Understanding Radon Management in French Homes: Barriers and Facilitators from Two Regions

***

Supplementary materials

TABLE OF CONTENT

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1. QUESTIONS ADDRESSED TO LOCAL PUBLIC ADMINISTRATION (GROUP A)

Note. — The questions are in **bold** font and listed A1, A2, … The probe are in *italic* and were used to stimulate the discussion if necessary and to code the answers provided with the Swiss Model for Outcome Classification in Health Promotion and Prevention (SMOC). The connexion between the questions and probes with SMOC is presented in § 2.

PART A. RADON IN HOUSES

A1 How did you hear about radon?

_____ *(flyer, workshop, contact with other local public administration)*

A2 Did you look for information on radon in houses?

☐ yes ☐ no

Was this information helpful? Could it be improved?

_____

A3 Did you propose to the inhabitants any actions for any of these steps?

- *Information on radon* ..... ☐
- *Favour measurement in home* ..... ☐
- *Diagnosis* ..... ☐
- *Remediation* ..... ☐
- *Re-test* ..... ☐
- *The case of new building* ..... ☐

A4 Why did you choose to develop these actions?

- *This is a radon prone area* ..... ☐
- *The concentration of radon could be elevated whatever the building, and including houses* ..... ☐
- *You wanted to know about radon levels in the community* ..... ☐
- *The testing was free/not expensive* ..... ☐
- *Worries about health/indoor air quality* ..... ☐
- *You have plans for support in renovation in the community anyway and thought it might be an opportunity to manage the two* ..... ☐
- *You wanted to support the radon information regulatory requirement for housing sale* ..... ☐
- *Radon tests were performed in the schools of the community* ..... ☐
- *Radon tests were performed in workplaces* .....
- *A health or radiation protection authority advised you to do so* ..... ☐
- *You knew other local public administration who included radon in their Plan* ..... ☐
- *To initiate a local community action promoting health/environment* ..... ☐
- *Other:* _____

A5 Why did some public local administration choose not to develop these actions?

- *Not enough information on radon* ..... ☐
- *No mandatory requirement* ..... ☐
- *No worry about health/indoor air quality* ..... ☐
- *Lack of time/too busy* ..... ☐
- *Inconvenient* ..... ☐
- *Lack of financial support* ..... ☐
- *Lack of political support* ..... ☐
- *Other:* _____
- *Do not know/no answer* ..... ☐

PART B. RUNNING THE PROJECT

B1 What were the evolutions in the political and administrative systems?

- *Decision-makers and key persons have been formally involved* ☐
- *Task and actions put in written documents* ☐
- *Functional evolutions in the organization* ☐
- *Meeting and cooperation* ☐
- *Other: _____*

B2 Did the action have any social impacts?

- *At individual level (ex. change of behavior)* ☐
- *Diffusion of the issues at stake beyond the initial population* ☐
- *At collective level (ex. creation of group of interest)* ☐
- *Collaboration with other parties* ☐

B3 Did you use any catalyst to promote your action?

- *Actions linked to the reduction of smoking* ☐
- *Actions linked to the reduction of the exposure from other toxic compounds, in liaison with the National Institute of Cancer or other* ☐
- *The radon management in public places and schools* ☐
- *The radon management in workplaces* ☐
- *Support plans for houses renovation* ☐
- *Improvement of indoor air quality* ☐
- *Improvement of ventilation* ☐
- *Ventilation to fight biological agent (covid-19)* ☐
- *Other: _____*

B4 Did you implement actions addressed to other stakeholders and what about the development of the actions?

- *Health professionals* ☐
- *Air quality professionals* ☐
- *Stakeholders with interest/competence in building renovation* ☐
- *Building professionals (and their federations)* ☐
- *Training centres* ☐
- *School/Education professionals* ☐
- *Scientific organization* ☐
- *Consumerist organization* ☐
- *Other local public administration* ☐
- *Other: _____*

B5 Do you have figures to report on the number of actions performed?

- *Information on radon* ☐
- *Measurements* ☐
- *Diagnosis* ☐
- *Mitigation* ☐
- *Re-tests* ☐
- *The case of new buildings* ☐

PART C. FEEDBACK

C1 Would you say that the actions reached the objectives?

- *Totally* ☐
- *Partly* ☐
- *No* ☐

C2 Overall, will you consider developing radon management actions again?

☐ yes ☐ no

C3 Would you say that the project developed as planned?

Totally ..... ☐
Partly ..... ☐
Not at all..... ☐

Good points: _____
Improvements needed: _____

C4 What are your advice to other local public administration who wish to start radon management actions?

_____

C5 Do you think it is worthwhile to include the stakeholders below in actions by local communities for radon in houses?

Health professionals ..... ☐
Air quality professionals ..... ☐
Stakeholders with interest/competence in building renovation ..... ☐
Building professionals (and their federations) ..... ☐
Training centres ..... ☐
School/Education professionals..... ☐
Scientific organization ..... ☐
Consumerist organization ..... ☐
Other local public administration ..... ☐
Other: _____

C6 Do you think the items below can act as catalyst to promote any actions led by local communities for radon in houses?

Actions linked to the reduction of smoking ..... ☐
Actions linked to the reduction of the exposure from other toxic compound, in liaison with the National Institute of Cancer or other..... ☐
Radon management in public places and schools ..... ☐
Radon management in workplaces ..... ☐
Support plans for houses renovation ..... ☐
Improvement of indoor air quality..... ☐
Improvement of ventilation ..... ☐
Ventilation to fight biological agent (covid-19) ..... ☐
Other: _____

C7 What additional support do you wish (ex. from national authorities)?

_____

2. CONNECTION BETWEEN THE QUESTIONS IN THE SURVEY INSTRUMENTS ADDRESSED TO LOCAL PUBLIC ADMINISTRATION (GROUP A) AND THE SWISS MODEL FOR OUTCOMES CLASSIFICATION FOR HEALTH AND PREVENTION MEASURES (SMOC[1])

GENERIC QUESTIONS AND PROBE	Developement of health-promoting services	Advocacy, co-operation of organizations	Social mobilisation	Development of individual skills	Health-promoting services	Health-promoting services and organisational policy	Health-promoting services social potential and commitment	Health-related life skills	Other
PART A. RADON IN HOUSES									
A1. How did you hear about?					■				
A2. Did you look for information on radon in houses?				■					
Was this information helpful? Could it be improved									
A3. Could you describe the actions addressed to the inhabitants?									
Information on radon	■								
Favour measurement in home	■								
Diagnosis	■								
Remediation	■								
Re-test	■								
The case of new building	■								
A4. Why did you choose to develop these actions?									■
This is a radon prone area									■
The concentration of radon could be elevated whatever the building, and including houses									■
You wanted to know about radon levels in the community	■								
The testing was free/not expensive	■								
Worries about health/indoor air quality	■								
You have plans for support in renovation in the community anyway and thought it might be an opportunity to manage the two		■							
You wanted so support the radon information regulatory requirement for housing sale		■							
Radon test were performed in the schools of the community									■
Radon test were performed in workplaces									■
A health or radiation protection authority adviced you to do so									■
You knew other communities who included radon in their Plan									■
To initiate a local community action promoting health/environment			■						
Other: _____									
A5. Why did some public local administration choose not to develop these actions?									
Not enough information on radon				■					
No mandatory requirement		■							
No worry about health/indoor air quality	■								
Lack of time/too busy	■								
Inconvenient	■								
Lack of financial support		■							
Lack of political support		■							
Other: _____									
Do not know/no answer									
***									
PART B. RUNNING THE PROJECT									
B1. What were the evolutions in the political and administrative systems?									
Decision-makers and key persons have been formally involved						■			
Task and actions put in written documents						■			
Functional evolutions in the organization						■			
Meeting and cooperation						■			
Other: _____									
B2. Did the action have any social impact?									
At individual level (ex. change of behaviour)							■		
Diffusion of the issues at stake beyond the initial population							■		
At collective level (ex. creation of group of interest)							■		
Collaboration with other parties							■		
Other: _____									
B3. Did you use any catalyst to promote your action?									
Actions linked to the reduction of smoking								■	
Actions linked to the reduction of the exposure from other toxic compound, in liaison with the National Institute of Cancer or other								■	
The radon management in public places and schools						■			
The radon management in workplaces						■			
Support plans for houses renovation						■			
Improvement of indoor air quality								■	
Improvement of ventilation						■			
Ventilation to fight biological agent (covid-19)								■	
Other: _____									
B4. Did you implement actions addressed to other stakeholders and what about the development of the actions?									
Health professionals			■						
Air quality professionals		■							
Stakeholders with interest/competence in building renovation		■							
Building professionals (and their federations)		■							
Training centres		■							
School/Education professionals			■						
Scientific organization			■						
Consumerist organization			■						
Other local communities		■							
Other: _____									
B5. Do you have figures to report on the number of actions performed?									
Information on radon					■				
Favour measurement in home					■				
Diagnosis					■				
Remediation					■				
Re-test					■				
The case of new building					■				

GENERIC QUESTIONS AND PROBE	Developement of health-promoting services	Advocacy, co-operation of organizations	Social mobilisation	Development of individual skills	Health-promoting services	Health-promoting services and organisational policy	Health-promoting services social potential and commitment	Health-related life skills	Other
PART C. FEEDBACK									
C1. Would you say the actions reached the objectives?									
Totally									
Partly									
No									
C2. Overall, will you consider developing radon management actions again?									
C3. Would you say the project developped as planned?									
Totally									
Partly									
Not at all									
Good points									
Improvement needed									
C4. What are your advice to other local public administration who wish to start a radon management actions									
C5. Do you think it is worthwhile to include the stakeholders below in actions by local communities for radon in houses?									
Health professionals									
Air quality professionals									
Stakeholders with interest/competence in building renovation									
Building professionals (and their federations)									
Training centres									
School/Education professionals									
Scientific organization									
Consumerist organization									
Other local communities									
Other: _____									
C5 Do you think the items below can act as catalyst to promote any actions led by local communities for radon in houses?									
Actions linked to the reduction of smoking, in liaison with the National Institute of Cancer									
Actions linked to the reduction of the exposure from other toxic compound, in liaison with the National Institute of Cancer or other									
Radon management in public places and schools									
Radon management in workplaces									
Support plans for houses renovation									
Improvement of indoor air quality									
Improvement of ventilation									
Ventilation to fight biological agent (covid-19)									
Other: _____									
C7 What additional support do you wish (ex. from national authorities)									

1. Spencer B, Broesskamp-Stone Ursel, Ruckstuhl B, Ackermann G, Spoerri B, Cloetta B, 2007. Modelling the results of health promotion activities in Switzerland: development of the Swiss Model for Outcome Classification in Health Promotion and Prevention, Health Promotion International **23**(1) doi:10.1093/heapro/dam038

3. QUESTIONS ADDRESSED TO INHABITANTS (GROUP B)

Note. — The questions are in **bold** font and listed A1, A2, … The probe are in *italic* and were used to stimulate the discussion if necessary and to code the answers provided with the Revised Protection Motivation Theory (RPMT) model. The connexion between the questions and probes with RPMT is presented in § 4.

PART A. THE FIRST STEPS

A1 **How did you hear about the radon testing campaign?** *(media, letter, discussion, …)*

_____

A2 **Why did you choose to perform a radon test?**

- *You knew what radon is/that you are living in a radon prone area* ☐
- *You wanted to know about radon level in your house* ☐
- *The test was free* ☐
- *Worries about health/indoor air quality* ☐
- *You wanted to make renovation in your house anyway and thought it might be an opportunity to manage the two* ☐
- *You wanted to sell your house and thought a radon test was appropriate* ☐
- *Husband/relatives/people advice you to make a radon test* ☐
- *You knew people who have tested/will test for radon* ☐
- *A radon test was performed in the school of your children* ☐
- *A radon test was performed at your workplace* ☐
- *To take part in a local community action* ☐
- *Other:* _____

Radon concentration in your house

A3.1 **Do you remember the radon concentration in your house?**

_____ (*in Bq.m^{-3}*)

A3.2 **Would you say the level of radon was?**

_____ (*high, moderate, low*)

Public meeting for the presentation of the result

A4.1 **Why did you choose to participate to the public meeting?**

- *You wanted to know more about radon* ☐
- *You wanted to know about the radon levels of others* ☐
- *The radon concentration was elevated and you were advised by the project leader to participate* ☐
- *Worries about health/indoor air quality* ☐
- *You wanted your house cleaned from radon* ☐
- *Husband/relatives/people advice you to attend to the meeting* ☐
- *You knew people who will attend the meeting* ☐
- *To take part to local community action* ☐
- *Other* _____

A4.2 **What results at the end of the meeting?**

- *You get the information you want about radon* ☐
- *You knew about the other radon levels* ☐
- *You were worrying about health/indoor quality* ☐
- *You knew how you can remediate radon in your house* ☐
- *You knew which professional to contact to remediate radon in your house* ☐
- *You were able to ask the questions you want to the experts* ☐
- *Other* _____

A4.3 **Would you say the public meeting met your expectations?**

Totally ..... ☐
Partly ..... ☐
Not at all ..... ☐

Good points: _____

Improvements needed: _____

Do you think a public meeting is necessary? ☐ Yes ☐ No

A4.4 **Have you been proposed to participate to a technical workshop?** ☐ Yes ☐ No

A4.5 **Did you accept?** ☐ Yes ☐ No

If a technical workshop was proposed and you accepted, go to B.
Not proposed/not accepted, go to C4.

***

PART B. TECHNICAL WORKSHOP ON RADON DIAGNOSIS AND MITIGATION

Why did you participate to the technical workshop?

You wanted more information about radon ..... ☐
The radon concentration was elevated, and you were advised by the project leader to accept the diagnosis ..... ☐
Worries about health/indoor air quality ..... ☐
The participation was free ..... ☐
You wanted your house clean from radon ..... ☐
You wanted personal advice on how you can mitigate ..... ☐
You wanted personal advice on how a building professional can mitigate .... ☐
You wanted contacts with building professionals ..... ☐
Husband/relatives/people advice you participate ..... ☐
Other: _____

B2 **What results after the workshop?**

You get the information you want about radon ..... ☐
You get the information you want on how you can mitigate ..... ☐
You get the information you want on how a building professional can mitigate ..... ☐
You get contact with building professional ..... ☐
You get a cost estimate ..... ☐
Other: _____

B3 **Would you say the technical workshop met your expectations?**

Totally ..... ☐
Partly ..... ☐
Not at all ..... ☐

Good points: _____

Improvement needed: _____

Do you think a technical workshop is necessary? ☐ Yes ☐ No

PART C. DIAGNOSIS BY A RADON EXPERT

C1 **Was any form of radon building diagnosis performed in your house?**

Yes, self-made ☐
Yes, by a professional ☐
No ☐
Other: _____

If no, go to C4.

C2 **What were the results from the diagnosis?**

You get the information you want on how you can mitigate ☐
You get the information you want on how a building professional can mitigate ☐
You get contact with building professional ☐
You get a cost estimate ☐
Other: _____

C3 **Would you say the diagnosis met your expectations?**

Totally ☐
Partly ☐
Not at all ☐

C4 **Why did you accept the diagnosis of your house?**

You wanted more information about radon ☐
The radon concentration was elevated and you were advised by the project leader to accept the diagnosis ☐
Worries about health/indoor air quality ☐
The diagnosis was free ☐
You wanted your house clean from radon ☐
You wanted personal advice on how you can remediate ☐
You wanted personal advice on how a building professional can remediate ☐
You wanted contacts with building professionals ☐
Husband/relatives/people advice you to have the diagnosis ☐
Other: _____

C5 **What were the results from the diagnosis?**

You get the information you want about radon ☐
You get the information you want on how you can remediate ☐
You get the information you want on how a building professional can remediate ☐
You get contact with building professional ☐
Cost estimate ☐
Other: _____

C6 **Do you support other manner to perform a diagnosis that can encourage more people to have one?**

A building professional perform the diagnosis ☐
A building professional perform a diagnosis and the mitigation ☐
Radon hotline with expert/professionals ☐
Development of web-based tool ☐
Development of a public smartphone application ☐
Other: _____

C7 **How much money would you be willing to spend for a diagnosis?**

Up to 100 € ☐
Up to 200 € ☐
More than 200 € ☐

Whatever it takes ..... ☐
Not willing to spend any money for a diagnosis ..... ☐

PART D. MITIGATION

D1 Was any form of radon mitigation performed in your house?

Yes, self-made ..... ☐
Yes, by a professional ..... ☐
Yes, you and a professional ..... ☐
No ..... ☐
Other: _____

If no, go to D4.

D2 You achieved the mitigation by yourself

You had enough information after the public meeting ..... ☐
You had enough information after the technical workshop ..... ☐
Cost efficient ..... ☐
More convenient ..... ☐
You made simple improvement of the sealing (hole, crack, door, …) ..... ☐
You modify the ground-building interface (basement) ..... ☐
You made simple improvement of the ventilation ..... ☐
You installed a new active ventilation system ..... ☐
You are opening the windows more frequently ..... ☐
Other: _____

Approximate amount engaged: _____ (€)

D3 You contracted a building professional for the mitigation

You had enough information after the public meeting ..... ☐
You had enough information after the technical workshop ..... ☐
Cost not an issue ..... ☐
More convenient ..... ☐
The professional made simple improvement of sealing (hole, crack, door) ... ☐
The professional modify the ground-building interface (basement) ..... ☐
The professional performed simple improvement of the ventilation ..... ☐
The professional installed a new active ventilation system ..... ☐

Approximate amount engaged: _____ (€)

D4 You did <u>not</u> mitigate

Because radon is not a problem ..... ☐
Because the radon concentration is low ..... ☐
You did not believe in the measurement ..... ☐
Not worried about radon/indoor air quality ..... ☐
You did not have enough information on how to remediate ..... ☐
You did not have contact with building professionals who can remediate ☐
The building professional did not understand/did not want to remediate ☐
Lack of time/too busy ..... ☐
Inconvenient/disruptive ..... ☐
Money issue ..... ☐
You wait for renovation work ..... ☐
Other _____
Don't know/no answer ..... ☐

D5 Did you re-test the radon concentration after the mitigation work?

☐ Yes ☐ No ☐ Undecided

Was the mitigation efficient?

☐ Yes ☐ No

Do you consider other mitigation work?

☐ Yes ☐ No ☐ Undecided

Why _____

4. CONNECTION BETWEEN THE QUESTIONS ADDRESSED TO THE INHABITANTS (GROUP B) AND THE THEMES OF THE REVISED PROTECTION MOTIVATION THEORY MODEL (RPMT^2)

QUESTIONS AND PROBES	SOURCES OF INFORMATION				COGNITIVE MEDIATING PROCESSES					COPING MODE		
	Verbal persuasion	Observational learning	Personality variables	Prior experience	Intrinsic/extrinsic Rewards	Severity-Vulnerability	Self Efficacy	External Efficacy	Cost/Disturbance	Single act	Multiple acts	Repeated acts
PART A. FIRST STEPS												
A1 How did you hear about the radon testing campaign? (media, letter, discussion, ...)												
A2 Why did you choose to perform a radon test?												
You knew what radon is/that you are living in a radon prone area				■								
You wanted to know about radon level in your house					■							
The test was free									■			
Worries about health/indoor air quality						■						
You wanted to make renovation in your house anyway and thought it might be an opportunity to manage the two					■							
You wanted to sell your house and thought a radon test was appropriate					■							
Relatives/people advice you to make a radon test	■											
You knew people who have tested/will test for radon		■										
A radon test was performed in the school of your children		■										
A radon test was performed at your workplace		■										
To take part in a local community action					■							
Other: _____												
Radon concentration in your house												
A3.1 Do you remember the radon concentration in your house?										■		
A3.2 Would you say the level of radon was?						■						
Public meeting for the presentation of the results												
A4.1 Why did you choose to participate to the public meeting?												
You wanted to know more about radon		■										
You wanted to know about the radon levels of others		■										
The radon concentration was elevated and you were advised by the project leader to participate	■											
Worries about health/indoor air quality						■						
You wanted your house cleaned from radon					■							
Husband/relatives/people advice you to attend to the meeting	■											
You knew people who will attend the meeting			■									
To take part to local community action					■							
Other _____												
A4.2 What results at the end of the meeting?												
You get the information you want about radon					■							
You knew about the other radon levels					■							
You were worrying about health/indoor quality						■						
You knew how you can remediate radon in your house							■	■				
You knew which professional to contact to remediate radon in your house								■				
You were able to ask the questions you want to the experts												
Other _____					■							
A4.3 Would you say the public workshop met your expectations?												
Totally												
Partly												
Not at all												
Good points: _____												
Improvements needed: _____												
Do you think a public workshop is necessary?												
A4.4 Have you been proposed to participate to a technical workshop?												
A4.5 Did you accept?										■		
***												
PART B. TECHNICAL WORKSHOP ON RADON DIAGNOSIS AND MITIGATION												
B1 Why did you choose to participate to the technical workshop?												
You wanted to know more about radon		■										
The radon concentration was elevated and you were advised by the project leader to participate	■											
Worries about health/indoor air quality						■						
The participation was free									■			
You wanted your house cleaned from radon					■							
You wanted personal advice on how you can mitigate							■					
You wanted personal advice on how a building professional can mitigate								■				
Your wanted contact with building professionals								■				
You knew people who will attend the meeting			■									
Husband/relatives/people advice you to attend to the meeting	■											
Other _____												
B2 What results after the workshop?												
You get the information you want about radon					■							
You get the information you want on how you can mitigate							■					
You get the information you want on how a building professional can mitigate								■				
You get contact with building professionals								■				
You get a cost estimate									■			
Other _____												
B3 Would you say the public workshop met your expectations?												
Totally												
Partly												
Not at all												
Good points: _____												
Improvements needed: _____												
Do you think a technical workshop is necessary?												

QUESTIONS AND PROBES	SOURCES OF INFORMATION				COGNITIVE MEDIATING PROCESSES					COPING MODE		
	Verbal persuasion	Observational learning	Personality variables	Prior experience	Intrinsic/extrinsic Rewards	Severity- Vulnerability	Self Efficacy	External Efficacy	Cost/Disturbance	Single act	Multiple acts	Repeated acts
PART C. DIAGNOSIS BY A RADON EXPERT												
C1 Was any form of radon building diagnosis performed in your house?												
Yes, self made										■		
Yes, by a professionnal										■		
No												
Other _____												
C2 Why did you accept the diagnosis of your house												
You wanted more information about radon					■							
The radon concentration was elevated and you were adviced by the project leader to accept	■											
Worries about health/indoor air quality						■						
The diagnosis was free									■			
You wanted your house clean from radon					■							
You wanted personal advice on how you can remediate							■					
You wanted personal advice on how a building professional can remediate								■				
You wanted contacts with building professionals								■				
Husband/Relatives/people advice you to have the diagnosis	■											
Other: _____												
C3 What were the results from the diagnosis?												
You get the information you want on how you can mitigate							■					
You get the information you want on how a building professional can mitigate								■				
You get contact with a building professional												
You get a cost estimate									■			
Other _____												
C4 Would you say the diagnosis met your expectations?												
Totally												
Partly												
Not at all												
C6 Do you support other manner to perform a diagnosis that can encourage more people to have one?												
The building professional perform a diagnosis								■				
The building professional perform a diagnosis and a remediation								■				
Radon hotline with expert/professionals												
Development of web-based tool							■					
Development of a public smartphone application							■					
Other: _____												
B3 Would you say the visit and the diagnosis met your expectations?												
Totally												
Partly												
Not at all												
Good points: _____												
Improvement needed: _____												
B4 How much money would you be willing to spend for a diagnosis?												
Up to 100 €									■			
Up to 200 €									■			
More than 200 €									■			
Whatever it takes									■			
Not willing to spend any money for a diagnosis									■			
***												
PART D. MITIGATION												
D1 Was any form of radon mitigation performed in your house?												
Yes, self made										■		
Yes, by a professionnal										■		
Yes, you and a professionnal											■	
No												
Other _____												
D2 You achieved the mitigation by yourself												
You had enough information after the public meeting		■										
You had enough information after the technical workshop		■										
Cost efficient									■			
More convenient									■			
You made simple improvement of the sealing (hole, crack, door, ...)											■	
You modified the ground-building interface (basement)												■
You made simple improvement of the ventilation (check, ...)											■	
You installed a new active ventilation system												■
You are opening the windows more frequently												■
Other _____												
Approximate amount engaged: _____ (€)									■			
D3 You contracted a building professional for the mitigation												
You had enough information after the public meeting to contract on		■										
You had enough information after the technical workshop to contract on		■										
You had enough information after the diagnosis to contract on		■										
Cost not an issue									■			
More convenient									■			
The professional made simple improvement of sealing (hole, crack, door)											■	
The professional modified the ground-building interface (basement)												■
The professional performed simple improvement of the ventilation												■
The professional installed a new active ventilation system											■	
Approximate amount engaged: _____ (€)									■			■
D4 You did not mitigate												
Because radon is not a problem						■						
Because the radon concentration is low						■						
You did not believe in the measurement			■									
Not worried about radon/indoor air quality						■						
You did not have enough information on how to remediate							■					
You did not have contact with building professionals who can remediate								■				
The building professional did not understand/did not want to remediate								■				
Lack of time/too busy									■			
Inconvenient/disruptive									■			
Money issue									■			
You wait for renovation work		■										
Other _____												
Don't know/no answer												
D5 Did you re-test the radon concentration after the mitigation work ?										■		
Was the mitigation efficient?		■										
Do you consider other mitigation work?											■	
Why _____												
***												

2. Rogers R W. 1984. Cognitive and physiological process in fear appeals and attitude change: a Revised Theory of Protection Motivation, in Social Psychophysiology: A Sourcebook, Guilford (pub.), J T Cacioppo, R Petty (ed.), Chap. 6, p. 153–175.

5. INFORMATION ON THE PROJECT ADDRESSED TO LOCAL PUBLIC ADMINISTRATION AND THE INHABITANTS AND CONSENT FORM TO PARTICIPATE

5.1 Presentation of the research project [local public administration version]

The RadoNorm project

The RadoNorm project is a European project[1] mixing scientific and social research to improve the management of radon in dwelling. One part of this project entails gaining insight in people's understandings and behaviours regarding radon in order to improve public awareness on this matter and to adapt management policies to the concerns of the inhabitants.

This study is being undertaken by Sylvain Andresz, Senior Researcher and Caroline Schieber, Project Leader at the Nuclear Protection Evaluation Centre (CEPN). In Bourgogne Franche Comté, CEPN is collaborating with the Pays de Montbéliard Agglomération since 2011 acting in support of the radon management strategy of the community and since 2019 under convention with the Regional Health Authority in support of radon initiatives in the region. In Pays de la Loire, CEPN was an early partner with Regional Health Authority, IRSN and Nuclear Safety Authority to support the regional radon action plan (2013-2016). CEPN is member of the National Radon Action Plan.

The interviews

While the radon regulation is somehow lighter in housing compared to in public buildings and workplaces, several local authorities have concretely engaged actions for the management of radon in houses (trough communication, local health plan, …).

The objectives of the interviews are:

1. To analyze the reasons/motivations why the communities and elected representatives have chosen to provide prevention measures for 'radon at home';
2. To explore the different approaches followed and their results;
3. To explore what are the obstacle faced and what can be done to overcome.

The interview will take approximately 20 minutes and entails answering a series of pre-defined questions. You are free to choose which questions you want to answer and you can stop your participation at any time without any justification. The interview will be made by phone (or videoconference) and will not be recorded.

Your data

The content of your interview will never be distributed, shared of communicated outside the research team. Your data will be pseudonymized and analysed by the CEPN only together with those of the other respondents. We will not collect more data than needed for the research and not collect any type of "sensitive" data.

You have the right to access, modify, oppose, delete, transfer and limit the data you have provided in the interview and can exercise this right any time by asking the researcher who have co-signed the consent form that will be given to you (see Annex).

As part of the RadoNorm project, the analysis and the results are intended to be published and distributed to the RadoNorm partners, the scientific community and any interested parties in the management of radon in homes. You will be informed about the publication of the results. A Data Management Plan compatible with the Horizon2020 project requirements has been prepared for this project and can be send to you upon request.

Ethical approval

[1] This project received funding under the Horizon2020 Euratom Research and Training funding programme under grant agreement No 900009. More information on RadoNorm: < www.radonorm.eu > (in English).

The RadoNorm Ethical Committee has been asked to provide an advisory consultation on the study. The application form can be sent to you upon request as well as the answer of the Ethical Committee.

5.2 Presentation of the research project [inhabitants version]

The RadoNorm project

The RadoNorm project is a European project[2] mixing scientific and social research to improve the management of radon in dwelling. One part of this project entails gaining insight in people's understandings and behaviours regarding radon in order to improve public awareness on this matter and to adapt management policies to the concerns of the inhabitants. The interviews are made for this purpose.

This study is being undertaken by Sylvain Andresz, Senior Researcher and Caroline Schieber, Project Leader at the Nuclear Protection Evaluation Centre (CEPN). CEPN is collaborating with PMA since 2011 in support of the radon management strategy of the agglomeration. CEPN and PMA were both engaged in the Démarche Pluraliste Qualité de l'Air Intérieur – Radon Bourgogne Franche Comté and now in the Jurad-Bat platform[3].

The interviews

The objectives of the interviews are:

1. To analyse how the inhabitants perceived the public meeting, public workshop/the diagnosis, their (learning) experience, if it was helpful and areas of improvement;
2. To analyse the reasons/motivation why they choose (or not)
    a. to attend the public meeting and/or the technical workshop;
    b. to perform an in-house radon diagnosis (if so);
    c. to implement radon remediation actions;
    d. to assess these actions;
3. To explore what are the potential obstacles at the different steps of the radon management pathways and conversely what can favour the implementation of radon remediation actions;
4. To draw lessons from these enquiries for the municipalities / authorities in charge of implementing such radon management campaigns.

The interview will take approximately 20 minutes and entails answering a series of pre-defined questions. Participants are free to choose which questions they want to answer and they can stop their participation at any time without any justification. The interview will be made by phone (or videoconference) and will not be recorded.

Data Management

The content of the interviews will never be distributed, shared of communicated outside our research team. The data will be pseudonymized[4] and analysed by the CEPN only together with those of the other respondents. CEPN will not collect more data than needed for the research and not collect any type of "sensitive" data[5]. Participants have the right to access, modify, oppose, delete, transfer and limit the data they have provided in the interview and can exercise this right any time by asking the researcher who have co-signed the consent form that they will receive (see Annex).

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2 This project received funding under the Horizon2020 Euratom Research and Training funding programme under grant agreement No 900009. More information on RadoNorm: < www.radonorm.eu > (in English).

3 Démarche Pluraliste Bourgogne Franche Comté < https://www.radon-qai-fcomte.fr >, JuradBat : < http://www.jurad-bat.net >.

4 Pseudonymisation is the processing of personal data in such a way that it is no longer possible to attribute the data to a natural person without further information. In practice, pseudonymisation consists of replacing identifying data (surname, first name, etc.) with indirectly identifying data (alias, number, etc.). Pseudonymisation thus makes it possible to process the data of individuals without being able to identify them directly. https://www.cnil.fr/fr/lanonymisation-de-donnees-personnelles

5. Data revealing alleged racial or ethnic origin, political opinions, religious or philosophical beliefs or trade union membership, as well as the processing of genetic data, biometric data for the purpose of uniquely identifying a person, data concerning health or data concerning the sex life or sexual orientation of a natural person, < https://www.cnil.fr/fr/definition/donnee-sensible >.

As part of the RadoNorm project, the analysis and the results are intended to be published and distributed to the RadoNorm partners, the scientific community and any interested parties in the management of radon in homes. Participants will be informed about the publication of the results.

A Data Management Plan compatible with the Horizon2020 project requirements has been prepared for this project and can be sent to participants upon request.

Ethical approval

The RadoNorm Ethical Committee has been asked to provide an advisory consultation on the study. The application form and the answer of the Ethical Committee can be sent to participants upon request.

5.3 Annex - informed consent for participation in a research interview

One copy of this document is for you, another copy is archived under the responsibility of the researchers.
PART (1/2) ———————————— FOR THE PARTICIPANT

I, the undersigned _____
agree to participate in a research study led by Sylvain Andresz and Caroline Schieber, Nuclear Protection Evaluation Centre (CEPN). The purpose of this document is to specify the terms of participation in the study.

- ☐ I have read the information letter.
- ☐ I have been given sufficient information about this research study. The purpose of my participation has been explained to me and is clear.
- ☐ My participation in this study is voluntary. There is no explicit or implicit coercion whatsoever to participate.
- ☐ Participation involves being interviewed by one/two researcher(s) from the CEPN. The interview by phone or videoconference system will last approximately 20 minutes. I allow the researcher(s) to take written notes during the interview. I am aware there will be no audio nor video recording.
- ☐ I have the right not to answer any of the questions without justification. I have the right to withdraw from the study without justification.
- ☐ I am aware that I have the right to access, modify, oppose, delete, transfer and limit the data I have provided upon request addressed to the researchers.
- ☐ I am aware of the goal for which the data provided by me will be collected, processed and used within the context of the project and treated in a confidential manner. I can access the Data Management Plan of this research by asking the researchers.
- ☐ I have been given the explicit guarantees that the researcher(s) will not identify me by any means in any reports using information obtained from the study, and that my confidentiality as a participant in this study will remain secure. I can access the Data Management Plan of the research upon request addressed to the researchers.
- ☐ I have been given the guarantee that the RadoNorm Ethical Committee has been informed by the research and the adequacy of the project with the ethical principles and the rights of person have been analysed. I can access the application form for ethical clearance and the answer from the RadoNorm Ethical Committee upon request addressed to the researchers. I can contact the RadoNorm Ethical Committee through the researchers of the project.
- ☐ I have read and understood the points and statements of this form.
- ☐ I have been given a copy of this consent form co-signed by the researcher carrying out the interview.

_____ _____
Participant's Signature Date

_____ _____
Researcher's Signature Date

For any information you can contact: Sylvain Andresz, < sylvain.andresz@cepn.asso.fr >, tél. 01 55 52 19 27

One copy of this document is for you, another copy is archived under the responsibility of the researchers.

PART (1/2) ———————————— FOR THE RESEARCHER

I, the undersigned _____
agree to participate in a research study led by Sylvain Andresz and Caroline Schieber, Nuclear Protection Evaluation Centre (CEPN). The purpose of this document is to specify the terms of participation in the study.

- ☐ I have read the information letter.
- ☐ I have been given sufficient information about this research study. The purpose of my participation has been explained to me and is clear.
- ☐ My participation in this study is voluntary. There is no explicit or implicit coercion whatsoever to participate.
- ☐ Participation involves being interviewed by one/two researcher(s) from the CEPN. The interview by phone or videoconference system will last approximately 20 minutes. I allow the researcher(s) to take written notes during the interview. I am aware there will be no audio nor video recording.
- ☐ I have the right not to answer any of the questions without justification. I have the right to withdraw from the study without justification.
- ☐ I am aware that I have the right to access, modify, oppose, delete, transfer and limit the data I have provided upon request addressed to the researchers.
- ☐ I am aware of the goal for which the data provided by me will be collected, processed and used within the context of the project and treated in a confidential manner. I can access the Data Management Plan of this research by asking the researchers.
- ☐ I have been given the explicit guarantees that the researcher(s) will not identify me by any means in any reports using information obtained from the study, and that my confidentiality as a participant in this study will remain secure. I can access the Data Management Plan of the research upon request addressed to the researchers.
- ☐ I have been given the guarantee that the RadoNorm Ethical Committee has been informed by the research and the adequacy of the project with the ethical principles and the rights of person have been analysed. I can access the application form for ethical clearance and the answer from the RadoNorm Ethical Committee upon request addressed to the researchers. I can contact the RadoNorm Ethical Committee through the researchers of the project.
- ☐ I have read and understood the points and statements of this form.
- ☐ I have been given a copy of this consent form co-signed by the researcher carrying out the interview.

_____ _____
Participant's Signature Date

_____ _____
Researcher's Signature Date

For any information you can contact:
Sylvain Andresz, < sylvain.andresz@cepn.asso.fr >, tél. 01 55 52 19 27

PART (2/2) ——————— FOR THE RESEARCHER

I, the undersigned _____
hereby confirm that I have informed the procedures as described in the information form with _____.
I have explicitly asked whether any ambiguities or questions remained and have answered these to the best of my abilities.

Furthermore, I confirm that
_____ has given
permission to participate in the study.

_____ _____

Researcher's Signature Date

6. CHARACTERISTICS OF THE PARTICIPANTS

Table 1 and Table 5 provides the main characteristics of the participants to the interview for each group.

Table 1. Characteristics of the local public administrations (Group A).

ID	Position of the individual or related plan/programme	Location
A1	Elected person	Tramayes (village)
A2	Programme of Public Interest (PIG)	Saône et Loire (county)
A3	Health and Hygiene Department	Nantes (city)
A4	Climate Air Energy Territorial Plan (PCAET)	Sud Mâconnais (county)
A5	Health and Handicap Service	Laval (city)
A6	Local Health Contract	Sud Vendée Littoral (county)

Table 2. Characteristics of the inhabitants (Group B).

ID	Result of radon test in $Bq.m^{-3}$ Living room / basement	Meeting	Workshop	Diagnostic	Mitigation	Result of radon re-test in $Bq.m^{-3}$
B1	508 / 617	ø	X	X	simple actions*	ø
B2	135 / 1,579	X	X	ø	ø	ø
B3	310/ 1,436	X	ø	ø	Simple actions*	ø
B4	967 / 973	X	ø	X	Simple actions*	With direct measurement in room, varying between 900-2,600
B5	495 / 1,858	(unsure)	ø	ø	ø	ø
B6	231 / 3,391	ø (impossible)	X (unsure)	ø	X	X 85 / 1,800
B7	246 / 366	X	ø	simple	Simple actions	ø

X: did participate/performed; ø: did not participate/not performed.

* 'Simple actions' refer to inspecting/improving natural ventilation of the basement, inspecting the ventilation system (if existing), sealing apparent cracks and hole, the passage of pipes etc. Complex actions (not implemented) can include installing a radon sump in the basement and/or improving the ventilation system in the inhabited areas.

7. DETAILED RESULTS FOR THE LOCAL PUBLIC ADMINISTRATION

The themes and sub-themes resulting from the qualitative analysis of the data collected are presented in Table 3 and detailed in the next paragraphs. The quotes are associated with the representative by their ID.

Table 3. Themes and sub-themes for local public administrations (Group A).

Themes		Sub-themes: facilitators (+) and barriers (–)
Initial motive	**i)**	(+) A former history with radon
	ii)	(–) Radon not a priority
Development of health and prevention promoting services*	**iii)**	(+) Different approaches adapted to the local context
	iv)	(+) Raising awareness through multiple channels
	v)	(–) Several difficulties in communication
Advocacy, cooperation of organizations*	**vi)**	(+) Including radon in existing plan/program
	vii)	(+) Engagement of decision makers/key persons
	viii)	(+) Organizational insights
Social mobilization*	**ix)**	(+) The importance of follow-up
	x)	(–) No clear vision beyond awareness
	xi)	(–) Lack of intermediary players
Development of individual skills*	**xii)**	(–) Difficulty in accessing information and knowledge
	xiii)	(–) Lack of skills for building professionals

The four themes indicated with * are the four promotion measures of the SMOC model and the 'initial motive' theme is an emerging theme.

7.1 Initial motive

It was apparent that all respondents had a **former history with radon**. In several cases, elevated radon concentration was spotted in buildings located in the community: "*the radon concentration in the school was very high. Above 2,500 Bq/m^3. This has ignited a lot of emotion among the public,* especially *the parents*" [A5], "*an elevated level of radon was found in a school. And the parents were very alarmed. This is quite old, it was in 2007 something, before I join the administration*" [A3] or in a house [A4] located in the vicinity. These experiences signalled the local administration that radon could actually be found in the buildings of the area, with elevated concentration and so "*it was necessary to step out the scope of the regulation*[6]*"* [A5]. Other references to the past were made: "*I remember the case of a notary who has to deal with a house-selling and the transaction was subject to the result of the radon measurement test*" [A6] and "[I knew about radon from] *word-to-mouth with another local public administration which was very much engage in the management of radon"* [A1] and finally "*I participated to an information session about radon and radon management set up by another administration, covering the theory and the practices surrounding radon. Later on, one participant representing an engineering office with experience in radon make contact with us*" [A4].

Clearly, none of the local public administration was naive about radon and it can be stated that their motives in starting a radon management action have been enhanced by a background of awareness and knowledge on radon, and previous experience in its management (*e.g.* in school). Conversely, the local public administrations who do not have such background will not be aware of the issue and did not find the

[6] Since the French Decree of 22 July 2004, a radon measurement shall be performed in some public places, including schools, located in the radon prone areas.

motivation to initiate action (as suggested by [A1] and [A6]). Worst, some local administrations "*don't want to know, because they assume the subject is complicated and not innocuous*" [A3].

But even if information has been provided, the respondents indicated that **radon is not a priority** for most administrations: "*radon does not present an immediate health threat*" [A1], "*this is a non-immediate issue and therefore radon is not a priority*" [A2]. They indicated that "*local administrations have many topics on the agenda, and the topics are piling up with the years, especially the last years, so they lack time, and when they have to make priorities, radon is not on the list*. *We are focused on immediate topics only*" [A1] and "*it is only a matter of priority*" [A5].

7.2 Development of health and prevention promoting service

It was manifest that each local administration had developed the radon management action **adapted to the local context**. The key points describing each radon management action are displayed in Appendix 7. No two actions were similar and notable variations can be found:

- In the stewardship: the action can be managed by the local public administration it-self [A3] or delegated/contracted to an association with experience in radon management: "*the association acting as a service provider has been essential to the action*" [A5], or a company (an engineering office operating with building diagnosis and audit [A4]). The stewardship can also be evolving: "*for the 2022-2023 radon campaign, we will choose a contractor*" [A3].
- In the geographical perimeter which goes from a small city district: "*we select a micro-district of the city every year*" [A3] to bigger than a county: "*we even received demands for radon detectors coming from outside the county. We included these people into the action*" [A5].
- In the durability of the action: the action could be meant to be repeated every year in a different place [A3] or it was a one-shot action [A1, A5].
- Several initiatives followed the "classical" radon management plan as described in §2.1 while the others were concentrated on informing/training professionals operating in building renovation or retrofit for energy efficiency who are in contact with the public: "*when the professional carry on an in-house visit, radon is an element of attention* and *integrated in the global renovation plan, especially if the house is located in a radon prone area and/or the house has characteristics bound to elevated radon concentration – and the professional can eventually advise the inhabitants to perform a radon test before starting the work*" [A2].
- The complete refurbishment and energy retrofit of an old collective house taking into account protection against radon from the onset was an exemplary and innovative approach [A1].

Raising awareness through multiple channels is done with flyers ("*flyers on the radon measurement campaign were available in the Housing Department of the town houses, at the energy info-points of the district and social landlord" [A5]; "[flyers] delivered in the postal box of the inhabitants*" [A3]), social networks, website, local press [A1, A3, A5], permanent office [A5] and public meetings [A3, A4, A5, A6]. In Bourgogne Franche Comté, a mock-up house using smoke to simulate the transfer of radon and the effect of ventilation has been built by the university several years ago and the device is still circulating with success: "*the mock-up generates questions, it has an impact*" [A4]. "*Because the lay public is clearly lacking information, we need to address this lonely topic by all available channels. There is no single answer: the topic should be addressed by all the means available*" and later during the interview: "*we need to multiply the usage of social media*" [A6].

But the local public administrations have also experienced **several difficulties in communicating on radon**, first because of its physical nature: "*radon is an inert gas, without colour nor taste. How to see the danger? It's just invisible!* Then "*the subject is absolutely unknown*" and the public "*has no clue about what is at stake*" [A1]. The content of the message to be broadcast reached no consensus: the need to play harder on the risk of lung cancer has been advocated by some: "*radon exposure means lung cancer, period*" [A3, A6], "*the Covid pandemic has de-sacralised the topic: before, no one even dare to talk about 'death'*" [A4], while others would like to play more lightly because it will act as a deterrent: "*these messages shall not be used*" [A2], "*cancer is frightening!*" [A1] and stated that the message will be better received if incorporated in a more general "*improvement of indoor health quality, inclusive of CO_2 which has attracted attention recently*" [A1], "*improvement of the indoor health quality and the risk CO_2 and CO*" and building energy retrofit programmes. And finally, the responsibilities about who should inform have also been discussed: "*it is not up to the mayor to be more pressing about radon*, *but is it the Ministry of Health or the Ministry of Ecological Transition? I do not know but there is a topic here*" [A1].

7.3 Advocacy, cooperation of organizations

In all cases a document has been developed to support the initiative, but it was in fact by **including radon in a pre-existing plan or programme** either dealing with health: "*the Local Health Contract*" [A5, A6] [7], "*one page on radon has been inserted in the Regional Health and Environment Program*" [A3] [8] and the "*health policy of the metropolitan area*" [A3] or dealing with building renovation and energy retrofit: in the "*program of public interest*" [A2], a "*programmed operation for the improvement of the housing*" [A1] [9] and the "*Territorial Climate, Air and Energy Program*" [A4] [10].

Including an item about radon in existing programmes is a strategical move to make the radon initiative official and to connect it with other initiatives whose support and budget are granted and dealing with best-known and appealing topics such as "*indoor air quality*" [A4, A5], "*global health*" [A1], "*efficient building renovation*" [A2], "*more generally thermal efficiency. And comfort*" [A4]. But at the same time, radon remains somewhat concealed because no standalone document for the radon management plan has been developed ("*Did you formalize tasks and actions about radon in document? Not at all*" [A4]) and no reference to the French National Action Plan has been made (N.B. there is no regional version of the national plan). Another illustration is that no change in the organization (part of SMOC model), such as modification of the structure of hiring someone dedicated to the radon management action has been reported by the interviewees.

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[7] The local health contract (CLS) is a contractual document established between a local public administration (generally a group of communities) and the Regional Health Agency (ARS) which describe a local strategy intended for the improvement of the health of the population and include objectives and the means to achieve the objectives for different topics aligned with the Regional Health and Environment Programme (see footnote below) and adapted to the context of the communities (*e.g.* allergy, access to health care, …). The local public administration can consider including an item about radon in the contract.

[8] The Regional Health and Environment Programme (PRSE) is supported by the State, the Region and the Regional Health Agency (ARS) and is a regional implementation of the National Health and Environment Programme by taking into account the specificities of the region. PRSE is also design in encouraging local actions. An item about radon can be inserted in the PRSE, most generally in the indoor air quality chapter.

[9] The programme of public interest (PIG) and the programmed operation for the improvement of the housing (OPAH) are two national programmes providing support for the renovation of buildings in poor condition and/or inhabited by vulnerable population. Although not related to radon, PIG and OPAH can be used a mean to promote radon information and testing and a financial support could in theory be used to cover the radon mitigation costs if merged with the overall cost of the renovation.

[10] The Territorial Climate, Air, Energy Programme (PCAET) is a mandatory planification tool for communities above a certain size which consider the reduction of the consequences of climate change, renewable energy and energy efficiency. The developers might consider integrating indoor air quality and radon in the PCAET.

The engagement of **decision makers and key persons** have been regarded paramount for the efficiency of the action and the respondents indicated that the elected representatives need to be at least informed and if possible "*be there at the public meetings*" [A3, A5] or even "*the elected representatives can take part to the radon measurement campaign. To show the example*" [A6]. A local steering group has been set up in a few cases, including the local public administration, local authorities and an association to "*build the strategy of the action and design the communication medium*" [A5, A6]. At a lower level, some respondents have organized information meetings within their structure: "*for the syndicate and the executive offices*" [A4] and "*between the departments*" [A3].

The respondents provided numerous **organizational insights** that can act as facilitators of the action**:** first, the radon management action is "*a project in-itself and requires a well-balanced strategy and planning*" [A5] and it should be supported by "*a clear voluntary political stance*" [A3, A5] because it is outside the regulatory requirements. And because of this, the implementation is also becoming a bit personal: "*it is only a question of good will and motivation*" [A4]; "*the project is also matter of persons*" [A3]; "*we had a privileged relationship with this structure*" [A4].

The local public administration should not work alone: there is the need to "*establish a good local partnership*" [A3], a "*local engineering model that host a maximum of concerned stakeholders*" [A2] and to make connection "*with those who have expertise, those who know*" [A1] and "*the right persons*" [A2] and also "*give great consideration to the interfaces between the structures to avoid any problem*" [A4]. When working with those with experience in radon management "*it was a piece of cake*" [A5]. The idea of a "*national call for expression of interest on radon*" [A1] to aggregate knowledge and experience has been proposed.

"*Repetition of the action is necessary*" [A3] to make sure it percolates but also to share the workload ("*the workload exists, it is necessary, it should be planned*" [A5]) a project can bear and due to the limited resources ("*we do not have many resource and the turn-over is elevated*" [A4]) and one proposed not to reiterate a project every year but every 2-3 years [A6].

The project developed as expected for most respondents, but not always "*the lockdown implemented during the pandemic has blocked the process, the visits, the testing*…" [A3]; "*with the pandemic, we could not perform visit, nor organize events that could have amplify the action* [and, later] *the programme* [for building renovation] *was stopped because it was not recognized by the national agencies*" [A4]. Nonetheless, most were keen to reiterate: "*for those who cannot participate the first time, and others too*" [A6], "*we must continue*" [A1], "*I encourage other local administration to start a project*" [A3].

7.4 Social mobilization

The importance of follow-up to build tangible results was incidentally shown by several respondents who had carefully monitored the implementation of the action, for example: "*We planned 7 meetings, distributed 340 detectors and the return rate was very elevated, 98%!, and 2 on-site radon diagnosis were performed in building showing concentration > 1,000 Bq/m^3. So we went in the field, we were there to answer the questions of the inhabitants and regularly do follow up, we call them ... I believe that the good figures can be explained by the individual approach we have adopted*" [A5]. Or for another action: "*1,500 invitations were sent by postal mail, then 1,500 detectors sent and returned; 25% of the results were above 300 Bq/m^3 and 3% above 1,000 Bq/m^3. We proposed 10 to 12 diagnosis and 5 to 6 were performed. But the*

latter figure is a bit exceptional, usually 2-3 diagnosis are performed" [A3]; "*All the 266 detectors were picked-up and later 15 results were higher than 300 Bq/m^3. One on-site diagnosis was performed*" [A6].

In contrast, a lower follow-up means a lower confidence in the result: "*I* think *we have informed around 70 persons about radon*" [A2, the interviewee was not sure about the result] and in one case, no indicator has been formalized at all: "*it was an experiment; therefore, we did not set objective*. *We did not formalize nor followed the numbers about information or radon measurement … we did not really have a vision of what was going on in the field*" [A4].

No clear vision beyond awareness. While the results and impacts in awareness were unequivocal, the respondents were less confident for the other steps: "*the people have been informed but have not stepped forward and taken any action to measure their home for radon*" [A4], "*it was a success for the information part, but no mitigation work has been performed*" [A2], "*we did not experience a snowball effect* […] *the social impact of this project is rather tiny*" [A1]. The figures associated with the post-measurement steps (*e.g.* number of diagnoses performed, number of mitigation) are very modest but it takes times (year) to grow and the local public administration do not plan a long follow-up; contributing to the lack of clarity on the end-results. While quantitative indicators were implemented, no local public administration has reported indicators of qualitative nature either at individual (change in behaviour, intention, …) or collective levels (feedback of the action, …): "*For the quantitative part, we know, but for the qualitative part, this is less sure*" [A3].

The **lack of intermediary players** to multiply the effects of the radon management action has been regretted by several respondents. The elected representatives were the most quoted: "*the mayors, the association of the mayors … they can tell people, especially those who are about to engage building renovation work and go to the town hall*" [A4]; *"we need to mobilize the mayors and use their mailing list*" [A6]; "*the executive board of the county … Their presence at the meeting would be essential … They can also demystify the results*" [A6]. Various professionals in contact with the public have been quoted as "*notary/solicitors who might be activated during the building transaction*" [A6], "*architects, especially for new houses … or for a good integration of radon mitigation in the overall work … to avoid renovating by small bit, only renovation from A to Z*" [A4] and also "*energy efficiency and building retrofit counsellors*" [A6]. Using the health professionals was also reported once: "*Pharmacists and medical counsellors for indoor air quality can be the relay of information. And general practitioners because people listen what family doctors say*" [A3] and also: "*We used to embark local consumer associations and scientific associations in the action, but this practice has vanished over the years*" [A3].

The consensus was adamant on including the building professionals "*who are in very close contact with the public and at the forefront of building work*" [A4], "*we need to approach the building professionals*" [A6]; "*we need to target the technicians*" [A2] and also in: "*the presence of professionals is missed*" [A3]; "*the presence of the federation of building professionals is deeply missed*" [A4].

7.5 Development of individual skills

The local administrations have experienced **difficulties in accessing information and knowledge** about radon in houses before starting the action. The information was mainly collected from the website of the national institutions and public bodies: "*we accessed the website of the National Institute for Radiation Protection* [IRSN] *and the Cerema*" [A3] and the on-line map of radon prone areas has been reported several times [A2, A5, A6] and despite these data were useful yet "*the information is dispersed and could benefit*

from being gathered and located in one place. Leaflet and info-sheet on radon prepared by national institutions will help" [A2].

Direct contact with promoter of former radon management action has been performed but only once, with benefits: "*the feedback of experience the city of Nantes has been essential for us to design our action. We contacted* [this association] *who already has experience with radon and then established the terms of a contract with them*" [A5].

The lack of skills for building professionals is a major hinder and a real strategy is needed to cope with: "*the training, the competences and expertise on ventilation, indoor air quality and radon are missing*" [and] *building construction norms against radon are missing"* [A6] and "*the building professionals have the tendency to reject the responsibilities of radon management to one another*" [A4]. The respondents have various proposals "*we need ready-to-use document*, *clear and readable materials address to the professionals* […] *and also exemplary and pilot projects*, *technical platform*" [A2], "*commissioning the rare experts on radon in all the country to train the building professionals*" [A1] *"I have some good hope with the DOREMI label which encompass indoor air quality in a global manner*" [A4] but noting that "*The building renovation is complicated enough … so how to integrate radon in the whole lot?"* [A2].

8. DETAILED RESULTS FOR THE INHABITANTS

The themes and sub-themes resulting from the qualitative analysis of the data collected are presented in Tableau 4 and detailed in the next paragraphs. The quotes are associated with the inhabitant by their ID.

Tableau 4. Themes and sub-themes for inhabitants (Group B).

Themes		Facilitators (+) and barriers (–)
Source of information*	**i)**	(+) A panoply of sources of information (and some missed opportunities)
	ii)	(+) Engagement fostered by an individual history
	iii)	(+) Public meetings and public workshops to deliver insights about radon mitigation
Cognitive mediating process*	**iv)**	(+) A personal and qualitative appreciation of the risk
	v)	(+) Understanding of the general concepts of radon risk management
	vi)	(–) Cost and complexity of mitigation works
Coping modes*	**vii)**	(+) Natural ventilation: a change in behavior
	viii)	(+) Implementation of simple action at controlled cost
	ix)	(–) Lack of follow-up overtime

The themes indicated with * are the themes in the RPMT model.

8.1 Source of information

Information about radon and radon measurement has been delivered to the inhabitants thanks to **a panoply of source of information**: "*the website of the community*" [B6, B7], "*I saw a poster in the town hall*" [B1, B2], a flyer (in the mailbox [B3]) and word-to-mouth [B2]. It seems that all the channels are valuable and working to deliver information to their target.

Yet there are also some **missed opportunities** in communication according to the inhabitants. Compared to all the coverage about building retrofitting, energy saving and the ecological challenges, radon "*is not audible*" [B5] and do not rank high in the list of priorities of the population. Furthermore, inhabitants are not warned about radon when planning a renovation or a construction, and one even proposed to make it mandatory in radon prone areas, by including a requirement in the building code: "*I worked in the administration of the community. It might be possible to deny a building permit because of radon consideration. And this can be made mandatory, the same way that, say, the recovering of rainwater is mandatory now*" [B5]. Another inhabitant proposed to associate the medical staff "*because the word of the physician is much heard than others*" [B7]. Close from this proposal, "*the health effects of radon are not known enough. It can leverage the information. A synthetical document is adequate*" [B3].

What was apparent is that the decision to move forward in the process and decide to test the house was **foster by a pre-existing history** about radon or risk management. Each history is different: "*I had already performed a radon test years ago. I know that radon was there and a neighbour had detected radon in his house*" [B4], "*I am an elected representative, and the schools were tested for radon*, *I know that radon was there and so I have to do the test*" [B5], "*my wife is working as nurse at the Montbéliard hospital. A lot of workers from the former foundry are treated there for silicosis – I know what a lung disease is and so measuring radon in the house was simply the right things to do*" [B7], "*I was a health and safety officer at the Peugeot manufacturing factory at Sochaux and occupational accident and disease were my every day. We measured everything at the factory like the air or the noise to get a picture of the risks. Measuring radon* [in my house] *was an application of the precautionary principle*" [B2]. By contrast, one respondent

suggested that the "French spirit" (promoting the independent point of view and systematic disagreement with the authorities) might hinder the intention to move forward in the process.

Curiosity was another driving principle: "*I thought it will be interesting to know the situation*" [B1], "*my brother is working at the Ministry of Land and Forest. I know radon is associated with granite but here the ground is essentially limestone. So, I was curious to know*" [B3], "*I am an amateur geologist. I read a bit about radon. And I was surprised to read from PMA that radon was also present in the region* […]. *I am curious*" [B6].

It was apparent that the radon measurement campaign proposed by PMA was an opportunity (not to say a pretext) for the respondents to engage: all have knowledge on radon, experience with health prevention, risk management and maybe possess a specific frame of mind: "*we were engaged. And we needed to travel to the very end of the process*" [B7], "*I was proactive and decided to play the game* [by performing a radon test]" [B6], that is not found in every person "*yes, I talked about radon and radon test to my friends and my neighbours, and no one wanted to perform a test. As often, I looked like a total marginal"* [B7].

An important volume of information was also delivered at the **public meeting and the public workshop**. It shall be noted that different tracks were followed: one respondent did not take part to the public meeting because of unavailability that night [B5], another did not join to the public workshop because the radon concentration was not elevated enough [B2]. Two respondents agreed upon hosting an in-house diagnosis performed by experts and obtained detailed and personalized recommendations. They agreed that such a diagnosis is worth 100-200 € and compared this value with existing building diagnoses [B1, B4].

The public meeting received many appraisals: it was "*interesting*" [B2, B6, B7], "*well managed*" [B7], "*extensive*" [B3], the speakers were "*very qualified*" [B2] and provided additional awareness and knowledge about radon and radon management. One point of improvement has been reported: "*radon mitigation in a school* [as presented] *is not transferable to a house*" [B3]. The public workshop was also hailed: it provides an opportunity "*for exchange*" [B6], "*to dialogue with professionals*" [B1] and obtain tailored advice for radon mitigation, which are "*very reliable and trustful compared to what can be found on the internet"* [B1]. All participants have deemed the meetings they participated "*necessary", "but they do not replace an in-house visit*" [B2], because "*every house is a special case*" [B1], especially if important works are to be engaged.

8.2 Cognitive mediating process

No inhabitant was able to provide the numerical value of radon concentration of their initial test nor the unit (Bq/m^3) but all used **a personal and qualitative appreciation**: "*it was low*" [B2] or "*inconsequent*" [B2], "*at the limit of the tolerance value*" [B7] or on the other side of the spectrum: "*not very good*" [B4], "*quite elevated*" [B1], "*important*" [B6]. Therefore, the radon concentration was not regarded as a pure objective data or a scientific object, but already appreciated and valued on a personal scale. To support this, the researchers noted that the result also had a more intimate impact on most of the respondents: "*the value was an alert*" [B6], "*then, there were a worry*" [B1], "*we are necessarily worried*" [B4] and conversely "*I am not worried as long as the value is low*" [B3].

As presented to the inhabitants, the principles of radon mitigation consist in preventing the gas from entering the occupied areas and/or extract it by using a combination of passive (ex. sealing) and active (ex. ventilating the basement and/or the living areas) techniques. It was apparent that the respondents **have**

well understood the concepts: they have a good memory of the advices provided and were able to present with precision what was recommended and used the appropriate terms and vocabulary: "*I had to ventilate, install a dedicated air intake for the stove and improve the air-tightness*" [B4], "*I knew what to do*" [B6] and, have integrated and interpreted, the data provided: "*It is simply not possible to remove the air intake in the basement, because it is the one needed for the chimney. So I decided that increasing the air renewal in the basement will be sufficient*" [B3], "*I perform my own diagnosis of the house*" [B7], "*the advices from the expert basically consist in transforming the basement into a bunker. But I am not staying in the basement!"* [B6].

The paramount barrier is that **mitigation work is considered as complicate and expensive:** "*it is complicated to perform mitigation work in a very old house, complicated to perform all the works that were recommended, especially the installation of the mechanical ventilation*" [B3]; "*The ground floor of my basement is just raw material. I cannot install tils everywhere!*" [B6], "*It is very complicated to achieve effective imperviousness"* [B4] resulting in "*we feel a bit powerless when it comes to the work*" [B3].

The economical aspect was very apparent: "*the financial aspect was a barrier*" [B1]; "a *double-flow mechanical system is simply too expensive*" [B4], all the more so since that no financial support can be expected for radon mitigation: "*Now I had radon. And I wanted to know what financial support I could expect. But there is no help for a mechanical ventilation*" [B4] and the benefits of the investment have been questioned many times: "*we do not know anything on the efficiency of the work*" [B4], "*the cost-effectiveness is not known*", "*too complicated, too expensive*, *it is not worth it* […] *I do not want to start something like that!*" [B6], "*what will be the return of investment of the* [mitigation] *work* [if I pay for it]*?"* [B1]. Considering the vast amount of financial support that is available for building energy retrofit, one indicated that it might be possible to reroute at least a part for supporting radon mitigation [B4] – a grant covering 80% of the mitigation work will be appropriate [B3].

8.3 Coping modes

All the respondents have modified their behaviour to increase the **natural ventilation** by manually opening the windows: "*we need to air*" [B4], "*I have changed my ventilation practice* [I open the windows] *in the morning, during the day etc. All the more so since the Covid-19 pandemic. This is a behaviour I learned during the public meeting*" [B7], "*the information campaign and the measurement have made us much more receptive to natural ventilation*" [B5], "*we ventilate regularly the basement. It is a matter of habit*" [B3, B5]. For all but [B4], the frequency and the duration of the natural venting are using their own senses: "*I do that twice a day*" [B7], "*I follow my feeling*" [B5].

Some of the respondents have also **implemented simple actions at controlled cost whenever possible** based on the recommendations from the meetings and the experts: "*I implemented the basic corrective measures and also because I have precise instruction* […] *I implemented the simple actions by sealing cracks and also the door leading to the basement* […] *it cost me around 80 €*" [B4]. "*A pipe was already in place* [connecting the basement to the outside] *and I installed a simple 7W ventilator and it costed me 20 €*" [B6]; "*I used compressed air to clean the mesh of the basement window and later I changed the mesh for a bigger one – it cost me hardly anything*" [B7]. One experience was exemplary: "*I bought a Canary detector to measure radon in real time. It cost me 120 € and now I can constantly monitor the radon concentration and adapt my natural ventilation on the basis of the measurement* […] *I keep record and have performed my own analysis. The efficiency depends on the weather conditions: pressure and temperature. It takes sometimes days before the radon concentration decreases. So it takes much more time to be effective with*

natural ventilation than the traditionally recommended 5 minutes and 3 times a day" [B4]. Unfortunately for this inhabitant "*the radon concentration rarely goes below 900 Bq/m³*" (N.B. only the simple actions have been implemented in the house).

An area of **improvement is the follow-up overtime** of the action, which has been revealed at three occasions. First, none but one [B6] respondent has acquired a new radon test to assess the efficiency of the simple actions or see if the situation has evolved. In consequence, the researchers have systematically invited the respondents to recontact PMA (who was running a radon measurement campaign for the winter 2022-2023) to obtain new radon tests. Second, one respondent has never received the written result of the in-house diagnosis [B1] and another was expecting PMA to inform or publish the results of the radon measurements campaign to a broader audience than the participants [B3]. And third, one respondent has apparently forgotten the issues of radon and engaged important energy retrofit work in one house and the construction of a new one with an ecological perspective but "*we did not think about radon*" [B5].

9. KEY CHARACTERISTICS OF THE RADON MANAGEMENT ACTIONS IMPLEMENTED BY THE LOCAL PUBLIC ADMINISTRATION

Table 5 provides the characteristics of the radon management actions as described during the interviews.

Table 5. Synthetic description of the radon management actions considered in the study.

ID	Position	Key points describing the action	Period
A1	Tramayes (village)	• The village bought an old building and intended to renovate it, to transform it in a collective house, taking radon into account. • The action included: assessment of the radon concentration before the work starts, inclusion of radon mitigation actions in the technical specifications for the renovation, regular follow-up on site by experts and delivering information to the building professionals and the inhabitants. • The action was initiated by the mayor and the Cerema provided the technical services and expertise. No such initiative ever take place and it is regarded as a first-of-its-kind project. • https://www.cerema.fr/fr/actualites/chantier-renovation-qui-integre-risque-radon-sensibilisation [in French]	2019-2022
A2	Saône et Loire (county)	• Considering that a notable part of the county is located in radon prone area, considerations about indoor air quality in construction and renovation plan were inserted in the programme of public interest (PIG) convention. The PIG[A] is initially meant to support effective building retrofit and renovation, especially building in poor condition and/or low-income population. • Information about radon were disseminated by the operators of the PIG at the occasion of on-site visit, public meeting and internal training. • https://www.saone-et-loire.gouv.fr/IMG/pdf/cluny_pac_type_vf.pdf (p.41) [in French]	2019-2022
A3	Nantes (city)	• Each year a small district of the city of Nantes is selected by the city Public Health Division to follow a radon measurement campaign. • Invitation to participate are send by postal letters, press and a public meeting with elected representatives, regional health agency (ARS) and nuclear safety authority (ASN) is planned, and radon detectors made available (November). • After the measurement period, the results are presented at another public meeting, where elected representatives also participate (April-May). • Two inspectors of the Division, with training and expertise on radon, perform a building diagnosis for the cases with the highest radon concentration and provide recommendations for the mitigation. The diagnosis if free of charge for the inhabitant. • https://metropole.nantes.fr/services/egalite-solidarite-sante/sante-publique/se-proteger-du-radon [in French]	Every year since 2007
A4	Sud Mâconnais (county)	• One objective of the Territorial Climate, Air, Energy Programme (PCAET[B]) was to support inhabitants owing a detached house for their building renovation plan. Support can take many forms: administrative assistance, financial, etc. and can include the visit of a counsellor. • One company who operates in building diagnostic, audit and control (energy score, lead, asbestos, …) and act as counsellor in the PCAET was trained to deliver information on radon and advice on how to take radon into account in the renovation. The interaction with the inhabitants occurred at the time of the visit. • Information was also disseminated during public meeting on renovation, website and broadcast by other (informed) individuals of the PCAET organization. • https://maconnais-sud-bourgogne.fr/actualite/34-renovation-energie-particuliers/372-le-bon-air-est-dans-la-maison-comment-lutter-contre-l-humidite-et-le-radon.html [in French]	2019-2021
A5	Laval (city)	• Distribution of information (flyers, social media, website …) to the inhabitants of the city and neighbourhood communities, organization of public meetings with authorities and elected representatives	2021-2022

		• One local association operating in support of public policies (member of the CPIE[C] network) has solid experience in radon management action and was contracted to implement the action in practice: distribution of the radon test, analysis of data and also the building diagnosis. • https://cpie-mayenne.org/projets/radon-laval/ [in French]	
A6	Sud Vendée Littoral (County)	• Distribution of information and organization of public meetings, setting up steering group with local representatives and authorities. • An association (member of the CPIE[C]) was contracted to implement the action: deliver and collect the radon test and perform the data analysis. • The inhabitants with the highest concentration were invited to participate to a meeting where the radon mitigation work was presented and recommendations on how to proceed were provided. • https://www.cc-sudvendeelittoral.fr/blog/actualites/respirez-vous-du-radon-dans-votre-logement-les-resultats/ [in French]	2021
B1-B7	Pays Montbéliard Agglomération (county)	• Initially (2006-2012): Distribution of information about radon and radon test kit, tailored by PMA to the inhabitants of the agglomeration. • Since 2012: constitution of steering group with PMA, the ARS, ASN and an association with an interest in air quality to develop a broader project of radiation protection culture with a multi-disciplinary approach, [6] (case study n°5). • Radon measurement campaigns implemented annually, the radon diagnoses were performed by the Cerema but due to change in the Cerema's strategy the experts could not perform on-site diagnosis and the workshop was implemented. • https://www.radon-gai-fcomte.fr/gai-radon-en-franche-comte.html [in French]	Since 2006

[A] **PIG**: Programme of public interest. The programme of public interest (PIG) and the programmed operation for the improvement of the housing (OPAH) are two national programmes providing support for the renovation of buildings in poor condition and/or inhabited by vulnerable population. Although not related to radon, PIG and OPAH can be used a mean to promote radon information and testing and a financial support could in theory be used to cover the radon mitigation costs if merged with the overall cost of the renovation.

[B]**PCAET**: Territorial Climate, Air, Energy Programme - The Territorial Climate, Air, Energy Programme (PCAET) is a mandatory planification tool for communities above a certain size which consider the reduction of the consequences of climate change, renewable energy and energy efficiency. The developers might consider integrating indoor air quality and radon in the PCAET.

[C]**CPIE**: the national union of the CPIE is an association, recognized of public utility. The association is composed with 80 local associations (in 60 departments) who are engaged in local action with individuals and organizations in favour of the ecological transition, sustainable development and the environment and have obtained the 'CPIE' label. Local CPIE/association have been involved in radon management actions because they are in contact of the public and/or have expertise in buildings thematic such as renovation, ventilation.