestation...
and infancy are linked to educational or behavioural detriment, rather than medical or mental health. To a large extent these will not be registered as clinical outcomes and therefore tackling the issue will not be a high priority amongst health professionals. However, because the outcomes are non-clinical and difficult to measure, they could be widespread, potentially affecting up to 40% of the population (the estimated proportion of properties with lead plumbing). The educational and behavioural deficits are likely to limit opportunities throughout adulthood, thus affecting quality of life. For health promotion this perspective is important for two reasons. Firstly, the media messages should be framed in terms of social rather than medical problems, although this may be less ‘attention grabbing’ it would be misleading to claim the latter. Secondly, appropriate communication with professional partners will strengthen and support implementation of health promotion. While awareness of the issue should be raised and prioritised, overstating the issue may have a negative effect. In working with different sectors or disciplines, preference should be given to targeting social professionals rather than health professionals for example working with children’s centre staff rather than paediatric clinical staff.

The developing foetus can be affected if maternal blood lead is high, since it can transfer across the placenta. Considering health promotion interventions, this is a difficult issue to tackle. Due to the longevity of storage of lead in bone, any practices to reduce exposure made during pregnancy will have a minimal effect on foetal exposure.

Breastfeeding is also a complex issue with regard to relative exposure of the infant to lead. Evidence is equivocal on the relationship between maternal body burden of lead and breast milk lead content. The amount of lead transferred to breast milk may change with time post-partum, and it is unlikely to be a linear relationship with blood levels, but findings so far indicate a transfer rate in the order of 10%, from maternal blood to breast milk. Using this figure, a woman with a blood lead level on the threshold of concern, 10\(\mu\)g/dl would express milk with a concentration of 1\(\mu\)g/dl or 10\(\mu\)g/l. The latter is equivalent to the future (2013) standard for water quality, indicating that in this scenario, the infant would be exposed to equivalent doses of lead from either breast milk or formula milk made up with tap water containing 10\(\mu\)g/l lead. From a clinical perspective, in the rare case of the mother’s blood lead being found to be this high (more likely where occupational exposure also contributes), the infant could be protected by feeding formula milk prepared with bottled water. However, from a public health perspective, especially considering the multiple benefits of breast feeding, the balance is in favour of generally encouraging breast feeding.

Children are thought to be at risk until about aged six, after which sensitivity to lead decreases. It is important to maintain risk-mitigating behaviours throughout childhood. At weaning food preparation changes and behaviours associated with making up formula milk may be forgotten. As the diet broadens it is important to remember how much tap water contributes, not only in drinks but also food. An overlooked factor is that lead can be absorbed by food cooked in boiling water. For example a large proportion of cooked rice or pulses (as well as dehydrated foods including pasta and noodles) is water. Furthermore lead appears to accumulate or concentrate within certain foods as they are boiled, for example peas. Further work is needed to establish the bioavailability of lead within these foods.
4.1.2 CURRENT STANDARDS FOR LEAD IN WATER

The current standard for lead in drinking water is given within the Water Supply (Water Quality) Regulations 2000 for England, which specify an interim standard of 25µg/l until 25th December 2013 when a final standard of 10µg/l will come into force. These standards follow the European Council Drinking Water Directive (98/83/EC)\(^{18}\). The values have been based on World Health Organisation calculations\(^{11}\) of maximum daily consumption for a bottle-fed infant which should limit blood lead levels to below the level of concern for clinical action: 10µg/dl\(^{19}\).

‘On the assumption of a 50% allocation to drinking-water for a 5-kg bottle-fed infant consuming 0.75 litres of drinking-water per day, the guideline value is 0.01 mg/litre. As infants are considered to be the most sensitive subgroup of the population, this guideline value will also be protective for other age groups.’\(^{11}\)

Compliance with these standards should avoid exposure to water resulting in lead doses above the clinical level of concern. However, there have been several reports giving evidence of ‘subclinical’ effects, i.e. cognitive deficits or behavioural problems, linked to blood lead concentrations below the threshold of 10µg/dl\(^{9,20,21}\). There is agreement that there is no safe threshold of exposure to lead therefore risk of exposure should be minimised\(^ {19}\).

4.1.3 NATIONAL AND LOCAL ISSUES

In the UK there are estimated to be nine million dwellings with lead water pipes\(^{22}\), with seven million in England and Wales (approx. 40% of properties)\(^ {23}\). In the north west an estimated 1.4 million properties have lead services (either the supply pipe, within the customers property, or the communication pipe linking the supply pipe to the mains)\(^ {24}\). The Chartered Institute of Water and Environmental Management estimates that it would cost about £10 billion to replace all lead pipes in the UK.

However, other current information sources appear to underestimate the size of the problem. For example ‘ThinkBaby’ website states that ‘it would be very rare to find any taps served by lead pipes anymore’\(^ {25}\). An article sponsored by Anglian Water and the Drinking Water Inspectorate in ‘You and Your Family’, a magazine and website backed by the Royal College of Obstetricians and Gynaecologists, informs parents: ‘In older properties however there is a small chance that some of the water pipes may still be made of lead\(^ {26}\).[Authors’ emphasis]

To tackle the hazard of lead in drinking water, three main strategies have been implemented within the UK:

1. ‘phosphate dosing’ (in the form of phosphoric acid or an orthophosphate salt) is added to drinking water to limit its plumbosolvency (tendency to dissolve lead). This method of control has yielded the most improvement over the last 125 years
2. other water treatments, including reducing colour and adjusting acidity (pH)
3. replacing some of the lead communication pipes (owned by the water company). The remainder will be replaced as and when customers replace their supply pipe

Comprehensive monitoring of tap water quality has revealed that these measures have, for the majority of houses, brought the lead concentration down to a level below the current UK regulation (25µg/l)\(^ {24}\). However there remain significant numbers of homes with lead plumbing...
that, from time to time, will not meet the future standard (10 µg/l) (Figure 3). Even if lead plumbing has been replaced within the home, the original lead supply pipe (between the home and the mains in the street) can remain. Sporadic financial support is available from local government for home-owners to replace their lead supply pipe. Even so, it still represents an investment and causes disruption. Tenants may not even consider approaching their landlord on this issue.

Random sampling of domestic water supplies is an effective way of monitoring control measures, including phosphate dosing. However it does not provide an accurate assessment of risks of exposure. Different sampling protocols have variable validity for measuring exposure, mainly due to the variation in lead levels over time. Also some sporadic samples show very high measurements, which are thought to be due to particles of lead becoming suspended in the water. The bioavailability of solid particles of lead is unknown, as is the frequency of this occurrence.

As described above the sampling indicates that phosphate dosing is an effective method of controlling exposure to lead from plumbing in the short term, however the long-term effects are not known. Hypothetically, lead salts could build up over time, which could potentially be dislodged causing higher exposure doses. Even though phosphate dosing is generally effective, there is a small percentage of homes in which the concentration of lead will exceed the future lead standard (10 µg/l) from time to time. Further action is required to protect these residents and also for long-term prevention.

4.1.4 RELATIVE EXPOSURE TO LEAD FROM WATER

Considering the many potential environmental sources of lead, an important, but contentious, issue is the relative contribution of drinking water to overall burden of lead (in children). A recent observational study followed a public health scare in Washington DC. In 2004 the media reported a ‘lead in drinking water crisis’ in the city. This prompted city wide public health advice, distribution of lead water filters and phosphate dosing.
The problem originated in 2001 when the water disinfectant was changed from chlorine to chloramine. The unknown effect of this change was an increase in the plumbosolvency of the water. Samples collected from houses showed a substantial increase in lead content. At the time, the public were reassured that there were no significant public health impacts, as city-wide screening showed that increases in blood lead levels were not clinically significant. However recent evidence suggests that in fact the exposure to lead varied with geographical area; some parts of the city were found to have high lead content in water samples, whereas others had low risk of exposure. The reason for this variation is not clear.

Analysing the data within these areas in Washington DC, it was found that children’s blood lead values were correlated with levels of lead in water in each area. The children living in high risk areas had greater than twice the risk of developing ‘elevated blood lead levels’ (above the level of concern: 10µg/dl) than children living in low risk areas. A mathematical model has been developed to calculate exposure levels from multiple environmental sources. This model was able to provide a good fit to the data from this study. However, for the general population it would be unlikely that sufficient data would be available to use this model to predict the relative contribution of water to overall exposure to lead. Overall this study has three important messages; firstly, the increase in lead exposure was not detected for three years which indicates the low profile of this environmental health hazard. Secondly, exposure levels are very sensitive to the properties of the water supply. While this study also shows the effectiveness of phosphate dosing for protecting against lead exposure, this should not be a cause for complacency. Thirdly, the link between lead in water and blood lead is clearly established from the coincidence of the changes over time. This indicates that lead in water can be major contributor amongst other environmental sources of lead\textsuperscript{27}.

4.1.5 Future direction of hazard reduction policy and practice

Although the health hazards of leaded petrol were widely accepted, particularly in relation to limiting development of intelligence in childhood, there was still a considerable delay in legislation to end this practice. Equivalent legislation has also limited domestic hazards; fitting lead plumbing (or solder) and using lead-based paints has now been curtailed. Thus the likely exposure to lead from many sources has decreased in recent times. Notwithstanding water companies’ efforts to reduce exposure, the increased control of lead from other environmental sources has brought to prominence the contribution from domestic drinking water. The changing sources and levels of environmental exposure have probably been an important factor in the mixed messages about lead toxicity. The general theme of American literature on lead hazards is that house paints are the most important source, for example exposure to paint dust when parents strip paint to redecorate the nursery. Drinking water hazards may be equivalent to those in the UK, but drinking water has not been a major cause for concern in the US and Canada. However a shift in emphasis in US policy and practice may now be occurring bringing drinking water into the spotlight rather than paint\textsuperscript{28}. In the UK literature lead plumbing appears to be the more important area of concern.

4.1.6 Risk reduction strategies.

The most effective strategy to reduce risk from exposure to lead in drinking water is to replace all lead plumbing on the property. However other strategies also offer good protection from risk with less investment and rapid implementation. Bottled water (spring, natural mineral or bottled drinking waters) has no or insignificant levels of lead. It is subject to the same water quality standards as tap water: 10µg/l\textsuperscript{29}.  

\textsuperscript{27} Lead Drinking Water Program, 2003.  
\textsuperscript{28} P.H. Newbold, J.T. Dietrich and J. Zhang.  
\textsuperscript{29} U.S. Environmental Protection Agency, 1998.
The main strategy advocated by the Drinking Water Inspectorate is to flush water that has been standing in the supply pipe for a prolonged length of time. It’s guidelines are as follows:

“Do not drink water that has been standing in the pipes for long periods, for example, overnight, or if no one has been in for several hours. In these circumstances, draw off a washing-up bowlful of water from the kitchen tap to clear the water which has been standing in the pipes. This need not be wasted but can be used on the garden or for something other than drinking or cooking. If the length of lead pipes exceeds 40 metres, more than a bowlful of water will need to be drawn off.”

4.2 THE VULNERABLE GROUP

Given the age-related differences in the toxicology of lead and the irreversible and cumulative continuing effects of early-years exposure that persist into adult life, any health promotion intervention will be most effective if it is targeted at the vulnerable group. For the purposes of this research, these are defined as:

- pregnant women (because of the risk to the developing foetus)
- families with infants and children between 0 – 6 years

From a geographical perspective, within England, residents of the north west are particularly at risk due to two factors:

- there are a large proportion of older (pre-1970) houses many of which still contain at least some lead plumbing (46% of all properties). Historically, Liverpool Corporation Water Works favoured lead plumbing
- the water is particularly plumbosolvent (good at dissolving lead) because it is soft

For these reasons the north west of England has been at the forefront of investigating and developing risk reduction policy and practice.

4.2.1 CURRENT RESOURCES AVAILABLE TO THE PUBLIC

Leaflets and websites concerning the hazard of lead in drinking water are available from water industry (water companies and water regulators) and local authorities. However this information is not targeted to the vulnerable group (pregnant women and caregivers of children under 6 yr). Although there is an abundance of general health information designed for this group, it is surprising to find that lead in water is rarely mentioned. Therefore from the perspective of someone planning a family or who already has young children, it is unlikely that tackling the risk of exposure to lead will be a priority.

4.2.2 INTERNET BASED PUBLIC INFORMATION

A review of websites that are likely to be accessed by pregnant women and partners, or caregivers of young children shows that there is a lack of awareness about the health risks posed by the potential presence of lead in water. Internet searches were performed using common search engines such as Google and Yahoo. Keywords included; lead, water, baby, formula. Although searches were a useful starting point, it is important to review information which the vulnerable group will be likely to find. Parents are unlikely to be searching for keywords such as lead and water. Instead parents will access health information through health service sites, baby-orientated and parenthood sites (provided by both commercial and public sector sources). Also blogs and social networking sites are increasingly a source of
information and support, at least for people with regular access to the internet\textsuperscript{32}. Therefore sites specific to the target audience were searched for the keywords above (using a keyword search within the web browser). Finally any relevant links were also followed.

Comments written by the public, on an open web forum, clearly indicate that people would appreciate information and guidelines on water safety, particularly for young children. On Baby and Bump website\textsuperscript{33}, a discussion comparing the situation in Germany with that in the UK, provides some revealing comments. In the first post a mother asks whether bottled water would be better for feeding her baby as she is aware that lead can be a problem. A response to this post mentions, erroneously, that boiling the water may help as that is what she has been advised. However she admits that she doesn’t know the reasoning behind this and perceives a lack of consistent guidelines from governmental departments.

This comment relates directly to advice from UK Department of Health on avoiding repeated boiling of water (although the ‘Birth to 5’ booklet does not explicitly mention lead as the risk factor referred to in this advice\textsuperscript{34}). The final post by the original ‘mum’ states she has gained further advice from a German forum, informing her of the risk of the potential for increasing lead concentration with repeated boiling.

**Baby and Bump website\textsuperscript{33} contained a forum thread with the following comments:**

**Forum: ‘Bottled water for making up baby milk? Or tap water?’**

**Topcat, Dec 6th, 2009, 20:07 PM**

...I've been researching the use of bottled water and according to UK government guides, it's not considered the best type of water to use. This is due to the high levels of minerals in the water. I've had a look at the water bottles and the sodium levels seem to be safe (again, according to recommended levels in the UK) but I'm not sure whether to continue using bottled water. On the other hand, high levels of lead seems to be a problem in German water, particularly in older apartments (which we are in).

It's a bit of a dilemma - so I wonder; what do you do use? Should I stick with bottled water or go to tap water?

**Cazza1982, Dec 7th, 2009, 10:35 AM, Oxfordshire, UK**

- This is going to sound really silly as I haven't researched it for you, but would it not make a difference to your bottled water if you boiled it first? I use tap water here and boil it, then wait for it to cool. Not sure why we are told to do this though?

The problem we all have is that the government guidelines are constantly changing and it is so hard to keep up with what is considered 'safe'.

**Topcat, Dec 7th, 2009, 10:51 AM,**

- you're right, the guidelines seem to change all the time! It's frustrating trying to find a consistent piece of advice. I always boil the bottled water first, so it should be ok. I did get some advice from a German forum and someone there suggested that if there was any lead in the tap water, boiling it would concentrate it, not reduce it. I think bottled water is my safest bet.
Another blog indicates some degree of public awareness of the issue: 

Post by Lauren on Yahoo answers
Do not use hot water from your tap!!! That is kind of gross even for us to drink. That water has been heating and sitting in your water heater for who knows how long. What's wrong with hot tap water? Many homes have plumbing with lead or lead solder and hot water can concentrate the lead. Running the water for 15 to 30 seconds and only using cold water can help reduce your baby’s exposure to lead from tap water. There is no reason to boil the water (that is an old practice that has been proven unnecessary) Use purified water or buy a water purifier.

While so many health and safety aspects of pregnancy and childhood are extensively covered in publicly available NHS literature, there may be a general assumption that what is not covered cannot be important. Since there is no mention of lead in drinking water within Department of Health information (‘pregnancy’ and ‘Birth to five’ guides), the result may be that even if parents and caregivers become aware of the potential problems associated with lead they may not prioritise tackling these risks. Furthermore, NHS media designed for a general audience, for example NHS Choices, also has no information on the risks from lead, either in tap water or other sources.

Although the blog posts above highlight the lack of information designed for the vulnerable group, they also indicate that there is a desire for information amongst the public. In turn this suggests that health promotion may be a successful approach to tackling the problem. The blogs also emphasise the fact that these health matters are discussed online by members of the public. This may indicate that peer support is important to these users, which could inform the approach to health promotion. Messages could be framed in a similar way to blog posts. Alternatively expert bloggers (some GP-parents write blogs) could actually post accurate information directly.

The WaterUK website has a large section detailing the health benefits of water for young and old. However, no risks from water are described in this section. It should be noted that information about lead is available elsewhere on this website, in a leaflet available to download. The leaflet ‘Looking after your water’ has sections describing how water is used in each area of the house. The kitchen section describes water quality problems. However lead is not mentioned in this section where it would seem most appropriate, but in a separate section, almost an addendum, entitled ‘other useful information’. From a quick reading of the leaflet the risks from lead could easily be overlooked; again the issue appears to have been downplayed by structuring the information in this way.

An international website search returned a good example of health promotion about the risks of exposure to lead in pregnancy. Published by the Missouri Department of Health and Senior Services, ‘Pregnancy and Lead Poisoning’ describes the risks of lead from all environmental sources. Water is mentioned as the second environmental source of lead. It recommends testing the water, but doesn’t mention any remedial action. Unfortunately as this is an American source it is likely that people would suspect that it doesn’t reflect the British situation.
4.3 COMMUNICATION AND HEALTH PROMOTION

4.3.1 BEHAVIOUR CHANGE
Changing behaviour is a complex process which is likely to involve different levels of cognition from conscious reasoning of the balance between costs and benefits to more subliminal processes such as converging with perceived social norms. Reference to various models can help unpick the stages that people go through prior to changing their behaviour, and help to identify effective interventions to help people move towards the ‘desired’ behaviour.

Several of the underlying principles of behaviour change may not necessarily be formally recognised as theories, but a good understanding of them and the elements needed to enact and sustain behaviour change is important, since this project is in essence all about encouraging a behaviour change that will promote health and reduce risks. The two most commonly used models, together with some more recent ideas will serve to underpin later recommendations for action.

4.3.2 HEALTH BELIEF MODEL
This was developed by psychologists in the 1950s to explain the lack of participation in health promotion programmes. The key variables used in the health belief model are:

- perceived threat: Perceived susceptibility indicating the subjective perception of the risk of ill health and its severity
- perceived benefit: The believed effectiveness of strategies designed to reduce the threat of ill health
- perceived barriers: The potential negative consequences that may result from taking particular actions, including physical, psychological and financial demands
- cues to action: Events, either bodily, e.g. physical symptoms or environmental that motivate people to take action
- other variables: Anything, such as socio-economic segmentation, or geography that affects perceptions and influences health behaviour
- self-efficacy: The belief in being able to successfully undertake the behaviour, in this case running the cold water tap before drawing water for drinking or cooking

The health belief model can be used to understand and explain why some individuals do and others do not change their behaviour. The model has been criticised because it fails to explore social norms, which are thought to be important in determining behaviour; and its abstract nature with an emphasis on the rationality of people’s behaviour probably makes it more useful as a framework rather than a true model.

4.3.3 THE TRANSTHEORETICAL OR STAGES OF CHANGE MODEL
This frequently cited model was first described in 1982, and later developed to incorporate the following clearly defined stages by Prochaska, DiClemente and Norcross in 1992.

The model suggests that when people engage in a new health behaviour, they travel on a continuum of behaviour change, and that it is important to understand where along the continuum anyone exists, so that advice and education can be tailored to their needs at the time.
There were originally four stages, but five or six are now recognised. The stages were originally considered to be linear, but are now thought to be more cyclical, with people moving around the cycle several times before sustainable behaviour change is achieved.

FIGURE 4. STAGES OF CHANGE

In relation to reducing the risk from lead in tap water, they could be described as:

1. pre-contemplation: A family is not concerned about the issue of lead in water and has no intention of changing behaviour. At this stage, consciousness raising, using information and education, possibly through a variety of media is needed
2. contemplation: A family acknowledges that they should be running the taps in the morning or changing their pipes. During this stage, affirmation from a professional about the importance of undertaking this activity is needed
3. preparation for action: At this stage, the family decides that they are going to do something, and may even contact the water utility for advice or further information about what to do. Professionals can help by providing continuous encouragement. Any discouraging or negative experience at this stage can easily send a family back to the pre-contemplation stage
4. action: The family change their pipes, or make a firm commitment to run the cold tap for a sufficient time first thing in the morning and whenever the water has been left standing in the pipes. Professionals can help by facilitating any home project to change the water pipes
5. maintenance: At this stage, the family needs regular encouragement to continue to run the water every day (assuming that lead pipes have not been replaced)

Similar to other models aimed at behaviour modification, a weakness of the Stages of Change model is that it focuses too much on personal responsibility, without assessing the important role of external environmental or structural influences.43,44
4.3.4 NUDGE THEORY

American economists Richard Thaler and Cass Sunstein have developed ‘nudge’ theory based on a libertarian paternalist approach. This is the view that people should be free to make their own choices but can be subtly guided through the ‘choice architecture’ so that they are more likely to make decisions that are in their long-term interests. According to this theory, people will change their behaviour incrementally if they are given small nudges in the ‘right’ direction. These nudges may simply be a question posed by a health or utilities professional or a poster providing some positive facts. Both transtheoretical and nudge theories suggest that changing community norms is important, so for example, instead of highlighting that there is a risk from lead in water, turn this around and reinforce the fact that the majority of families have changed their pipes or they run their water in the morning to protect their families from the adverse effects of lead.

4.3.5 SOCIAL MARKETING

The term social marketing was first coined by Kotler and Zaltman in 1971 to refer to the application of marketing to the solution of social and health problems. Marketing has been remarkably successful in encouraging people to buy products such as new cars, cola, and designer clothes and trainers, and it can also encourage people to adopt behaviours that will enhance their own lives and those of their fellow citizens. Many social and health problems are preventable and are linked to individual behaviour. Social marketing provides a mechanism for tackling such problems by encouraging people to adopt healthier lifestyles. The concept is not new and even in 1951, Wiebe suggested that the more a social behavioural change campaign mimicked that of a commercial marketing campaign, the greater the likelihood of its success. However, there are some important differences between social and commercial marketing.

Specifically, in social marketing:

- the products (ideas and behaviours) tend to be more complex
- demand is more varied
- target groups are more challenging to reach
- consumer involvement is more intense
- the competition is more subtle and varied

Since an independent review by the National Consumer Council in 2006 established its effectiveness, the use of a social marketing approach to encourage healthy behaviour has become a key feature of government policy and is now widespread. Social marketing uses traditional marketing strategies such as explicitly seeking to understand what consumers want, and then tailoring service developments to meet identified needs. In traditional commercial marketing, a happy family image or sex is often used to sell products. The key to good marketing is finding something that the customer wants or values and then working out what customers might be prepared to offer in exchange. The commercial market trader links a car with an attractive lifestyle, or something that the customer wants or values. This increases demand for the product and money is exchanged for an item that is wanted and both parties feel satisfied. The successful trader manages to link what is essentially a mundane product, such as soap powder, with something that the customer values. Good marketing makes the customer feel that if they buy the product, they will also buy in to the valued benefit associated with it.
Individuals working in health promotion have been trying with varying degrees of success to ‘sell’ good health for many years. Members of the public have been urged to stop smoking, use condoms, wash their hands or drink less alcohol because it is good for their own or other citizen’s health. The product being sold in these examples is good health. Campaigns encouraging young people to stop smoking – because it is good for health - do not appear to work as well as those suggesting that a person who does not smoke is more attractive or has fresh breath. Essentially stopping smoking is being sold, not because it is good for future health, but because it provides something, such as being attractive, that young people value more highly here and now. A social marketing campaign relies on having insight into what the customer values and wants; what they might be prepared to forego to ‘buy’ this and then linking it to the product or service on offer. Social marketing, when customised, developed with and delivered to disadvantaged communities has achieved a lot. Success however, is dependent on gaining a true understanding of the motives, needs and lives of the people living in the local communities.

A review of social marketing campaigns 49 found a number of key points that characterised successful social marketing initiatives that can be used as a checklist to ensure best practice:

- changing attitudes, behaviour and policy requires a long-term commitment with long-lasting organisational and financial support
- many social and public health issues are a challenge for society as a whole, not just a group of individuals. Adopting a perspective that facilitates policy change as well as individual behaviour change encourages broad ownership of a problem and collective responsibility for tackling it
- reframing a problem can be effective. For example, the ban on smoking in public places was achieved because the problem moved away from ‘victim blaming’ towards a public health issue – the protection of workers
- offerings showing humour, empathy and positive messages can engage people’s emotions as effectively as fear-based messages
- they often involve multiple approaches including upstream changes to policy and services as well as awareness-raising, education, legislation and continued support for behaviour change
- changing behaviour often means changing social norms because changing the way the public sees a problem can increase buy-in and encourages greater self-reflection
- they are built on understanding the target group’s attitudes, values and needs
- they analyse and address the ‘competition’ to the desired behaviour or policy change

5 Methodology

Ethical approval for this study was granted by Liverpool John Moores University Research Ethics Committee prior to commencement. In stage 1, focus groups were held amongst vulnerable group to establish values in life and views on information about lead in drinking water. This information was used to develop a leaflet and website.
The second stage consisted of randomised control trial, which used a questionnaire to measure the impact of the leaflet and website compared with standard UU leaflet and website. A small number of participants were asked to take water samples to estimate whether the interventions that they employed were effective at reducing the lead concentration in the water that they use. All records were maintained securely and confidentially. Records were destroyed at the end of the study. All quotations or views were anonymised for presentation.

5.1 STAGE 1

UU advised on four locations in the north west of England which, from local knowledge, have higher proportions of houses with lead plumbing:

- Birkenhead (BK) and Wallasey (WL) (NB These areas were labelled separately in Stage 2)
- Ellesmere Port (EP)
- Skelmersdale (SK)
- Southport (SP)

Specifications for the focus groups were drawn up and a market research agency was appointed to recruit for the focus groups. Participants were selected based on inclusion and exclusion criteria developed to match those in stage 2. The exception to these criteria was that, although participants were living in pre-1970 houses, identification of lead plumbing was not attempted. Store vouchers of £20.00 in value were used as compensation for the time taken to participate in the focus groups. Individuals were required to give informed consent before participating in the focus group.

The focus groups were each facilitated by two or three researchers. Solely for the purpose of aiding analysis, and with the consent of all participants, the focus groups were video and audio recorded.

Following an introduction to the project and a description of the aims of the focus group, the session was organised around the following main issues (see Appendix 1 for more details):

1. exploration of participants’ ‘values in life’ – using discussion based around priority sort cards
2. background to the issue of lead in water - open response
3. exploration of participants views about a range of statements about harm caused by lead in water - which have most impact on them?
4. discussion about strategies to avoid lead in drinking water, especially which are feasible
5. exploration of preferences and opinions about the strap-lines that might be used in the media
6. discussion about the delivery of media messages, especially where or when would be the best time

The first section, which has been used previously, was designed to examine lifestyle values of our target population in order to support a social marketing style of intervention. The exercise used a number of cards presented sequentially each of which had a phrase referring to a lifestyle factor – for example ‘family life’ or ‘holiday in the sun’. The group was
asked for their views on each and to place the cards in order of relative priority to them. The majority opinion for the final order was captured. Finally the group were asked whether there were other high priority issues for them which may have been missed. The aim of the first section was to gather views on people’s approaches to and values in life. It was also a useful exercise to ‘break the ice’; to get people chatting on familiar subjects. Without this, the technical nature of the issue may have made people feel uncomfortable or inhibited from interacting in the following discussion.

In the second section a brief overview of the issue of lead in water was given. The technical nature of the subject means that responses to the following sections may have been of limited value if the participants lacked background knowledge. This section was aimed at getting a sense of lay knowledge about health effects of lead and risks of exposure in drinking water.

The subsequent sections (3-5) were targeted to the content of a leaflet, where several options had been developed. Participants were asked which option may have an impact or encourage them to take action. The final section addressed at which stage during parenthood and which setting would be best to receive information.

A thematic analysis was used with recordings of each focus group. Themes concerning the groups lifestyle values and awareness of the risks of lead in drinking water were explored by three different researchers, before reaching consensus. Responses of the groups to various potential messages for health promotion were analysed in order to determine relative impact, shock, engagement and potential uptake of messages. This information was synthesised and used to further develop the health promotion material.

Based on the findings of stage 1 and using in-house (LJMU) graphic design and web development personnel, a leaflet and related website were developed.

5.2 STAGE 2

A pilot randomised control study was used to investigate whether the materials developed were able to modify the attitudes or behaviour of people within the vulnerable group.

Participants from the vulnerable group living in four areas (see areas listed for Stage 1) of the north west of England were recruited to the study. The researcher attempted to identify lead plumbing within the property. Participants were asked a questionnaire and were given either the control (UU50) leaflet or the experimental intervention leaflet (described above). After approximately two months the participants were contacted and a similar questionnaire was administered, to investigate whether the experimental intervention or control had changed their knowledge, attitudes or practices with regard to lead in drinking water. The same person within the household who answered the first questionnaire was requested to answer the second.

Water samples were collected by the participants, but these were not intended to be an outcome of the study. These were rather to give an indication of whether the participants were exposed to significant amounts of lead and whether the practices could be beneficial at reducing exposure.
5.2.1 Recruitment
The inclusion criteria for the randomised control trial:

- the householder is a parent or caregiver of children younger than 6 years or is expecting a baby (pregnant or partner)
- the residence is a house (no flats) that was built before 1970 and, where possible lead plumbing has been positively identified by the researcher
- the address is within the four areas of the study: Birkenhead (and Wallasey), Ellesmere Port, Southport and Skelmersdale

Exclusion criteria were:

- the person had been involved in the focus group (stage 1) (these addresses were not visited)

5.2.2 Randomisation Procedure
Each researcher assigned participants to intervention or control groups on an alternate basis. As the uptake rate of cold-calling door-to-door was expected to be low this approach was expected to give a random distribution of the two groups across each area.

The field researchers called on individuals and, provided they met the inclusion criteria, they were provided with written information about the project. If they were willing to participate, they were asked to sign a consent form.

All participants who completed the study were entered into a prize draw for an iPod as an incentive and to compensate them for their time.

The field researchers introduced themselves and the project and attempted to check visually whether lead plumbing was present on the property. Researchers asked participants the questions and completed a questionnaire (only one respondent per household).

The control group received the standard UU factsheet: ‘lead in drinking water’\textsuperscript{50}. This provides very general information, not targeted to a specific group. It also includes a web address where further information can be found.

The intervention group received the leaflet which had been developed for the project. The design had been targeted to the specific vulnerable group. It included the address of the website which had been designed to complement the leaflet and to provide more in-depth information. Participants in the intervention group were also given the standard UU factsheet\textsuperscript{50}.

The participants were not informed whether they were in the intervention or control groups. As the study was investigating health promotion, it was difficult to conceal from the participants whether they have received new information or currently available information. For example if they had previously received the standard leaflet from UU they could determine which experimental group they were in. Also, if participants talked amongst each other they could similarly work out which group they were in. However the risk of these factors confounding the study was considered to be insignificant due to the geographical distribution of participants. The researchers and analysts were not blinded due to the practical difficulty and this seemed an unnecessary complication for a pilot study.
After approximately two months participants were phoned and asked a second set of questions. This second questionnaire was broadly similar to the first, but had certain specific questions about whether they had used the supplied materials and their opinion of the most appropriate way to deliver the health promotion.

5.2.3 WATER SAMPLING
A small proportion of participants were asked to take samples of drinking water for lead analysis. There were several validation limitations of this sampling method; participants were taking the samples, introducing variation, also the small volume of the sample (50ml) could introduce errors. For example if the sample was taken immediately on opening the tap the water sampled will have been standing in the plumbing between the stopcock and the tap rather than the supply pipe. These components are likely to be copper or brass rather than lead. In general, lead concentrations vary over time for a number of reasons, and therefore this type of measurement is a poor indicator of level of risk\textsuperscript{24}. For these reasons it was decided to limit sampling to 10% of participants.

The aim of water sampling was firstly to support the selection of participants; any amount of lead present in the water would indicate that this group is at risk. Therefore participants were asked to take a sample first thing in the morning; a ‘first draw sample’. A secondary aim was to investigate whether their chosen intervention could be effective at reducing lead concentrations. Participants were asked to sample the same water that they used for filling the kettle or making drinks. This second sample would be likely to be tap water following flushing of the tap; a ‘flushed sample’; however if the participant used bottled water, they may sample that. Participants were not asked to state which practice they followed, because too many questions or instructions may have appeared too onerous, which may have reduced compliance and return of samples.

Samples were sealed and labelled with address, identification number and first or second sample. These were collected within two days and submitted to UU for analysis. Lead content was measured by inductively coupled plasma mass spectrometry following acid digestion using the standard protocol.

5.2.4 DEVELOPMENT OF THE QUESTIONNAIRE AND PILOTING
The investigative tool of the randomised control trial was the questionnaire, which was developed to estimate participant’s perception of risk and self-reported actions taken to reduce risk. The initial visit investigated the participant’s baseline response. A second questionnaire (excluding some of the baseline questions, see Appendix 4, Second questionnaire) investigated any changes that could be attributable to the experimental intervention compared with the control leaflet. As this study was novel, the questionnaire was designed to capture a broad range of information. The results will build a picture of participant’s current knowledge, attitudes and practices which will be useful for any future health promotion or policy development related to this issue. Also because this is a pilot study it was not known which questions were the most pertinent and sensitive to capture differences in participant’s knowledge and opinion.

The questionnaire was designed to capture several different areas and types of information from participants. It was designed to be delivered directly by a researcher; in the home or over the telephone. Assuming appropriate training of the researchers, delivery in this manner had the following implications for design of the questionnaire. The researchers were
instructed to ask questions sequentially, thus the ordering of the questions could minimise bias. For example general open questions addressing water quality were asked before questions exploring the risks of lead or practices to avoid lead. If the order were reversed the latter may trigger respondent’s concerns, and hence bias the response to the former. Furthermore delivery of the questionnaire by the researcher meant that if participants were unclear about the meaning of questions, these could be clarified.

Different areas investigated were:

- details of composition and income of household and tenure of property
- knowledge of the risks of lead in drinking water
- attitudes towards the risks of lead in drinking water
- practices to reduce exposure to lead from drinking water

A mixture of open questions and questions with categorical answers were developed. Care was taken in wording to minimise bias. Although the questions were designed in the above groups, the final order of the questions was determined by the need to reduce bias as mentioned above.

Once the questions had been formulated, colleagues were asked to provide views and suggestions on the draft questionnaire. Following modifications, a limited amount of trialling was carried out.

In addressing the details of lead toxicity there is a risk of causing participants untoward anxiety about drinking water. However previous work examining risks from drinking water did not find evidence of exaggerated fears.

Six field researchers visited homes enrolling participants and delivering the questionnaire. These researchers were given training on the subject of lead in drinking water, to give them the background to the study. They were also given detailed training in:

- selection of houses (built before 1970) and participants
- introducing themselves and the study to enable participants to give informed consent
- investigating whether there was a lead supply pipe in the house
- offering token reward for participating (a pen and entry into a prize draw)
- assignment of participant to control or intervention and giving them the appropriate leaflet
- personal safety

Researchers were given a guide containing some of the above information and also a script to be followed when introducing themselves and the study. These supporting documents aided consistency in approach between researchers.

Participant’s responses were marked on copies of the questionnaire, along with a participant ID code.

Participants were followed up after at least two months to allow them time to read and take action on the information within the leaflet (either control or intervention). Two researchers conducted the second questionnaire over the phone. The second questionnaire was similar to the first, except some questions were omitted. Questions about family details and housing
and also some questions which related to prior knowledge were not repeated in this questionnaire. Additional questions about the leaflet and delivery of information were appended.

5.2.5 STATISTICAL ANALYSIS
A database was built from the responses to both questionnaires in the analytical software, PASW Statistics 17.0 (SPSS Inc). Data were stored on a secure university server and backed up on portable memory device, which was kept in a locked drawer. Data from the first questionnaire were analysed to investigate participant’s responses before intervention. In itself this could be useful information for developing health protection strategies. Data from both questionnaires were analysed to examine the effectiveness of the intervention in changing the behaviour of participants in regard to their exposure to lead in drinking water. Key co-variables examined were family status and access to information and support. Family status, such as tenure of property and family income may determine available options for taking action. Access to information and support may aid decision making and support implementation of action, whereas without this support the issue may be disregarded.

The target of this pilot study was to achieve more than 200 participants.

6 RESULTS

6.1 STAGE 1
Focus groups were held with members of the vulnerable group in four locations in the study area (see Methodology, Stage 1). The qualitative data was used to develop a leaflet and website as well as gain an understanding of the issues against a rich contextual background.

6.1.1 EXPLORATION OF PARTICIPANTS’ ‘VALUES IN LIFE’ - PRIORITY SORT CARDS

<table>
<thead>
<tr>
<th>Skelmersdale</th>
<th>Southport</th>
<th>Ellesmere Port</th>
<th>Birkenhead</th>
</tr>
</thead>
<tbody>
<tr>
<td>highest priority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>happy family life</td>
<td>happy family life</td>
<td>long &amp; healthy life</td>
<td>family long &amp; healthy life</td>
</tr>
<tr>
<td>long and healthy life</td>
<td>family values</td>
<td>eco-living</td>
<td>clean living</td>
</tr>
<tr>
<td>happy relationship</td>
<td>long &amp; healthy life</td>
<td>social life</td>
<td>good environment</td>
</tr>
<tr>
<td>education</td>
<td>good services</td>
<td>owning home</td>
<td>good job</td>
</tr>
<tr>
<td>having children</td>
<td>holiday in sun</td>
<td>owning home</td>
<td></td>
</tr>
<tr>
<td>good job</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>good social life</td>
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<tr>
<td>owning home</td>
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<tr>
<td>holiday in sun</td>
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</tbody>
</table>

TABLE 1. PRIORITIES OF LIFESTYLE VALUES FROM FOCUS GROUPS (PINK CELLS; PARTICIPANT SUGGESTED FACTORS)
The first part of the focus group asked participants which lifestyle factors they prioritised. Cards were described and discussed individually before trying to reach a decision as to whether they were of higher or lower priority than previous cards. There was general agreement between participants and also between the groups on the order of the lifestyle factors. ‘Happy family life’ was consistently a top priority (the Ellesmere Port group wanted to add ‘long and healthy’ to the ‘family life card’). Smoking was connected to the issue of healthy or clean living. Two participants (Ellesmere Port and Southport) mentioned how concern for their children’s health was a motivator to give up.

‘Happy relationship’, with their partner, was often a high priority, but several participants pointed out that this definitely came second place to their children. Interestingly, considering all participants had children, ‘having children’ was frequently rated halfway down the priority list, possibly this indicates that participants were satisfied with their family size. ‘Social life’ was relatively high priority for two groups, but lower priority for the other groups. ‘Owning home’ was low or even lowest priority which may indicate that most of the participants were tenants and were content with this. ‘Holiday in the sun’ was consistently at the bottom of the priority list.

Several other lifestyle factors were described by the groups in addition to our pre-prepared cards. Interestingly ‘education’ and ‘services’ (local health and social) were put forward by the Skelmersdale group; rated as medium priority. Environmental and ethical values, including doing activities together with their children, were noted issues for Southport and Ellesmere Port, whereas ‘money’ was an issue for the Birkenhead group.

Considering that participants were selected on the basis of being parents (or caregivers) of young children or expecting a baby, a simplistic view would be to expect that they would share priorities about lifestyle factors. However differences in socioeconomic level may explain some differences in perspectives of the groups. The following discussion concerns specific points raised, but the final part of this section describes some characteristics which differentiate the groups, from an overall perspective.

6.1.2 DISCUSSION OF POSSIBLE OPTIONS FOR HEALTH PROMOTION MESSAGES
A common opinion was that the risk from lead in water should be made explicit. The Ellesmere Port group discussed their fears of air pollution and referred to an ‘advert’ which suggested that if people could see air pollution they would avoid it. The group developed this concept by suggesting images for the leaflet should show a baby drinking from a bottle that was visually contaminated or ‘dirty’. Further ideas involved showing a cross section of a lead pipe and showing a microscopic image of lead particles (or molecules even) coming off into the water. The inspiration for this is likely to have been the TV series ‘CSI’ which often employs zooming imagery from normal vision down to a supposed microscopic view. These sequences can be thought of as developing links between (exciting) real life and the (boring) ‘sciencey-bit’. Although both of the above images could be visually shocking, while the second idea could be considered as merely informative, the first would be categorised as a shock factor. Several participants from the different groups recommended using ‘scary messages’. They thought that this approach would have a higher impact and that people would be more likely to pick up and take interest in the leaflet. A more moderate view from one person in Southport was that the most effective approach would be to set ‘gentle alarm bells ringing’.
Discussing the harm that lead can have on the developing brain generated a strong reaction in several group members. Reactions of at least two mothers indicated feelings of guilt or blame.

These mothers felt guilty that they had been giving their children formula milk containing lead and that they would be to blame if their children suffered as a result. Facilitators of the focus groups tried to reassure these worried mothers that this was not their fault, that their children wouldn’t necessarily be affected and that there are many other factors which contributed to their children’s future success and happiness. These reactions highlight the importance of avoiding approaches which may make people feel guilty or to blame by their past or current actions. Indeed this point is emphasised within social marketing theory which recommends avoiding any ‘negative’ words. On the other hand guilt and responsibility were interpreted from an entirely different approach by one member who said that medical conditions were frequently used as an excuse by people who simply had children with bad behaviour. He suggested that promotion of the effects of lead toxicity may add to the list of excuses that parents could give for unruly children. However there was a general level of consensus that people appreciated having the information and being given the opportunity to take action. Messages should be framed in this sense; encouraging responsibility for future action rather than imply guilt for past practice.

Following some of the above points, there was general consensus that messages should be clear and concise. Text should be direct about the risks and give a clear course of action. Several groups voiced limitations of time and attention, particularly at this time in their lives when they are busy looking after their baby or child. On the other hand the approach should not be too dictatorial. Some of the statements given to the focus groups were seen as ‘telling you what to do’ or ‘sounded like a sales pitch’. Striking the right balance is an important point in terms of nudging behaviour change.

The majority of participants expressed concern about various factors that may affect their children’s health. In different groups the risks of alcohol, smoking and air pollution were raised, as well as concerns about water quality. The health of their children was a key motivator for two participants to give up smoking. Perception of relative risk is a complicated issue, but several comments showed that the groups were aware that lead would be one of a multitude of factors that could affect their children’s health and development. For example there were opinions that messages about risk should include the phrase ‘tends to affect…’ rather than ‘will affect’, describing the probabilistic nature of the risk. These points highlight an important objective of the leaflet; to generate trust in the target audience about the relative risk of lead in drinking water.

Following these issues of trust in the message is the question of trust in the author. Some participants indicated cynicism about the motivation of UU in publicising the problem, indicating a possible ulterior motive of profit to be made by encouraging people to replace
their pipes. Most participants held health professionals in high regard, so endorsements by a GP, midwife or community health visitor were valued and would be beneficial to changing behaviour.

Comments from several of the groups raised concerns about values placed on academic achievement. Statements concerning children’s grades or performance at school were disliked as was the implied connection between performance at school and doing well later in life. It was felt that the latter connection was not a direct link; that people’s quality of life was not necessarily dependent on academic qualifications. Another criticism of a statement including a phrase referring to children doing well at school was that this could refer to other factors such as bullying.

Strong feelings were expressed about statements concerning children’s behaviour. It was felt that anti-social or bad behaviour were value judgements and had become negative, victimising labels. Messages should concentrate on children’s health rather than mental abilities or ‘anti-social’ behaviour. Also ‘chances of doing well later in life’ was viewed as a positive message. One positive aspect concerning behaviour which was suggested was that frequent media coverage of attention deficit and hyperactivity disorder (ADHD) means that this is a well known concept and that messages relating to poor attention or hyperactivity may have a high impact.

There was some discussion about having a shower or flushing the toilet first thing in the morning before filling the kettle for making a cup of tea or formula milk. Generally participants stated that they would shower or flush the toilet first. This volume of flushed water is likely to have some protective effect, as it would run off at least some of the water that has been standing in the supply pipe overnight, accumulating lead. Some participants also reported running the taps first thing in the morning. The reason given was that their parent or grandparent always ran the taps. Other participants were worried about the cost of this practice. One participant was expressing her concern about the cost of running water when other participants reminded her that she didn’t have a meter and so wouldn’t be directly charged. Apart from the evident lack of awareness, this exchange may give an indication of the pervasiveness of media messages about the fairness of water metering (or conserving water). It indicates a general feeling that water is expensive, or should be conserved. These messages may counteract health promotion messages which recommend flushing tap water.

During the first exercise, home ownership appeared to be a low priority. This may indicate a low proportion of homeowners in the groups. Tenants may find requesting their landlord to replace pipes is not a straightforward process. It follows that replacing pipes should not be the primary message. This may be too much of a barrier for action for both homeowners and tenants, which may lead to the issue simply being ignored. Furthermore it may indicate that more could be done to encourage landlords to replace lead plumbing.

Birkenhead focus group member: ‘Some people put other things above that [school], some people think being happy and playing is more important.’

Ellesmere Port focus group member: ‘That one with intelligence, I hate that word, intelligence, I would have stopped there and then.’
6.1.3 Overall characteristics which differentiate the groups

Differences between the groups were found throughout the session. This is particularly apparent in the first section, using the example of their suggested lifestyle factors, the ones which were additional to those which were presented. The Birkenhead group suggested ‘Money’. This group tended to be more cynical about issues, including spending money to avoid lead hazards. Other comments indicated the group was fairly anti-authoritarian; they did not like messages that seemed to be ‘telling them what to do’. They wanted messages to be short, clear and to the point and that the media should also be eye-catching.

From observing conversation and group behaviour, the Skelmersdale group seemed like a more close-knit community than the other groups. Some comments suggested a long family history in the town. Discussion of renting from the housing association suggested that most were tenants. They seemed relatively easily worried by certain statements and there was an extent of the group becoming more anxious by comments that other group members made. Their suggestion of ‘Good services’ suggests concerns about extent or quality of local provision of health and social services.

Ethical and moral issues were raised by the Southport group. A larger proportion indicated that they were homeowners. Their views on the issues discussed seemed to be more considered and ‘weighed up’. They discussed the conflicting messages of conserving water for reasons of environmental protection versus running the taps as the facilitators were suggesting. One member commented that he had moved up from the ‘South’ indicating that the group was perhaps more geographically mobile and outward looking.

‘Good environment’ was the additional comment from the Ellesmere Port group. They raised concerns about air pollution from nearby heavy industry (oil refinery and lead additives plant). They also raised social concerns, for example, about behaviour of neighbours and being moved between social housing accommodation.

Both Ellesmere Port and Birkenhead groups were concerned that messages highlight long-term prospects in life rather than focusing on child education or behaviour, as these were seen as too narrow. There was a tendency towards defensiveness in their feeling that the latter approach could be taken as a judgement on children’s academic ability. Further, they felt that emphasis on academic achievement and behaviour supported an already biased social value system. Members of the Southport group voiced similar concerns and raised a further criticism; that buzzwords, like ‘antisocial’, or labels such as ‘ADHD’ (attention deficit and hyperactivity disorder), were overused and detrimental, as they felt that children were becoming victimised by this approach.

For the purpose of using a social marketing approach for developing health promotion material, a key aspect is to target specific groups within the population using in-depth knowledge of their values and lifestyle factors. Although at first inspection, the issue of lead exposure from drinking water may seem to be an impersonal, even a technical, issue, a more thorough analysis reveals the differences in attitudes towards the problem and perceived value judgements in potential health messages.
The participants who contributed their views may represent their local population. In which case the preceding paragraphs indicate that even within one region (greater Liverpool) local populations differ in key aspects of lifestyle and attitudes. Socioeconomic status is likely to be an important factor in these differences; however other geographic and demographic factors will also contribute. The most prominent factor for this study is likely to be tenure; if people are renting it is likely they will feel less responsible for utilities and hence less engaged in action concerning water supply.

On the other hand it may not be the case that these participants represent their local population. Aspects of the methodology may have introduced selection bias. Although we tried to arrange focus groups at a convenient time (early evening) this may have excluded certain groups, for example shift workers. Single parents may not be able to attend, due to difficulty finding childcare. A financial reward/compensation was offered to all participants; however those with higher household incomes may have found this of lower relative value (and would be more likely to be dissuaded by inclement weather). Finally if people already had fears or worries about water quality they may have been more likely to come to the focus group and may give a stronger opinion than the majority of local residents. All of these factors may bias the results of the focus groups. In order to validate findings from the qualitative work, questions addressing similar aspects were added to the questionnaire. This approach enabled attitudes from a broader section of the population to be sampled.

However if the responses are assumed to represent the local population, an interpretation of the differences in views between the groups can be applied to development of health promotion media. On this basis, messages could be designed to specifically target a section of the vulnerable group. As mentioned above, if tenure is a key factor, different media could be designed for tenants and homeowners. For example messages for tenants may centre around running the taps in the morning, whereas for homeowners it may focus on replacing lead plumbing. Using these principles media could be developed which would be appropriate to different populations across the country, taking into account differences in water supplies (plumbosolvency).

6.1.4 KEY FACTS TO CONSIDER INCORPORATING IN MEDIA
The researchers reached a consensus on the key themes emerging from the qualitative data which would be important to cover in health promotion media:

- you cannot see or taste the lead in your drinking water
- boiling and filtering does not get rid of lead
- UU have done all they can; in the eyes of government, responsibility now lies with you
- how to check your pipes
- the effect on your children is cumulative – there are minimal effects from a one-off dose
- run the tap first thing in the morning before filling the kettle
- bottled waters are free from lead (levels of sodium and nitrate in most bottled water is safe for your children)
- lead affects the foetus during pregnancy as well as young children
6.1.4.1 Development of media

Information acquired from the focus groups was very useful for developing the leaflets (and subsequently the website). Although there were contradictory opinions there was also some agreement. On the basis of these findings the content of the leaflet was developed in the following structure:

1. strapline: ‘Do the best for your kids’:
   Designed to be a positive message that does not have a dictatorial tone or make people feel guilty
2. the facts: A clear statement of the distribution of lead plumbing and the health risks:
   In easy to understand language (low reading age) and broken up into small sections. The difficulty is that there is quite a lot of technical information to be communicated
3. a guide to identification of lead plumbing:
   Unless the resident is convinced that the issue relates to their property, there will be a tendency to avoid tackling the issue
4. mum’s blog:
   The aim is to convey the technical and medical points in an approachable, ‘peer-learning’ style
5. references to the website and United Utilities website and enquiries phone number:
   The website was designed to match the leaflet in design approach and content. It also included more references if the reader was interested in finding out more

6.2 Stage 2

Media developed from qualitative research in Stage 1 were tested by randomised control trial. Firstly a questionnaire was developed to investigate participant’s knowledge, attitudes and practices. Information from this questionnaire was expected to be informative by itself as well as being the outcome measure of the trial. The questionnaire was delivered face-to-face before giving the participant either the experimental intervention or the control. After two months participants were questioned again, mostly by telephone.

6.2.1 Participants recruited & followed up

<table>
<thead>
<tr>
<th>Area</th>
<th>First questionnaire response (% of total)</th>
<th>Second questionnaire response</th>
<th>Percentage lost to follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK</td>
<td>62 (38)</td>
<td>69</td>
<td>16</td>
</tr>
<tr>
<td>EP</td>
<td>21 (10)</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>SK</td>
<td>25 (12)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>SP</td>
<td>33 (15)</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>WL</td>
<td>56 (26)</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>217 (100)</td>
<td>178 (82%)</td>
<td>overall 18%</td>
</tr>
</tbody>
</table>

TABLE 2. NUMBER OF RESPONDENTS TO THE QUESTIONNAIRES AND PERCENTAGE LOST TO FOLLOW-UP BY AREA (BK; BIRKENHEAD, EP; ELLESMORE PORT, SK; SKELMERSDALE, SP; SOUTHPORT, WL; WALLASEY)
Over a four week period, the six researchers visited houses in the four areas (the largest area on the Wirral extended beyond Birkenhead into Wallasey, however, due to high numbers recruited, these participants have been grouped separately). Response rate was highly variable with different areas and also time of day. The general opinion of the researchers was that if the person who answered the door fitted the inclusion criteria, there was a good chance that they would be willing to participate. A minority refused or were not willing to give details such as phone numbers. Many people said they were too busy and suggested the researcher call back later, which was sometimes successful.

Researchers noted addresses at which no one had answered the door, so that they could try again on another occasion. However, it was decided that this was not an efficient use of time. It was felt that it would be more efficient to move on to streets that had not been attempted before. In this way, although the response rate was low, the majority of appropriate streets in each of the areas were covered.

The number of respondents for the first questionnaire was 217. Table 2 shows response rates of each area. Birkenhead and Wallasey yielded the greatest proportion of participants, which may have been due to the high density of appropriate housing. All researchers started at Birkenhead before moving to different areas (for full details see Appendix 5, Participants recruited by researcher and area).

6.2.2 PARTICIPANTS LOST TO FOLLOW-UP

Two months after the first visits the participants were phoned to participate in a second, follow-up questionnaire. Some participants were visited at their home address again, particularly if the phone number had not been given or was incorrect. Two of the researchers phoned and visited participants over a four week period. All participants who gave a valid phone number were called and repeated on several occasions if they did not answer or were too busy. Some participants refused or hung-up half way through the questionnaire (n=8), others were not available or had moved house (n=6). The final percentage of second full responses was 82%.

Of the 39 participants who were lost to follow-up almost equal numbers were from the control (19) and intervention (20) groups (not significant by $\chi^2$ test). There were also participants from each area who were lost to follow-up. A large proportion of these participants (22) could not be contacted by phoning and/or visiting their house. A further small group (9) were unavailable due to several reasons such as moving house or being in hospital. Finally eight participants refused to complete the second questionnaire, including those who hung-up part-way through.

To check that participants lost to follow-up were not different in key areas addressed by the questionnaire, baseline data were compared. Table 3 compares frequency of responses to questions with yes or no answers. For two factors; access to the internet and owning their home (with or without mortgage) there are significantly fewer ($\chi^2 p<0.05$) positive responses for the group lost to follow-up than the group that completed the study. For three other factors; gender, whether participant is a first-time parent or whether they are pregnant, there was no significant difference.
TABLE 3. COMPARISON OF PARTICIPANTS LOST TO FOLLOW-UP WITH PARTICIPANTS WHO COMPLETED THE STUDY

Responses to four questions with multiple categories were also compared; age of respondent, number of children, household income, and educational level. Frequencies of each category were compared with the remainder of the total responses (to generate a 2x2 $\chi^2$ test). Using this analysis number of children, income, and educational level showed no difference between the group lost to follow-up compared to those who completed the study. The only significant difference ($\chi^2 p=0.033$) showed that there were proportionally more participants in the older category (combined categories >36 yr) in the group that was lost to follow-up.

Finally, the concerns reported by participants lost to follow-up were checked. A potential reason why participants may have dropped out of the study is that they were worried about the issues raised and did not wish to discuss them further. However, an analysis of respondents who were lost to follow-up shows a very small proportion reported concerns about either lead or other issues (a total of 6 of the 39 respondents lost to follow-up voiced specific concerns in response to Question 10 see appendix 2). This indicates that level of worry was not a major reason for participants to drop out of the study.

Bearing in mind the near-equivalent loss of participants from both arms and the very small proportion (4%) of refusals, it seems appropriate to analyse only the data from respondents who completed the study, excluding 39 participants who did not respond to the second questionnaire fully. However, the factors where differences were found with the group lost to follow-up should not be disregarded. Homeownership and access to the internet could have relevance to the take-up of health promotion messages. Any recommendations that arise from this study should take into account the slightly different needs that this group have.
6.2.3 Initial Analysis of Control and Intervention Groups

| Table 4. Comparison of Simple Baseline Data for Control and Intervention Arms *All Participants Who Completed the Study

Questions about the respondent and their household for control and intervention arms were compared. Responses to Yes/No questions (some had a third choice of don’t know) showed no significant difference by 2x2 $\chi^2$ test. Questions with multiple categories also showed no significance by $\chi^2$ test. These include age category and educational level of respondent, number of children in household, and income category. These data indicate that there were no significant differences in the characteristics of participants between the control and intervention arms.

6.2.4 Characteristics of Participant Group and Baseline Responses

Looking at all participants who completed the study (combining intervention and control) gives information about the characteristics of the sample. As this is the first study of its kind the novel data generated (about knowledge and attitudes) will be important for further health promotion programmes.

| Table 5. Characteristics of Participants Who Completed the Study (RSL; Registered Social Landlord)

Of particular interest in Table 5 is the low proportion of participants who responded that they had a water meter (5.6%) (and a similar amount who said they didn’t know (6.2%)). As running the water is one method of reducing risk of exposure to lead in drinking water it is important to know whether the target audience believe they are paying for this water. For
participants with water meters, messages could emphasise the small cost of running the water every day. For participants without meters, the message could highlight that running the water protects their children ‘for free’ (at no extra cost).

A small but noticeable proportion of participants stated that they did not have internet access (14.6%). Although using the internet for health promotion has advantages, it is important to bear in mind the ‘digital divide’. Initiatives using the internet should also use other media so that population groups without access are not excluded.

Participants were almost equally split by tenure, almost half being homeowners (48.9%, including having a mortgage). Only a small proportion responded that they were renting from registered social landlords (‘housing association’, 6.7%), with the remainder renting from private landlords. For tenants (the majority of participants) the option of replacing the lead pipes is unlikely to be straightforward, as it will depend on the cooperation of the landlord, and may require involvement of the local authority. This indicates that the primary message of health promotion should not be to encourage pipe replacement, as this may seem out of reach to the majority.

Linking the previous two points, it may not be surprising to find that there were significantly more tenants who did not have internet access compared to homeowners (Pearson $\chi^2$ p<0.01, odds ratio (OR) = 3.809 (95% confidence interval (CI) 1.44 to 10.07)). Again this has implications for choice of media; while a website may be appropriate to target homeowners, material targeted to tenants should be primarily in other media (leaflets, radio broadcast).

The next groups of data show responses to questions with multiple category answers. The majority of participants had only one child with decreasing proportions having two, three or four children in the household (Figure 5). No families had greater than four children and a very small proportion of participants were pregnant with no other children in the household. The latter data may reflect the sampling method, as pregnant women with no other children may have been at work during the daytime when the researchers called.
Figure 6 shows household income; the modal category was £15-24000, with a reasonable spread of responses over all categories. A large proportion declined to volunteer income.

![Figure 6. Distribution of Household Income (Question 47)](image)

The frequency distribution of educational level most recently achieved or currently studying shows, unsurprisingly, the most common response is GCSE level with decreasing frequency of higher levels and only a small proportion studying at postgraduate level (Figure 7).

![Figure 7. Distribution of Educational Level (Question 46)](image)

6.2.5 External Influences

The opinions and practices of family, friends and neighbours have a strong influence on an individual’s behaviour. Awareness of common practices is important in people’s perception of social norms. From nudge theory, if the desired behaviour can be demonstrated to be a social norm, this can be used to encourage people to modify their own behaviour. Figure 8 shows the response when participants were asked whether they knew of other people (eg. friends or neighbours) who took action because of concerns about the safety of their drinking water (question 9). Multiple responses were acceptable and many participants reported two
responses. Interestingly the most frequent responses were of using bottled water (42% of participants) or running the tap before drinking (35%). This has important implications for health promotion, because this indicates that these practices are familiar to this population. Therefore if initiatives encourage people to adopt these practices they will not be seen as completely new and they will be more likely to be acceptable. From the stages of change theory greater than 30% of this sample is already in the contemplation phase for these two practices, suggesting that behaviour change is possible.

![Bar chart showing the proportion of participants who knew of friends or neighbours who took action on water quality (Question 9)](chart)

FIGURE 8. PROPORTION OF PARTICIPANTS WHO KNEW OF FRIENDS OR NEIGHBOURS WHO TOOK ACTION ON WATER QUALITY (QUESTION 9)

Another question (question 34) asked whether participants had older generation family members who ran the tap first thing in the morning. The research team suspected that this used to be common practice, possibly to reduce lead exposure, but maybe also for other reasons. If respondents remembered family members running the taps it may influence their behaviour, or their willingness to adopt this practice. A large proportion of participants responded that they did remember older family members running the taps first thing in the morning (49.3%). These data were then compared with data concerning participant’s own practice. It was interesting to note that a majority of the group who recalled an older generation member of the family running taps first thing in the morning also reported running their own taps (question 32, Figure 9 combining the intervention and control groups). There was a significant association between the responses of these questions ($\chi^2 p<0.01$, OR 0.422 (95% CI: 0.227, 0.783)). This indicates that some behaviours are passed down the family. Again the implication for health promotion is that this commonly remembered ‘family history’ could be used to reinforce suggested practice.
Within groups of respondents, with family history or no family history, proportion of respondents who run water first thing in the morning (combining intervention and control groups) (Question 32,34)

However it is not clear if the rationale of the older family members was concern about lead or any other factors. In fact there appears to be no association between remembering older family members running the taps and either knowledge of health risks of tap water (question 10), or concern about effects of environmental lead on children (question 23). Nevertheless, the reasoning behind the behaviour is not necessarily important. According to either nudge theory or social marketing, the participant’s awareness of this practice could be useful in reinforcing health promotion messages.

Another question asked about participant’s general use of water and whether they conserved water or whether they used high volumes for car washing or hosing the garden (Figure 10). Linked to this, participants were asked whether they had a water meter. Among participants who reported having a water meter, a significantly larger proportion (70%) said that they conserved water to keep their bill low than amongst those who did not report having a meter (28% of participants responded no meter or don’t know) (Fishers exact 2 sided, p <0.01). Among participants who reported not having a meter almost 40% said that they always ran the tap in the morning, compared to less than 10% of the participants who reported that they had a meter ($\chi^2$ p<0.01). Of course these results are intuitive, indicating that people who have a meter conserve water to keep their bill low. However this is an important finding and the implication is that health promotion media need to emphasise the insignificance of the cost of the volume of water to be flushed to protect from lead exposure.
6.2.6 EXPERIMENTAL RESULTS
The following data show responses of the intervention group compared to the control for the second questionnaire. If the data show no significant difference, the control and intervention were examined in combination, comparing responses of the second questionnaire with responses to the first. Differences in the latter comparison could be interpreted as the effect of the standard UU leaflet (control) or simply the confounding effect of the visits from the researcher. Any changes in practice in the whole sample may suggest that people are willing to change, but that the health promotion media need further development to be significantly effective. It is also important to bear in mind the small scale of this pilot study.

6.2.6.1 WATER QUALITY AND HEALTH RISK
The first question addressing water quality was ‘How would you describe the general quality of the tap water in your home’ (question 7). The majority of responses were positive; the most frequent response in each group was ‘good most of the time’ (Figure 11). There was no significant difference between the frequency of responses from the intervention and the control groups. Also, looking at whole group responses, there is no significant change at follow-up compared to initial questionnaire. These findings indicate that during the course of the research study unnecessary fears or worries were not raised about the general safety of drinking water, which had been a concern for the ethical impact (see Development of the questionnaire and piloting).
Further questions investigated participants understanding of health risks associated with drinking tap water. Overall there is an increase in frequency of responses of health risks from tap water, when comparing the second questionnaire to the first (question 10, Figure 11. How would you describe the general quality of the tap water in your home? (before; first questionnaire, after; second questionnaire, int; Intervention, cont; control groups) (question 7), intervention and control combined \( \chi^2 p=0.004 \), odds ratio = 0.393 (95% CI 0.25 to 0.62)) (as this is a themed interpretation of responses to an open question, if no response was given this was interpreted as not having specific concerns). However there was no significant difference in the responses between control and intervention groups.
A paired analysis was performed with the themed interpretation of responses to the open question ‘Do you think there is a health risk from drinking tap water – if so what is it?’ (question 10). The analysis investigated whether participants became more or less concerned about specific health risks from tap water (Figure 13). The largest group are those who reported concern about lead in the second questionnaire who had previously not mentioned lead as a concern (they may have expressed other concerns or not). These data may indicate that the leaflets are raising awareness about the risks of lead in tap water; however the experimental intervention does not show a greater effect than the control. Alternatively, changes may have been due to the methodological design that involved researchers visiting homes and discussing the issue, thus increasing awareness, independent of the interventions.

A minority of participants responded that they were concerned about lead in the first questionnaire but then did not report concern in the second (either no concerns or other concerns). This could indicate an attitude of denial (discussed below). Even smaller groups reported concern about lead in both questionnaires.

Other participants became concerned about other issues, for example other chemicals or biological contamination, which they had not reported in the first questionnaire. This is a good indication that our study did not raise anxiety about the general safety of the tap water amongst the majority of respondents.

![Figure 13. Changes in Tap Water Concerns (Question 10)](image)

6.2.6.2 Knowledge of Plumbing

A group of questions was aimed at establishing the level of knowledge that participants had of their own plumbing system. Without some extent of this technical knowledge, it would be
difficult for members of the public to establish whether they are at risk from exposure to lead in drinking water. A key question was whether the respondent was aware that their supply pipe is made out of lead (question 13). There was a significant difference in reporting of material of the supply pipe in the second questionnaire compared to the first (looking at all respondents; control and intervention). Unexpectedly, there appears to be a greater proportion of participants reporting that they do not know what material their supply pipe is made of in the follow-up (Figure 14). This may indicate that after reading the information in either leaflet they have realised that they do not really know from which material their supply pipe is made. This seems counter-intuitive as the study protocol included the researchers attempting to identify lead plumbing within the house, which is likely to raise participant awareness.

Alternatively the change in participant's views may be an aspect of denial, which is another aspect of The transtheoretical or stages of change model (see 4.3.3). People within the contemplation or preparation stage can become discouraged from taking action. To rationalise this change, people may re-interpret their understanding of the issues, such that issues are no longer seen as important or that it is not their responsibility to take action. A group of participants who changed their response concerning the material of the supply pipe, during the study, from 'lead' to 'not known' supports this theory; that people may deny knowledge in order to avoid taking action.

Another explanation for the change in response is that it may be caused by the difference in questioning method, possibly when questioned over the phone participants are more likely to say 'don't know'. This difference may be attributed to them feeling rushed. Also the options may not have been as clear when read out over the phone compared to being able to see the options on the paper questionnaire, this is an aspect of recall bias. There is no significant difference between responses from the control and intervention groups.

FIGURE 14. DO YOU KNOW WHAT THE SUPPLY PIPE IS MADE FROM? (QUESTION 13) (FIRST QUESTIONNAIRE; Q1, SECOND QUESTIONNAIRE; Q2)
Question 14 asked who owns the supply pipe. Again there was no statistical difference between intervention and control. However responses to the second questionnaire (combining intervention and control) show a significantly greater frequency of participants saying that either they don’t know or that UU own the supply pipe (Figure 15). There are also fewer responses of ‘property owner’ (combined homeowner, landlord and housing association). Similar to the previous question, there is a decrease in the appropriate answer; ‘property owner’, and an increase in ‘not known’. Furthermore, it is interesting to note that the proportion of participants who indicated that UU was responsible for the supply pipe increased in the second questionnaire compared to the first. UU branded information was given to all participants who may have subsequently framed their denial into an interpretation of UU being responsible for the issue. Both of these cases may indicate participant’s abdication of responsibility in order to avoid progressing to action, in the stages of change model.

6.2.6.3 Knowledge of risks of lead exposure

Moving on to questions about other environmental sources of lead, question 20 asked: Do you know of any health issues caused by exposure to lead? Responses to this question shows that in the follow-up questionnaire, a significantly larger proportion of all participants (combined intervention and control) were aware of health risks ($\chi^2 p<0.001$, odds ratio = 2.22 (95% CI 1.45 to 3.45) (Figure 16). However there was no significant difference between the intervention and control groups.
6.2.6.4 Attitudes and relative concern

A series of questions explored participants’ attitudes towards the hazard of exposure to lead in the environment. Question 21 investigated participants’ level of concern about exposure to lead from different environmental sources; air, paint dust, tap water, soil or children’s toys. This question probes perceptions of relative risks from different sources of lead. For example if a commonly held perception was that lead-containing toys were a major hazard, then in relation to this risk, people may not perceive water to be an important issue. If a commonly held perception was at odds with a scientific evaluation of the hazard, then this may be a priority issue to tackle within health promotion. This situation does not appear to be the case with the sample of people studied. None of the sources of lead specified in the questions revealed higher levels of concern. There were no commonly held concerns about sources which were not specified in the questions.

Responses from the first questionnaire (Figure 17) shows a larger proportion of participants report a level of concern (compared to not concerned) about lead in water compared to lead in paint or soil. The distribution of concerns for water was significantly different than paint ($\chi^2 p=0.045$) or soil ($\chi^2 p<0.0005$). Of the participants reporting concern about lead in water, a larger number reported that they were ‘slightly’ rather than either ‘moderately’ or ‘very concerned’. It is possible that the findings of this question were biased to some extent by the methodological design that led to researchers raising awareness about potential health risks of water in the process of the interview. During this question respondents would be more likely to report concern about lead in water rather than other environmental sources due to the fact that the researcher was discussing water issues.

Responses to the second questionnaire showed that there were no significant changes in concern about lead exposure for the whole group, neither were there differences between the control and intervention arms. The lack of difference between the first and second questionnaires for question 21 appears to be at odds from previous questions (question 10 Figure 12 and Figure 13 and question 16 Figure 17) which indicated an increase in concerns about tap water and lead respectively.
Question 23 asked whether participants were concerned about the potential exposure of their children to lead. Although the intervention group showed a higher proportion of concerned responses (combined responses of ‘very’ and ‘slightly’ concerned compared to combined responses of ‘don’t think it’s a problem’, ‘no’ and ‘don’t know’, OR = 1.684 (95% CI 0.91 to 3.13)) this was not significantly different. However, when looking at the combined responses of intervention and control arms, participants had become more concerned about lead affecting their children compared to the initial questionnaire; 48% concerned responses in first questionnaire increased to 65% in second ($\chi^2 p=0.001$, OR = 2.00 (95% CI 1.31 to 3.06)).
The leaflet was designed to raise awareness of the owner’s responsibility for the supply pipe. Participants were asked to estimate how much they would be prepared to spend to replace the supply pipe, which was hoped to be an estimate of whether participants felt they held responsibility for the supply pipe. This question (26) may also give some insight into participant’s perception of the relative importance of the issue. The responses indicated that all housing association tenants and the majority of private tenants felt that this was not their responsibility. The most common response of homeowners is up to £300. This is slightly lower than an estimated value of £400 for an average house. However, the distribution of responses showed no significant differences either between intervention and control groups or at follow-up compared to initial questionnaire.

![Figure 19: Distribution of responses from homeowners for question 26 'How much would you be prepared to spend to replace the lead supply pipe?'](image)

To try to establish participants perception of risk from exposure to lead in water, question 27 asked whether participants viewed this as being relatively more or less harmful to their children than artificial food additives (eg ‘e-numbers’). Figure 20 shows a larger proportion of respondents indicated that they were more concerned about lead (much worse) than artificial food additives. Although the intervention group shows a larger effect than the control, this is not significantly different (odds ratio = 0.927 (95% CI 0.51 to 1.67)).
6.2.6.5 Knowledge Score

A combined score was developed from responses to eight different questions with the aim of representing the level of knowledge for each participant about the issue of lead in water (questions 10, 11, 13, 16, 20, 22, 23, 25. Some questions had multiple parts or could have more than one response; maximum score 15 points). The normal distribution curve (Figure 21) shows that the data for the first questionnaire is well described by this distribution indicating that this method of combining responses from several questions into one score is appropriate for this population. The distribution of data from the second questionnaire indicates a skew to the right, due to some participants improving their knowledge scores to a greater extent than others. To test whether there was a significant difference the non-parametric Mann-Whitney test was used. This test shows that distributions of responses to the second questionnaire were significantly different from the first visit (two-tailed, p=0.044).
Alternatively because the same participant gave before and after responses, these data could be analysed by a paired t-test. Figure 22 shows the mean knowledge scores for the responses to the first and second questionnaires. These indicate that the mean participants’ knowledge about lead toxicity improved over the course of the study by 0.64 points (t=3.865, p<0.0005).

FIGURE 21. DISTRIBUTION OF KNOWLEDGE SCORES IN FIRST AND SECOND QUESTIONNAIRES (CURVE REPRESENTS NORMAL DISTRIBUTION)

FIGURE 22. MEAN KNOWLEDGE SCORES FOR FIRST (Q1) AND SECOND (Q2) QUESTIONNAIRES (+/- SEM)
Each correct response to individual questions in the combined score contributes 1 point (out of a maximum of 15), therefore the mean change detected (from all participants who completed the study) was less than an improvement of one correct answer about lead toxicity and exposure.

Figure 23 shows the frequency distribution of knowledge scores for intervention and control groups respectively. The distribution of both of these groups shows a skew to the right, however as the variance is similar for both samples, the unpaired t-test could be used. This showed no significant difference in knowledge score between intervention and control groups (t-test p>0.05).

![Figure 23. Distribution of knowledge scores for intervention and control (overlaid normal distribution)](image)

The use of the combined knowledge score is in the pilot stage of development. To determine whether this knowledge score could be used as a tool for further studies requires estimations of sample size in order to give sufficient power to differentiate a certain effect size. Firstly an estimation of the population standard deviation is required. For the knowledge score, estimating the population standard deviation from all responses to the second questionnaires gives a value of 2.134. With generally accepted values of 80% power to generate 5% significance, 146 participants would be required to establish a change in effect of 1 point. A change in score of 1 is equivalent to an improvement in correct response to one
question (out of a maximum of 15 points). It may be argued that without such an improvement in knowledge, a change in behaviour would be very unlikely (not considering changes in attitude or perception of risk).

Following this line of argument suggests that the current sample size was sufficient to detect a minimal change in knowledge (n=178). Thus the conclusion drawn from this analysis is that, with statistical power of 80%, the intervention designed in this study was not able to significantly (at 5% level) improve knowledge by the minimal effect size (1 point), relative to the control leaflet.

A final consideration is the effect of the researchers. As they visit homes, seek informed consent and deliver the questionnaire, they are likely to raise awareness about the issues amongst all participants. This increase in awareness may mask the effect of the intervention. From the paired analysis of all participants there is an increase in mean knowledge of 0.64. This could have been due to the interventions, or the researchers visiting or unknown confounders (e.g. news media). Unfortunately as this was due to the methodology, it was not possible to adjust or standardise for the effect of the researchers visiting.

6.2.6.6 Practice
The response to question 32, asking 'Do you run the cold tap first thing in the morning before drinking or filling the kettle?' was used as an indicator of whether participants changed their practice during the course of the study. Responses were coded into two groups; positive (most of the time, or always) or negative (never or very rarely, or sometimes). However no statistical significance was found between intervention and control groups (odds ratio (intervention/control) = 1.154 (95% CI; 0.56, 2.36)). Looking at the overall change in responses from first to second questionnaires, there is a substantial and significant increase in proportion of participants responding that they do run the taps ($\chi^2 p<0.001$, OR = 4.313, 95% CI 2.71 to 6.86). This suggests that factors other than the intervention were responsible for changing practices. As reasoned for the knowledge score, above, this may have been due to the control leaflet (UU) which was also given to the intervention group. Alternatively it may have been the effect of the researchers visiting participants’ homes, which in itself would raise awareness.

![Figure 24. Changes in practice of running taps first thing in the morning, from first questionnaire (Q1) to follow-up (Q2) (Question 32)](image_url)
6.2.6.7 Delivery of Intervention

The second questionnaire asked additional questions about the intervention and the most appropriate delivery of the intervention. The first set of questions addressed whether the participant or their family had read the leaflet or looked at the website. The majority reported that they had read the leaflet, but less than half reported that their family had read it. A very small proportion reported looking at the website. There was no significant difference between responses from the intervention group compared to control.

![Figure 25. Proportion of Uptake of Health Promotion Intervention (Questions 48, 49, 50)](image)

An important question is when is the best time to target the vulnerable group with health promotion information. Figure 26 shows the participants' choices from several different stages in parenthood. This shows that the most popular choice was to receive information as early as possible, preferably before birth.
When asked where would be the most appropriate location to receive information about lead in water most common responses were GP surgery or at home (Figure 27). Less than 20% of participants said that hospital would be an appropriate place. Even fewer suggested that community venues would be best. Findings from this and the previous question supports the findings from the focus groups; that the most appropriate delivery of health promotion material about lead in water would be during early pregnancy from the GP surgery.

The final question asked which media were preferred for finding information about baby and child care. Surprisingly leaflets were the most popular choice. Books and other family members were the next most popular sources.
6.2.6.8 COMMENTS FROM PARTICIPANTS DURING SECOND QUESTIONNAIRE

Whilst researchers were conducting the second questionnaire, several interesting comments were recorded. Whilst being anecdotal evidence, these comments highlight some important issues. For example the questionnaire did not ask whether participants had replaced their supply pipe, because this was assumed to be unlikely in the time of the study. However two participants noted that they had replaced the supply pipe. Several comments indicate that the issue has been discussed amongst the family. Other comments indicate appropriate ways of delivering information.
Participant’s comments (participant ID)

F35 – pipe replaced

D2 – father / landlord changed pipe subsequent to the visit of the researcher

E31 – wasn’t bothered about health risks in water until visited for the first questionnaire, though has read leaflet and told family about it

D16 – very concerned about lead. Had to send a children’s toy back to China. Granddad was paranoid about lead, ran the pipes for at least half an hour, now sees he was right. Changed to pure fruit juice rather than drinking water, and rest of family too

F33 – knew of a couple of things about lead in children’s toys over Christmas. The respondent used to work in lead factory and had blood tests every 3 or 4 weeks. The job involved making batteries and lead for windows and involved standing over a big bowl of lead and breathing it in

E10 – visit of researcher spurred a family debate

D20 – to be honest, I don’t drink tap water anyway unless it’s boiled. Didn’t read leaflet-had just had baby when first questionnaire was done

F26 – Husband was sanding down woodwork and wife was pregnant at the time and was concerned about lead so went away for the weekend until job was done. Difference between what heart and head says… can’t afford £500. Suggest give leaflet with folic acid boxes

A20 – found survey helpful highlighting the issues. Thinks it best if someone comes with the information

D23 – leaflet would be best in Bounty pack provided by midwife

B21 - lead is worse than e numbers, though less of a risk in our everyday lives
6.2.7 **Website**

The website was developed in parallel to the leaflet, with similar messages and design style. The potential advantage of the website medium is that information can be multi-level on different pages enabling the initial page to be uncluttered and welcoming, with more depth of information on subsequent pages. The website did have a greater depth of information in places than the leaflet.

![Screenshot of Website Homepage](image)

**FIGURE 29. SCREENSHOT OF WEBSITE HOMEPAGE**

Use of the website was monitored over the study period. The web address was not released to internet search engines, which should mean that visitors to the site were likely to be participants from the study who had the website address in the leaflet. However the data indicate that the majority of visits were from search engines. This is also apparent from the locations of people visiting the site – although the majority are from the UK (69%), a substantial amount were from US (23%) and small numbers from other countries.
94 users from the UK visited the site. They visited an average of 4.9 pages, spending an average of 2 minutes 40 seconds on the site.

**FIGURE 30. FREQUENCY OF ALL VISITORS TO THE WEBSITE OVER THE STUDY PERIOD**

A contact page was included on the site for feedback and comments, however none were received. Again this indicates that participants were not unduly worried about the information.

**6.2.8 WATER SAMPLES**

Participants were asked to take two water samples during one day; the first from the kitchen cold tap first thing in the morning, for the second they were asked to sample the same water that they used for filling the kettle or making drinks. The intention of the latter was to capture the quality of the water after their chosen intervention, which could be bottled water or tap water following flushing of the tap. Analysis of the samples by UU shows that 86% of the initial samples have a lead concentration higher than 0.5µg/l (Figure 31A) (detection limit of the assay is 0.25µg/l). This is a good indication that the majority of participants do have a lead supply pipe. One participant’s sample showed a concentration of 14.7µg/l, which is within the current standard, but higher than the future standard. 69% of participants (whose first sample was greater than 1µg/l) showed a decrease in the concentration of lead in the second sample compared to their first. This would be expected as levels of lead decrease with use of water through the day. However the data would also support the effectiveness of participant’s interventions. The analysis of water samples was not viewed as an outcome of the RCT. Participants were informed of their approximate lead level following completion of the study.
6.2.9 LIMITATIONS OF STAGE 2

The nature of the sampling was designed to recruit parents at home whilst looking after young children. Working parents would be relatively excluded from the study. However some participants were shift workers.

There is likely to have been variation between approaches to questioning of the researchers. There were six researchers administering the first questionnaire, and two for the follow-up (see Appendix 5, Participants recruited by researcher and area). Although all researchers were trained together, each researcher could have a slightly different way of expressing questions and interpreting responses. The follow-up questionnaire was almost always conducted by phone. This may have changed the nature of the questioning. For example, for questions with multiple choice responses, researchers often showed the participant the options on the questionnaire. This was not possible for the phone questionnaire, so

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**FIGURE 31. LEAD CONTENT OF WATER SAMPLES; A) SAMPLE OF TAP WATER TAKEN FIRST THING IN THE MORNING, B) CHANGE IN LEAD CONTENT OF SECOND SAMPLE AS A PERCENTAGE OF THE FIRST SAMPLE (EXCLUDING DATA WHERE THE FIRST SAMPLE WAS LOWER THAN 1µG/L) (ID CODES OF PARTICIPANTS, SK; SELMERSDALE)**
responses may differ due to lack of remembering answer categories, rather than real changes of opinion, i.e. recall bias.

The questionnaire was designed with advice and testing of other health professionals. However no testing was performed with the target population. In this sense this study is a pilot and further adjustments to the questionnaire and methodology may be necessary before repeating or expanding.

Although study areas within 30 miles of Liverpool were chosen, we have no reason to believe that the findings or the media developed would not be equally effective in other regions across the UK.

7 DISCUSSION

7.1 AWARENESS

The study clearly shows a lack of awareness of the risks of exposure to lead in drinking water amongst the vulnerable group. Although this study did not attempt to capture the level of knowledge at the focus groups, it was clear that participants knew very little about the issue, apart from general concern. For the first questionnaire the mean of the combined knowledge score was five out of a potential maximum of fifteen. It is difficult to relate this score of knowledge to the chances of participants taking action to avoid the risk, but our assumption was that the minimum effect size of an increase in knowledge score of one point may have stimulated behaviour change.

There was a lack of information in resources accessible or targeted to the vulnerable group in either printed or web media. However anecdotal evidence from public comments on website blogs, also supported by focus group discussion, indicated that people are keen to find out more about the issue.

Raising awareness amongst members of the public is a common theme for most health promotion initiatives. Stages of change theory would describe this as the step between pre-contemplative to contemplative (see 4.3.3 The transtheoretical or stages of change model). For the purpose of this study there are two aspects of the hazard which people should know to be able to understand that they are at risk; living in a property with a lead supply pipe and expecting a baby or having infants in the household. Data from this study indicates that although there was some awareness of lead toxicity, and also that infants may be most sensitive, there was little knowledge about the current risk from lead plumbing. From the focus groups, views were expressed that this was an old issue and if it were a current problem they would have been told about it. These views are understandable considering key sources of information for parents, the Department of Health’s guides to pregnancy and care of infants, do not describe the risk of exposure to lead in water. From conversations with health practitioners (community nurses and environmental health officers), there also appears to be a lack of awareness of the risks of exposure to lead in water. Practitioners have expressed similar views to the participants; that if it were a risk the Department of Health guides would mention the issue. Conversations with environmental health officers indicate that a common view is that the risk is insignificant. This gives anecdotal support for the need to raise awareness amongst health professionals as well as the public.
7.2 FAMILY HISTORY, FRIENDS AND NEIGHBOURS

Important factors linked to whether people change behaviour following health promotion initiatives are whether they have any familiarity with the new behaviour. If people have some awareness of the new behaviour, for example through friends of family, there is a much higher chance that they will adopt the behaviour themselves. In the transtheoretical (stages of change) social theory (see 4.3.3), this corresponds to the contemplative stage. The focus groups and questionnaire (Q34) indicate that a proportion of the population are aware of a parent or grandparent running the taps in the morning. Question 9 asked whether participants know of other people who have concerns about the safety of the tap water and take action; common responses were using bottled water and running the taps before drinking. This question does not mention family members, so people referred to may be friends or neighbours. Again this reinforces the idea that some people within the population are already taking action to avoid perceived health risks from tap water. Of course there are alternative reasons for using bottled water or running the taps before drawing, for example taste and temperature of the water. An analysis of the group of participants who responded that family members ran the taps indicates that they did not have a higher awareness of health risks than other participants, which may suggest that this habit is not health-related. However in terms of behaviour change, the perceived motivation may not be important.

7.3 PRACTICES OF WATER USE AND WATER METERING

The main intervention which our media promoted was running the taps in the morning in order to flush water which stands in the supply pipe overnight, as this has the highest chance of significant lead exposure. However concerns were voiced in the focus groups that water was expensive (even by participants who did not have a water meter). Responses to several questions revealed that these views did influence practices in the wider population sampled. Only a small proportion of participants said that they had a meter. Of this group a larger proportion stated that they conserved water to keep the bill low. Also, a smaller proportion with a meter ran their taps in the morning compared to people who did not say they had a meter. This indicates the need to emphasise the very low cost of this practice for customers with a meter; and the fact that it is ‘free’ for non-metered customers.

Attitudes to water use were addressed in focus groups and questionnaires. Some members of focus groups stated that ‘Eco-living’ was an important lifestyle issue. Question 28 revealed the reason for the majority of participants conserving water was to be environment friendly. Reports of water shortages in parts of this country or water scarcity globally may encourage people to conserve domestic water supplies. These media messages conflict with this study’s health promotion message of running the taps. This conflict could be addressed in further development of health promotion media.

7.4 WILLINGNESS TO CHANGE PRACTICE

The findings from the focus groups, questionnaires and anecdotal comments from participants (during follow-up questionnaire) indicate that members of the vulnerable group are willing to change their practices. One quote from a focus group indicated that once people knew about the risks from exposure to lead in drinking water people would immediately take action. Another said that she was going to the supermarket the next day to buy bottled water. Although the RCT showed no significant extra benefit of the intervention over and above the control leaflet, the overall effect of the study increased the frequency of
the practice of participants running the taps in the morning (Figure 24). This may have been due to the control (UU leaflet) or may have been an effect of the researchers visiting the homes and hence raising awareness.

The data for the practice of using bottled water did not show particular trends, however it indicates that a small proportion of people will choose bottled water. For optimal health protection, the intervention of choice is replacement of lead supply pipes, but due to the time and planning involved in this work it did not seem appropriate to include in the questionnaire. The researchers were surprised, therefore, to learn during the follow-up that two of the participants had replaced their pipes.

7.5 EFFECTIVENESS OF PRACTICE

A selection of participants (n=23) were asked to take water samples for lead content analysis. Lead assays indicated that almost half of these participants had low concentrations of lead in their drinking water (48% were between 1 and 5 \( \mu g/l \)). Only one participant had a high level of lead (14.7\( \mu g/l \)) which was below the current standard, but is above the future standard (10\( \mu g/l \) standard in 2013). Only one participant’s water sample had a negligible lead content, indicating that they did not have lead plumbing. Assuming this small group is representative of the whole study sample, this suggests that greater than 95% of our participants had lead plumbing. This supports our method of selection of participants for the study.

These participants were asked to take a second sample on the same day, this time sampling water they would use to fill the kettle or make a drink. The aim was to collect samples after their chosen intervention (generally running the taps). Nine out of twelve participants (with an initial sample greater than 1\( \mu g/l \)) showed a decrease in lead content of the second (post-intervention) sample. The decrease in lead content indicates that householders are able to protect themselves, although the data is not robust enough to link practices with exposure levels (it was not designed to be an outcome measure).

7.6 BARRIERS TO BEHAVIOUR CHANGE

Some barriers to behaviour change have already been identified above, for example; media messages about water consumption, also the cost and inconvenience of replacing pipes. There is a commonly held view in the UK that the majority of houses no longer have lead plumbing and therefore there is no longer any risk. Contributing to this could be the common perception that British health and safety regulations are so strict that the public feel they are largely protected from hazards in the home. One focus group participant could not believe that there is a risk, because if there were she would have heard about it from government. Another aspect of the perception of lead is its familiarity and complacency about any risk, because it has been commonly used in the domestic environment for centuries.

The absence of information on the risks of exposure to lead in drinking water in media sources supported by Department of Health or other medical institutions may reduce the effectiveness of health promotion media developed by other organisations, due to the lack of reinforcing information.

There is some evidence from this study that there may be an aspect of denial, which is another aspect of The transtheoretical or stages of change model (4.3.3). People within the
contemplation or preparation stage can become discouraged from taking action. To rationalise this change, people may re-interpret their understanding of the issues, such that issues are no longer seen as important or that it is not their responsibility to take action. Data concerning knowledge about the plumbing supports this model. Participant’s knowledge of the material or ownership of the supply pipe appears to decrease in the second questionnaire compared to the first. This may indicate that participants are in denial of the hazard, or abdicate responsibility for taking action.

7.7 MESSAGE DELIVERY AND ENDORSEMENT

Social marketing theory emphasises the importance of targeting health promotion to specific population groups (see 4.3.5). This is particularly relevant to this issue as the vulnerable group are defined by two very different factors; geographically and by family lifecycle. The majority of previous public information has been designed for a general population\(^\text{30,50}\). In some cases this is targeted geographically, as water utility companies deliver the information to residences in which samples do not meet the lead standard (in fact, a very small number). To reach a greater proportion of at-risk families, a proactive delivery of health intervention is needed.

A key finding from both qualitative and quantitative parts of this study is that timing and setting of delivery of health promotion is important. Our intervention was delivered in participants homes by an ‘academic’ researcher. The researchers also mentioned the water company, UU, so participants may have interpreted the messages as coming from the water industry. Some responses from the focus groups indicated that information published by the water utility company may be treated with cynicism and distrust. Therefore it may be more appropriate for information to be endorsed by a health agency or organisation. This would also be appropriate if the message was being delivered in a healthcare setting.

The follow-up questionnaire asked several questions about the delivery of information, which indicated that home or GPs surgeries were the most popular routes for delivery. The next stage could be to target people expecting a baby or with a young infant, through GPs or other community health professionals. To be most efficient, this would target areas of older housing, however the public will still be unsure whether they are personally affected, unless they check their plumbing at home.

7.8 VARIATION BETWEEN AREAS AND DEMOGRAPHICS

The demographics of the target audience can be varied. People of all socio-economic status may be living in older houses supplied by lead pipes. The four areas covered by the present study represent quite different housing styles and demographics. Although not shown, responses to the questionnaire indicate differences, particularly in tenure, internet access and age of participants. However for the purpose of this study these differences were not significant as the outcomes did not vary by area (nor by these underlying variables). However the effectiveness of the intervention may have been limited due to it not being designed specifically for participants of a particular socioeconomic status. Further development of health promotion media should take this into account.
8 CONCLUSIONS

To the authors knowledge this is the first study of people’s perceptions and attitudes towards the risks of lead in drinking water. As such it has yielded important findings including the low level of awareness about the issue. The randomised control trial did not show significant benefit of the leaflet and website developed compared with the control UU leaflet. Overall however the study showed that participant’s knowledge and practices improved. It could be that both experimental and control interventions were equally effective. On the other hand the improvement could have been due to the process of gaining informed consent and also of interviewing, raising awareness, which may have a greater effect than the leaflet intervention. The positive aspect is the indication that people are willing to take action, and that face-to-face delivery of health promotion may be effective.

8.1 AWARENESS

The study clearly shows a lack of awareness of the risks of exposure to lead in drinking water amongst the vulnerable group. The data indicate that although there was some awareness of lead toxicity, and also that infants may be most sensitive, there was little knowledge about the current risk caused by lead plumbing. This may be due to a lack of appropriate information which is readily accessible to the vulnerable group (people expecting a baby or caring for young children). However participants did appear keen to learn about the hazard, so that they can take action to protect their children from potential harm.

To improve awareness of the current risk it would help to have more detailed information about the current distribution of the risk. Current risk levels are based on estimates of the distribution of lead supply pipes. Conducting a survey of properties, or building a database from existing data, would raise awareness of the current situation, in turn strengthening the case for professionals to take action. With this greater knowledge health promotion can be improved, by specific targeting, but also using a ‘social norms’ approach; encouraging people to take action because the majority of local people have already taken action.

8.2 FAMILY HISTORY, FRIENDS AND NEIGHBOURS

This study found that participants remembered practices of relatives, friends or neighbours connected to water quality. These included running the taps first thing in the morning, and using a water filter or bottled water. These themes could be used to develop more effective health promotion messages by triggering recall of these practices. There is also potential benefit from the social norm effect; if these practices are emphasised as being ‘common practice’ then people are more likely to take up the practice to ‘fit in’ with their peers. This would be consistent with Nudge theory as outlined above (4.3.4).

8.3 PRACTICES OF WATER USE AND WATER METERING

Installation of water meters has been a controversial issue in recent years. Due to media coverage, many people are aware of the need to conserve water for ecological as well as economic reasons. Unfortunately this may appear to conflict with the message to encourage running the taps to reduce exposure to lead. Participants who had a water meter were less likely to run the taps in the morning. Participants were also aware of the need to conserve water for sustainability of the natural environment, which may mean that they are less keen to run the taps. In the short term, health promotion should emphasise the insignificance of
the volume flushed (and suggest other uses for it). However in the long term the water conservation message could be used to encourage replacement of lead plumbing, which is the ultimate solution.

8.4 WILLINGNESS TO CHANGE PRACTICE

This study shows that participants are willing to change their practices to reduce their potential exposure to lead in drinking water. It is important that these findings are fed back to national organisations, in order that policy makers are aware that people are prepared to take action that is immediate and requires no investment. This contrasts markedly with a programme of lead pipe replacement, which would require large investment and long timescale at a national level.

8.5 EFFECTIVENESS OF PRACTICE

To maintain behaviour, people should be reassured that their practices are effective (see 4.3.3 The transtheoretical or stages of change model). A selection of participants (n=23) were asked to take water samples for lead content analysis. They were asked to take one sample first thing in the morning and the second when they filled the kettle or made a drink. The aim was to check that lead levels decreased between samples, on the same day. Of twelve participants with initial lead levels greater than 1 μg/l, nine showed a decrease in the second sample. Although the data is not robust enough to link specific practices with exposure levels, and this was not an outcome measure for the study, it indicates that exposure is amenable to participant’s action.

Health promotion aimed at publicising the effectiveness of flushing taps could support people’s continued practice, for example by estimating the difference that running the tap every morning can make to the cumulative level of exposure of a 6 year old child, previously fed formula milk. Obviously, these are very difficult messages to design, in order to avoid being either too technical or too alarmist.

8.6 BARRIERS TO BEHAVIOUR CHANGE

There are very limited sources of information about health risks of exposure to lead from drinking water in UK media. The historical background of the widespread use of lead in the domestic environment means that it is perceived as a familiar household metal. Furthermore, a common perception is that health and safety legislation controls, or at least warns, of any health risks that the public may face. Together, these factors are likely to have strong influences on people’s risk perception and will be a barrier to effective behaviour change through health promotion.

The data indicate that there is potential for people to fall into denial about the issue rather than taking action. Denial may be framed in the following terms; that the issue does not apply to them, that it’s not their responsibility (potentially UU’s responsibility) or that it’s not a significant risk. Approaches to tackle this barrier to action include giving further information about the hazard, or further support to make taking action appear easier. Personalisation of information is a key aim of Social marketing framework (4.3.5), and a tool to help people evaluate their personal risk, based on detailed information on family, property and geography, may empower action. Further messages indicating the insignificant cost or
The inconvenience of taking action (running the tap in the morning) may encourage action and hence reduce the denial reaction.

8.7 MESSAGE DELIVERY AND ENDORSEMENT

The target population is defined by two very different factors. The first is the distribution of the hazard of lead in water, defined by the presence of lead plumbing and characteristics of the water supply. The second is whether people have young children or are planning to start a family. To specifically target media to people defined by either factor is possible, but defining a population by the combination of both factors, and designing media specifically, is potentially very difficult. This study selected people on the basis of both criteria by visiting pre-1970 houses during the day, when parents and carers were likely to be home with children. However this targeting procedure would not be possible for health promotion. The follow-up questionnaire asked several questions about the setting for delivery of media. These questions were concerned with the second factor; how to target people expecting or caring for young children. Responses indicated that the most popular setting for delivery of information was the GP clinic.

In common with most health promotion media messages, the difficulty is to convince the at-risk population to attend to the messages whilst not raising unnecessary concerns amongst the population who do not have lead plumbing. A simple question addressed by a health practitioner may be able to select members of the at-risk population whilst also effectively raising awareness. Given appropriate media this could be a simple intervention which could be delivered by any member of staff with patient contact, for example surgery receptionist or health trainer.

Another complex issue is that of branding. Although our researchers introduced themselves and the study in the context of academic research, they also mentioned United Utilities and gave each participant a UU branded leaflet. Therefore participants may have viewed messages as being from the water industry. Some cynical views concerning the interests of private water companies were expressed at the focus groups, thus further research is required to establish which brands (for example UU, NHS or Drinking Water Inspectorate) may be most appropriate for media.

A proportion of participant’s children will have been reaching the age when sensitivity to lead decreases (6 years old), in which case these participants may have felt a lesser need to attend to the issue. Views from the focus groups and from the second questionnaire indicate that the antenatal stage would be the most appropriate time to receive information.

8.8 VARIATION BETWEEN AREAS AND DEMOGRAPHICS

The four areas covered by the present study represent quite different housing styles and demographics. Lead plumbing was common in all houses built before 1970, therefore the risk factor is likely to have a similar distribution amongst houses irrespective of size. As some pipes may have been replaced since fitting, the distribution may have changed. It is possible that affluent homeowners are more likely to have replaced their pipes, which may cause a slight bias in the distribution, thereby decreasing the risk factor for more affluent households. However information from United Utilities indicates that the number of customers who have replaced pipes is so low that this effect would be small. 

For the purposes of social marketing it is important to design messages to specific target groups. In this case the vulnerable group are all carers of infants or young children, however they may be of diverse socioeconomic status. One important aspect is tenure; from this study, householders who rent are more likely to have a lower income than homeowners. Also homeowners are more likely to know some information about their plumbing system and are able to invest in pipe replacement, whereas tenants have less power to act. This implies that different media should be designed for homeowners and tenants.

Designing health promotion messages for a specific population within the vulnerable group is likely to increase the effectiveness of the programme. However, whilst geographical data on the demographics and family status is available, the information on lead plumbing in properties is limited. As mentioned above, a recently developed approach calculates risk to local populations from water sampling data. Development of a detailed database, starting with this current knowledge would aid specific targeting of most at risk areas for health promotion programmes. A database will be required, at some point, if the goal of replacing all lead pipes is ever to be reached. Furthermore, the programme of developing the database will raise awareness amongst the health professionals (through personal involvement and advertising the project) of how the issue affects their locality.

8.9 POLICY ISSUES

Development of media fits within a bigger picture of policy involving many stakeholders. On one side, from the legislative perspective, the Drinking Water Inspectorate (DWI) and Health Protection Agency (HPA) support the intervention. On the other hand, from discussions with health professionals and local authority professionals, it appears that current levels of lead in drinking water are not considered to be a significant health risk. The difference in perspective may explain inconsistencies in public messages about this issue.
9 RECOMMENDATIONS

Based on the findings from this study, as well as the literature search and discussions with stakeholders, the following three communication strategies are recommended. The first recommendation has long-term aims and could be labelled ambitious whereas the last is short-term and is pragmatic. Some of the potential benefits (✓) and barriers (■) are listed for each:

- **build a database of properties with lead plumbing**
  - ✓ will be required to achieve long term aim of replacing all lead plumbing
  - ✓ health promotion can be targeted very specifically
  - ✓ residents of these properties can start taking action immediately (with no investment needed) by flushing the taps
  - ✓ coincidentally raising awareness of the scale of the issue amongst health professionals involved in the database
    - ▪ will require multi-sector coordination
    - ▪ confidentiality of residents
    - ▪ ownership and maintenance

- **coordinated programme of raising awareness**
  - ✓ using media developed in this study, but also developing media for other target populations and other formats (eg posters)
  - ✓ campaign involving regions of the country most affected.
  - ✓ target services visited by the vulnerable group, such as children's centres and GP surgeries
    - ▪ training of health professionals involved in the campaign
    - ▪ multi-sector approach
    - ▪ substantial investment required

- **develop a web-based tool so that members of the public can assess level of risk**
  - ✓ individual assessment of risk is likely to encourage people to take action
  - ✓ technical aspects of the tool may improve knowledge of level of risk amongst health professionals
    - ▪ to reach significant population information in other media (eg posters and leaflets) will be needed to raise awareness of the website
    - ▪ promotion or training required for health professionals, who are best placed to ensure such a tool reaches the vulnerable group, including those without internet access
10 ACKNOWLEDGEMENTS


*contributed to analysis

Alan Godfree, Peter Cardew and Charmian Abbott, United Utilities

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Ivan Gee and Conan Leavey, Faculty of Health and Applied Social Sciences, LJMU

Tracey Lambert, ChaMPs (public health network for Cheshire and Merseyside)
APPENDIX 1, STRUCTURE OF FOCUS GROUPS

1. exploration of participants' ‘values in life’ – discussion based around priority sort cards
2. background to the issue of lead in water - open response
3. exploration of participants views about a range of statements about harm caused by lead in water and which have most impact on them. Lettered points are our statements, roman numerals list the groups responses.
   a. lead can affect the development of your child’s brain
   b. lead can affect intelligence and make it harder for your child to do well at school. Children who have been affected by lead tend to have lower grades in school
   c. children who are affected by lead find it very difficult to concentrate
   d. children who are affected by lead tend to be more badly behaved and act in a way that can be considered antisocial
   e. because children who are affected by lead do not do as well in school, this can limit their chances to do well later on in life
4. discussion about strategies to avoid lead in drinking water, especially which are feasible
   a. changing pipes
   b. bottled water
   c. running taps first thing in the morning
5. exploration of preferences and opinions about the strap-lines that might be used in the media
   a. Forgotten but not gone-Is lead in water haunting your family
   b. Would you like a lead pipe with your glass of water
   c. Do the best for your kids – get rid of those old lead pipes
   d. Many people have already changed their old lead pipes, what’s stopping you?
   e. Mum’s blog - Posted today: ‘…since I heard that tap water from my lead pipes could cause my kids problems at school, I always run the tap first thing in the morning’
6. discussion about the delivery of media messages, especially where or when would be the best time
   a. United Utilities should deliver leaflet through door regularly
   b. GP should give you a leaflet when they confirm pregnancy
   c. You should be given information at ante-natal classes
   d. Your midwife should talk to you and give you a leaflet or show you a web-site
   e. There should be information about this at children’s centre
   f. Your health visitor should talk to you about this and guide you to appropriate information
MUM’S BLOG! MUM’S BLOG!

Posted a week ago:

Phoned United Utilities today – they agreed that running the tap in the morning is effective. For most houses filling a washing up bowl is enough. Also having a shower and flushing the loo can help! Other things you can do:

Bottled water — most brands are suitable for making formula milk (check that the sodium (or Na) level is below 200mg/l). There is no lead in bottled water, so this will protect your baby. It’s not too expensive, but it’s heavy to carry.

Replace the lead supply pipe - the pipe between the main in the street and the house. This is the best thing to do, but it will mean getting the plumber in — it’s quite expensive and a bit of a hassle.

More details at:
http://www.unitedutilities.com/LeadpipeReplacement.htm

Posted today:

Running the tap for a couple of minutes first thing in the morning is a habit now. It’s definitely worth it to protect my kids.

Come to think of it, I remember my Nan doing the same when I was a kid.

If I don’t take action now, it’d be like giving the kids a lead pipe instead of a straw with their drink.

For more information, see the website
www.leadinwater.info Or call United Utilities on;
Telephone: 0845 746 2200, Textphone: 0800 143 0295

THE RISKS OF LEAD IN WATER

DO THE BEST FOR YOUR KIDS

www.leadinwater.info
THE FACTS

Lead is harmful, but it is also common in our surroundings – it can come from the air, soil, old paint or water.

**Lead in water is invisible, and has no taste.**

The water company has made major improvements over the years, and there is no lead in the water in the mains. But houses that were built before 1972 will probably have a lead supply pipe. This is the pipe that connects the main under the street to the house.

Water can pick up lead from the supply pipe, especially after the water has been standing in the pipe overnight. This is a particular problem with soft water, which is common in the North West area.

**You cannot get rid of lead by boiling or filtering the water.**

Even small amounts of lead in drinking water can build up in the body and affect the health of babies and children. So it is best to try to avoid it.

---

**Lead can affect brain development**

From pregnancy up to about 6 years old, your baby's brain is developing rapidly. Lead can slow down or limit the growth of your child's brain.

Children with higher levels of lead in their bodies tend to have difficulties with learning and behaviour. This can reduce their chances of doing well later on in life.

It's safest to try to prevent your baby drinking water with lead in it.

**Do you have a lead supply pipe?**

1. Find the stopcock, this is usually under the kitchen sink.
2. Look at the pipe below the stopcock.
3. If it's a dull grey or painted, and it's easy to scratch – leaving shiny marks, then it's lead.

*If unsure, call your plumber.*

---

**MUM'S BLOG!**

**Posted 1 month ago:**

I just heard that my tap water may have lead in it because I have lead pipes. My baby’s on formula so I’m worried he might be affected. I’m going to ask my doctor.

**Posted 3 weeks ago:**

Asked my doctor – she said that small amounts of lead from the pipe can get into the water. Over a long time, this can affect the development of my baby’s brain.

It’s important to take action to avoid lead while you’re pregnant and until your child is 6 years old.

My doctor recommended that I run the tap in the morning. This is because lead builds up in the water, while it’s in the pipe overnight. After flushing this out, use the cold tap to fill the kettle or making drinks.

She also said that breast feeding is best and fully protects the baby, because there’s no lead in breast milk.
## APPENDIX 3, FIRST QUESTIONNAIRE

### WATER QUESTIONNAIRE – FIRST VISIT

<table>
<thead>
<tr>
<th>ID NUMBER</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Address</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Postcode</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Home phone number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mobile</th>
</tr>
</thead>
</table>

### 1. Your age

- [ ] 16 – 20
- [ ] 21 – 25
- [ ] 26 – 30
- [ ] 31 – 35
- [ ] 36 – 40
- [ ] 41 – 45
- [ ] 46+

### 2. Gender?

- [ ] Female
- [ ] Male

### 3. How many children under 5 years of age live in the household?

- [ ]

### 4. Are you first-time parents or expecting your first child?

- [ ] Yes
- [ ] No

### 5. Do you have a water meter?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

### 6. Do you have access to the internet?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

### 7. How would you describe the general quality of the tap water in your home?

<table>
<thead>
<tr>
<th>Always very good</th>
<th>Usually very good, but not always</th>
<th>Good most of the time</th>
<th>Adequate, but often not very good</th>
<th>Inadequate most of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. If you have any concerns about the tap water, what are they? Describe up to a maximum of three. **Researcher prompt:** e.g. cloudy, coloured, smell of chlorine, bubbles/air in water, low pressure, other contamination. (If applicable, how often does each of these happen?)

<table>
<thead>
<tr>
<th>Concern 1</th>
<th>Concern 2</th>
<th>Concern 3</th>
</tr>
</thead>
</table>

9. You may know of people who are concerned about the safety of their tap water. If so, do you know of any actions that they take because of this:

- a. Use bottled water
- b. Run the taps before drinking
- c. Use a water softener
- d. Use a water filter
- e. Boil water
- f. Other, please specify below:

10. Do you think there is a health risk from drinking tap – if so what is it?

11. Why do you think this is a risk?

12. Thinking about the plumbing in your house, what material are the pipes made out of? (ignore drain pipes)

<table>
<thead>
<tr>
<th>Steel</th>
<th>Copper</th>
<th>Plastic</th>
<th>Lead</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

**Tick as many as you like**

<table>
<thead>
<tr>
<th>Other</th>
</tr>
</thead>
</table>

13. The supply pipe runs from the stop-tap under the pavement to the stop-tap in your house. This can sometimes be made from a different material. Do you know what the supply pipe is made from?

<table>
<thead>
<tr>
<th>Steel</th>
<th>Copper</th>
<th>Plastic</th>
<th>Lead</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

**Tick as many as you like**

<table>
<thead>
<tr>
<th>Other</th>
</tr>
</thead>
</table>
14. Who owns the water supply pipe? *(or is responsible for – the pipe running from the stop-tap under the pavement to the stop-tap in your house)*?

<table>
<thead>
<tr>
<th>Homeowner</th>
<th>Housing Association</th>
<th>Landlord</th>
<th>United Utilities</th>
<th>Council</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

15. How do you think you would know, or could find out, whether your tap water contains lead?

Idea 1

Idea 2

16. Who do you think could test for lead in water? *(Tick as many as you think apply)*

- Plumber
- Council (not housing association)
- United Utilities
- Landlord
- Housing Association
- Other, please specify below:

**Tick as many as you like**

17. In the last five years, has your tap water been tested for lead?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

18. If so did the result show that the lead level was:

<table>
<thead>
<tr>
<th>High or well above normal</th>
<th>Above average, but nothing to worry about</th>
<th>About average</th>
<th>Lower than average</th>
<th>Can’t remember</th>
</tr>
</thead>
</table>

19. Which tap in the house do you think is the safest for drinking or making food?

20. Lead is common in our surroundings. Do you know of any health issues caused by exposure to lead?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If yes, specify
21. There are several possible ways that lead can get into our bodies. What are your concerns that you or your family may be taking in small amounts of lead in these ways?

<table>
<thead>
<tr>
<th>One tick per row</th>
<th>Not concerned or don’t know</th>
<th>Slightly concerned</th>
<th>Concerned</th>
<th>Very Concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Air pollution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b Dust from old paint in the house</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c Tap water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d Dirt from garden soil on hands before eating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e Children’s toys</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please specify</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22. Which groups of people do you think may be at greatest risk?


23. Do you think your children may swallow or breathe in small quantities of lead (in the ways mentioned above)?

<table>
<thead>
<tr>
<th>Yes and I’m very concerned about it</th>
<th>Yes and I’m slightly concerned about it</th>
<th>Yes, but I don’t think it’s a problem</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

24. If you are pregnant - do you think your baby is at risk from lead that you may breathe or swallow?

<table>
<thead>
<tr>
<th>Yes and I’m very concerned about it</th>
<th>Yes and I’m slightly concerned about it</th>
<th>Yes, but I don’t think it’s a problem</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

25. Who would you go to if you wanted to replace the water supply pipe (running from the stop-tap under the pavement into your house)?

<table>
<thead>
<tr>
<th>Not my responsibility</th>
<th>Council</th>
<th>Housing Assoc.</th>
<th>Landlord</th>
<th>Plumber</th>
<th>United Utilities</th>
</tr>
</thead>
</table>

26. How much would you be prepared to spend to replace the lead supply pipe?

<table>
<thead>
<tr>
<th>Not my responsibility</th>
<th>Nothing</th>
<th>Up to £100</th>
<th>Up to £300</th>
<th>Up to £500</th>
<th>Over £500</th>
</tr>
</thead>
</table>
27. Comparing lead in water with artificial food additives (e.g. E-numbers) which do you think is more harmful for your child?

<table>
<thead>
<tr>
<th>E-numbers much worse</th>
<th>E-numbers slightly worse</th>
<th>About the same</th>
<th>Lead slightly worse</th>
<th>Lead much worse</th>
<th>Don't know</th>
</tr>
</thead>
</table>

**PRACTICES**

28. Thinking about how much water you use; do you

**Tick as many as you like**

- [ ] a. Minimise use to keep bill low
- [ ] b. Minimise use to be environment friendly
- [ ] c. Use a hose to water the garden
- [ ] d. Use a hose when cleaning the car
- [ ] e. Run the taps first thing in the morning

29. Do you regularly use water from the hot tap for filling the kettle or cooking?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

30. Do you filter the water that you use for drinking?

| Never or very rarely | Sometimes | Most of the time | Always |

Please specify type of filter

31. Do you filter the water that you use for filling the kettle or for cooking?

| Never or very rarely | Sometimes | Most of the time | Always |

Please specify type of filter

32. Do you run the cold tap first thing in the morning before drinking or filling the kettle? (run the tap for at least 5 seconds)

| Never or very rarely | Sometimes | Most of the time | Always |

33. If so how much water do you run? (time or volume estimate)
34. Can you recall your parents or grandparents normally running water before drinking or filling the kettle? *(anyone of 'older generation')*

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don't Know</th>
</tr>
</thead>
</table>

35. First thing in the morning people often go to the loo or make a cup of tea! We hope you don’t find this rude, if we ask which order you do these?

<table>
<thead>
<tr>
<th>Always flush the loo first</th>
<th>Tend to flush the loo first</th>
<th>Either</th>
<th>Tend to fill the kettle or glass of water first</th>
<th>Always fill the kettle or glass of water first</th>
</tr>
</thead>
</table>

**FOR THOSE EXPECTING A BABY**

36. When drinking a glass of water or making a cold drink do you use:

<table>
<thead>
<tr>
<th>For all these questions, one tick per row</th>
<th>Never</th>
<th>Infrequently</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Bottled water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b The cold tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c Filtered water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

37. When filling the kettle for a hot drink, or cooking, do you use:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Infrequently</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Bottled water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b The cold tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c Hot tap water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d Filtered water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

38. If you use the cold tap, do you run the tap for at least 5 seconds before drawing water?

<table>
<thead>
<tr>
<th>Never or very rarely</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Always</th>
</tr>
</thead>
</table>
**For People Who Use Formula Milk for Their Child**

39. Do you use formula milk? 

<table>
<thead>
<tr>
<th>Yes</th>
<th>Sometimes</th>
<th>No</th>
</tr>
</thead>
</table>

40. When making formula milk do you use:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Infrequently</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Bottled water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>The cold tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>The hot tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Filtered water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

41. If you use the cold tap, do you run the tap for at least 5 seconds before drawing water?

<table>
<thead>
<tr>
<th></th>
<th>Never or very rarely</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Always</th>
</tr>
</thead>
</table>

**For Those with Children**

42. When your children drink a glass of water or make squash do they use:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Infrequently</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Bottled water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>Kitchen tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Bathroom tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Filtered water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

43. When using water for cooking, do you use:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Infrequently</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Bottled water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>Cold tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Hot tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Filtered water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

44. If you use cold tap water, do you run the tap for at least 5 seconds before drawing water?

<table>
<thead>
<tr>
<th></th>
<th>Never or very rarely</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Always</th>
</tr>
</thead>
</table>
EVERYONE - HOUSE AND FAMILY

45. Do you own or rent your home?

<table>
<thead>
<tr>
<th>Housing Association ('Council')</th>
<th>Private Landlord</th>
<th>Home Owner / Mortgage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

46. When did you complete your education?

<table>
<thead>
<tr>
<th>Left school at 16</th>
<th>Left school or college at 18</th>
<th>Completed a vocational course at college (but not a degree)</th>
<th>Completed a degree course</th>
<th>Completed a postgraduate degree course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

47. Could you please estimate your average annual household income? (before tax)

<table>
<thead>
<tr>
<th>Income from benefits</th>
<th>&lt; £15,000</th>
<th>£15-25000</th>
<th>£25-34000</th>
<th>£35-45000</th>
<th>&gt;£45000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CLOSING

Thank you very much for your time. We hope the findings from this survey will be useful for your household and neighbourhood. We will enter you in a prize draw for an iPod to say thank you. *(Check got address right)*

We would like to phone you in 2 months time to ask you another set of questions. Would you prefer mobile or landline. *(If they are not happy about being called we could visit)*

<table>
<thead>
<tr>
<th>Mobile</th>
<th>Landline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We would also like to phone a few people at random to check that you are satisfied with the research study. *(Quality Assurance)*

We will give you some information now which we hope will be useful to you. We would like you to read it and also have a look at the website mentioned in the leaflet.
**APPENDIX 4, SECOND QUESTIONNAIRE**

To avoid repetition and reduce the time needed, several questions from the first questionnaire were not asked at follow-up. However additional questions were asked about the intervention and potential delivery of the intervention.

Questions from the previous questionnaire: 1,2,7,10,11,13,14,16,20,21,22,23,24,25,26,27,32,33,35,36,37,38,39,40,41,42,43,44,47

**ADDITIONAL QUESTIONS CONCERNING DELIVERY**

48. Did you read the leaflet?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

49. Did other family-members read the leaflet?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

50. Did you look at the website mentioned in the leaflet?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

51. When would be the most effective time to receive leaflet? (tick one)

<table>
<thead>
<tr>
<th>Planning Pregnancy</th>
<th>Early Pregnancy</th>
<th>Antenatal</th>
<th>Before child is a year old</th>
<th>Between 1 and 5yr</th>
</tr>
</thead>
</table>

52. Where would be best to receive information? (tick one)

<table>
<thead>
<tr>
<th>GP surgery</th>
<th>Home</th>
<th>Hospital</th>
<th>Community Centre/Library</th>
<th>Childrens Centre</th>
<th>Other</th>
</tr>
</thead>
</table>

specify other: _______

53. Which are the best sources of information for baby and child care? (tick one)

<table>
<thead>
<tr>
<th>Books</th>
<th>Magazines</th>
<th>Leaflets</th>
<th>Websites</th>
<th>Blogs</th>
<th>Family</th>
</tr>
</thead>
</table>

Thank you very much for your time. We hope the findings from this survey will be useful for your household and neighbourhood. We will enter you in a prize draw for an iPod to say thank you.
### Appendix 5, Participants Recruited by Researcher and Area

<table>
<thead>
<tr>
<th>Area</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>All researchers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>15</td>
<td>28</td>
<td>19</td>
<td>1</td>
<td>82</td>
<td>38%</td>
</tr>
<tr>
<td>EP</td>
<td>9</td>
<td>10</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td>10%</td>
</tr>
<tr>
<td>SK</td>
<td>2</td>
<td>1</td>
<td>13</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>12%</td>
</tr>
<tr>
<td>SP</td>
<td>8</td>
<td>4</td>
<td>13</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>33</td>
<td>15%</td>
</tr>
<tr>
<td>WL</td>
<td>14</td>
<td>18</td>
<td>5</td>
<td>11</td>
<td>8</td>
<td></td>
<td></td>
<td>56</td>
<td>26%</td>
</tr>
<tr>
<td>All areas</td>
<td>28</td>
<td>33</td>
<td>24</td>
<td>33</td>
<td>54</td>
<td>44</td>
<td>1</td>
<td>217</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>13%</td>
<td>15%</td>
<td>11%</td>
<td>15%</td>
<td>25%</td>
<td>20%</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11 REFERENCES

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7 Barbosa F, Tanus-Santos JE, Gerlach RF, Parsons PJ. A critical review of biomarkers used for monitoring human exposure to lead: Advantages, limitations, and future needs Environmental Health Perspectives 2005; 113 (12): pp. 1669-1674


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51 Keith Osborn, retired senior lecturer in environmental health, Centre for Public Health, Liverpool John Moores University, personal communication

52 Ian Wood Services, plumber, personal communication