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Barriers to climate change and health research in India: A qualitative study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2023-073381
Article Type:	Original research
Date Submitted by the Author:	07-Mar-2023
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Keywords:	PUBLIC HEALTH, QUALITATIVE RESEARCH, EPIDEMIOLOGY

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1 Barriers to climate change and health research in India: A qualitative 2 study

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17 Word count: 6684

18 Keywords: Climate change; health; research barriers; environmental health; qualitative study;
19 stakeholder perspectives; India; LMIC

Abstract

Objectives: Almost a quarter of the global burden of disease and mortalities is attributable to environmental causes, the magnitude of which is projected to increase in the near future. However, in many low- and middle-income settings, there remains a large gap in the synthesis of evidence on climate-sensitive health outcomes. In India, now the world's most populous country, little remains known about the impacts of climate change on various health outcomes. The objective of this study is to understand the challenges faced in conducting climate change and health research in Puducherry, India.

Design and setting: In this study, we employed key informant interviews to understand the perceived research barriers in Puducherry. The findings were analysed using data driven qualitative thematic analysis to elaborate the major perceived barriers to conducting environmental health research.

Participants: This study was conducted amongst 16 public health professionals, including medical researchers, and professionals involved in environmental policies and planning in Puducherry.

Results: We identify three key barriers faced by public health professionals as key stakeholders, namely: (i) political and institutional barriers; (ii) education and awareness barriers; and (iii) technical research barriers. We show there is a need, from the professionals' perspective, to improve community and political awareness on climate change and health; strengthen technical research capacity and collaboration amongst researchers; and strengthen health surveillance, resource allocation and access to health data for research.

Conclusion: Evidence informed policies and interventions are a key element in the adaptation response for countries. In the context of the paucity of data on environmental health from India, despite recognised climate change related health vulnerabilities, these findings could contribute to the development and improvement of relevant interventions conducive to a strong research environment.

Strengths and limitations of this study:

- This study identifies crucial challenges faced in conducting environmental health research by public health professionals. This is the first study of its kind from this region in India.
- The findings can be used to further elaborate and address these challenges, in order to further motivate the professionals, strengthen the environmental health research capacity and improve understanding of health vulnerabilities and risks attributed to climate change in India.
- The sample was restricted to Puducherry district and not representative of the entire Union Territory of Puducherry, much less India as a whole. The results might thus only reflect the studied context and participants.
- The sample is also restricted to the opinions of a selected group of experts and we could not include the experiences and perspectives of other public health professionals or stakeholders.

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4 75 • Our sample size was also limited by the ongoing COVID-19 measures. Nonetheless, the
5 76 results of this study could be useful for the research community and policy makers
6 77 alike to strengthen climate change and health research and engagement.
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79 INTRODUCTION

80 An ever-growing body of research has irrefutably shown the global health impacts of climate
81 change through both direct and indirect exposure pathways [1, 2]. Multiple risk and
82 vulnerability factors determine the population resilience and adaptive capacity, from socio-
83 political, demographic and biological factors to infrastructure, urban planning, health
84 information systems and health workforce [2, 3]. Given the regional variations in climate
85 systems, the health impacts of climate change differ between and within countries and
86 communities, mediated by interconnected socio-economic and environmental determinants
87 of health [4, 5]. Non-communicable diseases (NCDs), such as respiratory diseases,
88 cardiovascular diseases (CVDs), mental health conditions, have been recognized as growing
89 climate-sensitive health outcomes, in addition to other communicable diseases like vector-
90 and water-borne diseases and malnutrition [3, 6].

91 With the rapid pace of climate change, the health impacts attributable to it are also projected
92 to increase [7]. Strengthening the adaptive capacity of countries is therefore an essential
93 component of the climate change response [8]. Timely public health interventions can do
94 much to protect population health from the potential adverse health impacts of climate
95 change [9]. Low- and middle-income countries (LMICs), such as India, remain
96 disproportionately affected by climate impacts, with a critical need to strengthen the
97 healthcare response to climate impacts [10, 11]. One of the key steps in the regional or local
98 adaptation response is assessing the true burden of the health impacts within the population
99 of that location [12]. However, owing to the complexity of the relationship between climate
100 change and health, identifying and estimating this association remains one of the biggest
101 global and environmental health challenges, especially in LMICs [11].

102 In India, the existing health and social disparities within the population make it one of the
103 most vulnerable to climate change impacts, compounded by climatic diversity [13-16]. There
104 have been recent efforts from the Government of India to focus on climate change and health,
105 as evinced by the recent addition of a health mission to the National Action Plan on Climate
106 Change (NAPCC). This led to the formulation of the National Action Plan on Climate Change
107 and Human Health (NAPCCHH) and the drive for State Action Plans for Climate Change and
108 Human Health (SAPCCHH) [17, 18]. While the government recognizes in those official
109 document several diseases as climate-sensitive, public health engagement, action and
110 research on health impacts of climate change have been curiously limited in India, especially
111 in light of the magnitude of climate impacts to which it is vulnerable [19, 20].

112 Medical and public health professionals play an important role in researching, managing and
113 responding to climate change impacts on health. Along with being considered credible
114 sources of information, these groups of professionals also have the capacity for scientific

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3 115 inquiries into the climate change attributable impacts of health [21-24]. Globally, there is an
4 116 acknowledged need to train the health workforce to engage on, study and manage health
5 117 impacts of climate change. As there are currently gaps in this domain, it is therefore
6 118 particularly important to understand how this group perceive the needs and the barriers for
7 119 their appropriate level of engagement and action any perceived research needs and barriers
8 120 identified by this group [25, 26].

12 121 The aim of this study is to understand some of the contextual barriers to environmental health
13 122 action-research amongst two relevant professional groups in Puducherry, India. We focused
14 123 our study on: (i) medical professionals, both in active research and practicing; and (ii)
15 124 members of the Department of Science, Technology and Environment working on climate
16 125 change in Puducherry. As this study is a part of a larger project on CVDs and climate change
17 126 in India, we also highlighted the CVD specific challenges and barriers to conducting research.
18 127 As the focus of our paper is to understand challenges, research enablers have not been
19 128 highlighted.

23 129 **METHODS**

24 130 **Study setting**

25 131 This study employed key informant interviews following a semi-structured interview guide.
26 132 The methods have been described in detail elsewhere [27]. Briefly, the focus of our study was
27 133 Puducherry district, which lies on the south-eastern coast of India, with a population of
28 134 950,289, as per the Government of India 2011 Census [28]. Puducherry has one main State
29 135 government run tertiary care hospital and medical college, several private clinics and primary
30 136 care health centres. It is also home to the Central Government Jawaharlal Institute of
31 137 Postgraduate Medical Education and Research (JIPMER), an 'Institute of National Importance'
32 138 and tertiary care referral hospital. Within the Department of Science, Technology and
33 139 Environment (DSTE), there also exists a specialized Puducherry Climate Change Cell with the
34 140 aim to integrate knowledge about climate change and facilitate the NAPCC implementation,
35 141 including the state specific Action Plan [29].

42 142 **Data collection and analysis**

43 143 A total of 16 semi-structured interviews were conducted between January 2022 and March
44 144 2022 in Puducherry and virtually over Zoom for two participants. Using purposive sampling
45 145 based on prior connections followed by snowball sampling, we invited medical professionals
46 146 (research or practicing) and DSTE staff working on the Puducherry State Action Plan for
47 147 Climate Change (hereon referred to as environmentalists). Interviews continued until
48 148 information saturation was reached in the interviews or we had interviewed all the relevant
49 149 target participants, as in the case of the DSTE staff. Practicalities such as participant schedules
50 150 and ongoing COVID-19 restrictions also influenced our informant recruitment. The full
51 151 interview guide and framework with the main categories has been given in the
52 152 Supplementary material Table S1.

53 153 There was an equal balance between research-engaged professionals from the medical and
54 154 environmental field combined and practicing doctors. Eleven of the participants had a medical

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3 155 background and were actively engaged as practicing doctors or researchers. Within the
4 156 doctors, we mainly targeted cardiologists, emergency medicine or general medicine
5 157 physicians who were involved in areas relevant to our study. The majority of the participants
6 158 was male, with only three females, out of which only one had a medical background. The
7 159 participant profile is presented in the Supplementary material Table S2 and further described
8 160 in [27].

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12 161 The interviews lasted between 15 to 50 minutes and were audio recorded with informed
13 162 consent using a simple voice recorder with field notes taken to optimize the interview guide
14 163 and note key topics to minimize bias by S.S. We used an *a priori* developed interview guide
15 164 with broad and open-ended questions to allow participants to freely bring up and discuss
16 165 relevant topics. All interview recordings were assigned a number prior to transcription to
17 166 ensure anonymity throughout the analysis process. Verbatim transcription and analysis was
18 167 done using the MaxQDA software by S.S.

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23 168 For the analysis, we followed a combination of deductive and inductive thematic analysis was
24 169 used as described by Gale et al [30]. Broad themes were developed based on the aim,
25 170 framework and interview guide. During analysis, major themes were inductively developed
26 171 for emerging topics, which we then clearly defined. After familiarization with the transcripts,
27 172 an initial codebook was developed from coding the three interviews with the richest data; the
28 173 remaining interviews were indexed and coded further. The codes were classified into
29 174 categories, sub-themes and themes. The final analytical matrix included three themes. S.S.
30 175 and T.L. independently validated the codebook and agreed on the final framework matrix
31 176 that considered all relevant codes. The matrix was then used to chart relevant quotes
32 177 supporting our findings and draw comparisons between participants.

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37 178 The conceptual framework for climate change risk perceptions developed by van Eck *et al*
38 179 [31] and the framework for health inequalities proposed by Rudolph *et al* [32] were used as a
39 180 base for our analytical framework, shown in Figure 1. While there are three major themes,
40 181 this paper focuses only on the theme of 'Institutional determinants'. The findings from the
41 182 two other themes have been elaborated elsewhere. Within the context of this paper,
42 183 'institution' is used as a broad term covering all governmental structures including policy,
43 184 education, and occupation. We identify how these determinants can be perceived as barriers
44 185 to environmental health research. The framework matrix with relevant themes and categories
45 186 has been provided in Supplementary material table S3. Additional supporting quotes have
46 187 also been provided in the Supplementary material.

47 188 **Ethical consideration**

48 189 There was no prior relationship between the researcher and participant. Before the interview,
49 190 the researcher went over the informed consent form, which was then signed by both parties.
50 191 The participants were aware of their right to withdraw from the study at any time, and they
51 192 were provided the contact details of all the researchers involved in the project. All interviews
52 193 were carried out by S.S with R.L being present as a passive observer for three interviews.

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3 194 Additionally, all the quotes presented in this analysis have been assigned only by serial
4 195 number to ensure anonymity.

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7 196 This study was approved by the Institute Ethics Committee (Human Studies) of the Indira
8 197 Gandhi Medical College and Research Institute (A Govt. of Puducherry Institution); No.
9 198 318/IEC-31/IGM&RI/PP/2021 and by the Ethics Committee Northwest and Central
11 199 Switzerland (EKNZ); Statement ID- AO_2020_00034. The methodology used in this project
12 200 abided by the principles laid out in the Declaration of Helsinki and the COREQ checklist.

14 201 Patient and public involvement

15 202 As we employed a combination of purposive and snowball sampling, some participants were
16 203 involved in helping us identify suitable participants to interview. Beyond that, no members of
17 204 the public were involved in the design, conduct, reporting or dissemination plan of our
18 205 research.

21 206

23 207 RESULTS

24 208 We first lay out the knowledge participants had regarding the institutional framework,
25 209 including policies, for climate change and health followed by perceived institutional barriers
26 210 to research, namely political, educational and technical barriers. As this study is part of a
27 211 larger study examining climate change impacts on CVDs, we also chose to highlight CVD
28 212 specific barriers.

32 213 Institutional determinants: knowledge and perceptions

33 214 *Limited knowledge and awareness on climate change and health related policies*

34 215 We found limited awareness among the participants about climate change and health related
35 216 policies, such as the NAPCC, NAPCCHH and SAPCCHH. Aside from the environmentalists, who
36 217 worked on it, only three medical professionals who worked on one of the Action Plans were
37 218 aware of it. Four participants expressed belief about the non-inclusion of climate change in
38 219 disease specific policies and the lack of integrated climate change and health policies and
39 220 guidelines.

41 221 *“Our country has different policy, environmental policy, health policy. But I have doubt
42 222 whether health policy has any component of climate change. So, it needs to be incorporated
43 223 in a health policy of national importance as well as the state, but currently, this element is not
44 224 in place, that is my feeling.” #8, Environmentalist.*

45 225 One of the environmentalist also mentioned challenges faced by the government in
46 226 integrating climate change in development plans. The emphasis on socio-economic
47 227 development was made apparent, which was countered by ongoing efforts to include climate
48 228 change adaptation as co-benefits of development.

49 229 *“The challenge is that the government sectoral officers are not aware of how the climate
50 230 adaptations need to be integrated into their developmental plans. Because they, whenever
51 231 they plan for a project, they plan it from the socio economic development perspective.” #7,
52 232 Environmentalist.*

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3 233 Health system vulnerabilities due to climate change in Puducherry were considered a growing
4 234 challenge and highlighted by multiple doctors. Most participants expressed limited
5 235 knowledge about climate change and health and agreed on the importance of education as
6 236 the first step to increase awareness and research capacity. Several participants, especially in
7 237 those working in hospitals, displayed support to reform existing guidelines to reflect health
8 238 risks from climate change, conditional to more contextual research to inform these changes.

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11 239 *“This climate and health is a very good topic. To be frank, we don't have much knowledge*
12 240 *about climate and health. ... After knowing all these things, after getting an idea what to*
13 241 *happen, we should have a plan, national policy or something, we should make a national*
14 242 *policy so that the government can do whatever needed during the season. So I think this will*
15 243 *be the first step.” #13, Practicing physician.*

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19 244 In addition, we found varying knowledge among participants about the health impacts of
20 245 climate change. Vector borne diseases were most commonly associated with climate-
21 246 sensitivity while other diseases like NCDs or CVDs were perceived to be primarily lifestyle
22 247 related. When it came to research, very few participants mentioned having been part of
23 248 environmental health studies or knowing about current research. The need for regional
24 249 research for knowledge synthesis on health risks from climate change was expressed
25 250 throughout the interviews.

26 251 Political and institutional barriers

27 252 *Disengaged leadership and low political prioritization of climate change and health*

28
29 253 Political leadership that did not consider health impacts of climate change as a pressing
30 254 matter was perceived as one of the barriers to conducting research on the topic. Rather than
31 255 viewed as a cause for immediate concern, several participants mentioned how climate change
32 256 was rather seen as future concern by policy makers as well as the general public. Given the
33 257 perceived little awareness on health impacts, a few participants also mentioned the slim
34 258 likelihood of decision makers actually being aware of it. One participant described the issue
35 259 as being *“not mainstream enough”* to warrant focused work, contributing to the perceived
36 260 low priority assigned to environmental health research.

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40 261 Many participants felt that the governmental focus was inclined towards non-health impacts
41 262 of climate change. The most pressing climate change impacts, which also influence research
42 263 focus, were thought to be pollution, coastal sensitivity and natural resource depletion and
43 264 degradation, especially in the context of Puducherry as a coastal region. Additionally, existing
44 265 sectoral programs already running were seen as a hindrance to focusing on climate change
45 266 related programs by one participant.

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49 267 *“The problem is everybody has to understand at the level of the minister or the secretaries.*
50 268 *They have to come forward...because so many programs are there. Not only about climate*
51 269 *change, other programs are there so they do not focus much on (climate change) programs...*
52 270 *Actually, what I have seen for the past 2-3 years, they don't care much about climate.”#1,*
53 271 *Practicing physician/policy advisor.*

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3 272 The challenges India faces from other vulnerabilities were perceived to outrank climate risks
4 273 to health, including unmet nutritional and economic needs. Despite climate change being
5 274 recognized as a health risk factor, there was a clear disconnect between on-paper
6 275 government plans and practice when it came to environmental health research.

9 276 *"I'm an adviser to government of India on health related research. But we did discuss a lot of*
11 277 *things but we did also touch upon climate-effects of climate on health...That was considered*
12 278 *as an important topic, but we didn't dwell much upon how to take it forward because there*
14 279 *are more pressing problems."* #15, Practicing physician/academic.

16 280 *Weak inter-departmental integration and co-ordination for climate change and health*

17 281 The compartmentalization of topics within institutes or sectors was seen as a barrier to
18 282 conducting inter-disciplinary research by the participants. One participant discussed the
19 283 newly formed Puducherry Climate Change and Health Action Plan (2022), with the aim to
21 284 bring together a multi- sectoral team under the leadership of the health ministry, to focus on
22 285 health impacts of climate change.

24 286 However, apart from one participant, most others voiced a perceived need for an
25 287 independent, coordinating body focused on environmental health, incorporating a research
26 288 agenda. Partially, this was due to climate change being thought of an added responsibility for
27 289 health professionals and vice versa for environmentalists, especially for those working in the
28 290 government. As highlighted by a few participants, officials were likely to prioritize their
29 291 primary work profile over the added responsibility of climate change and health research.

32 292 *"Especially government departments, they are loaded with a lot of work. Today, an officer*
34 293 *comes in, he has to do his own work, not the work that other departments asks us to do..."* #9,
35 294 Environmentalist.

37 295
38 296 Several participants mentioned the Puducherry Climate Change cell created in response to
39 297 address climate change impacts. However, despite that, one medical researcher mentioned
41 298 the current difficulties in identifying the focal point of contact for climate change and health.
42 299 Another concern in the existing scenario was inter-sectoral, collaborative research being
43 300 dependant on higher officials being receptive to their employees researching a topic not
44 301 entirely within the scope of their respective department. This was also viewed from the sense
45 302 of improving coordination between the sectors, with a dedicated head of climate change and
46 303 health, supported by relevant sectorial bodies.

50 304 *"Intersectoral body and there should be one decision maker. So now, everybody is like they*
51 305 *are the leader in the particular sector, but if they need the support from other one, that*
52 306 *coordination may be lacking...There won't be any one dedicated person for the climate*
53 307 *change. So they will be in charge of multiple departments. For example, somebody's going to*
54 308 *be in charge of immunization or the child health. So the priority will be child health obviously."*
55 309 #3, Medical doctor/academic.

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3 310 Educational and informational barriers

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5 311 *Gaps in climate change and health in higher education curricula*

6 312 One of the strongest emergent themes was the need for environmental health education,
7 313 either by incorporating climate change in the health curriculum or health impacts of climate
8 314 change in the environmental curriculum in universities and schools. The prevalent feeling was
9 315 the source of climate change and health literacy needs to be from multiple sources, with
10 316 formal education being the most important one. Most participants also felt that at present
11 317 there was a disconnect between environmental and health education, as a result of which
12 318 there was a relatively low level of awareness on climate change impacts on health.

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16 319 *“Education system need to be addressed from beginning...Even the medical college students*
17 320 *who are completing five years courses, I do not see any syllabus which contains impact on*
18 321 *health by the climate change even though it is very important...my son is studying medical-*
19 322 *medicine, but I guess I just go through the syllabus, but nothing is there.” #8, Environmentalist.*

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23 323 All the environmentalists professed to never having specifically studied health impacts of
24 324 climate change during the course of their education. On the other hand, the health
25 325 professionals expressed incongruent views on climate change-health education. While one
26 326 said:

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29 327 *“Climate sensitive diseases, this is a part of the curriculum, we are seeing lot of diseases. And*
30 328 *the epidemiology portion they will tell this is exacerbated during this season, this is*
31 329 *exacerbated during this climate. That will be there in our curriculum.” #12, Practicing*
32 330 *physician.*

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35 331 Another said,

36
37 332 *“No. So diseases we have been trained, but we have not been taught that this is so much*
38 333 *related to the climate change. Once we completed our MBBS or MD, or during your MD we*
39 334 *may have read it, but as a separate training or as a separate chapter, 'these are the climate*
40 335 *sensitive diseases' or separate training for a week or a module, that is not part of the core*
41 336 *curriculum.” #3, Medical doctor/academic.*

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45 337 Continuing education courses specific for health impacts of climate change were suggested
46 338 by a few participants as potential options to bridge the gap between the environment and
47 339 health. Two participants also suggested including short courses on this topic for all people
48 340 working on topics related to climate change, health, adaptation and resilience.

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51 341 *Weakness in inter-sectoral information dissemination*

52 342 Many of the participants mentioned having little to no awareness on climate change-health
53 343 related research unless actively searching for it, pointing to the scope for improving related
54 344 education and science dissemination, especially among the scientific community. Some
55 345 participants were also of the opinion that awareness on health impacts of climate change in
56 346 general was lacking, especially among medical professionals. Environmental risk factors were

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3 347 not commonly associated with health inherently, partially attributed the low scientific
4 348 exposure on the topic.

5 349
6 350 *“And among doctors itself, there is not much awareness actually. How it's going to affect,*
7 351 *because now people are only focusing on environment change and other things actually. How*
8 352 *we decide an impact on health, we use a lot of data. (Data) has to be there, it needs to be*
9 353 *published.” #6, Practicing physician.*

10 354
11 355 CVDs were seen as a ‘silent’ disease, with many people are not trained to look for symptoms,
12 356 much less correlate them to weather conditions, all suggesting the need for improved CVD
13 357 literacy and awareness on the topic. On the other hand, many participants were open to
14 358 changing their current schools of thought on risk factors for health to include climate change,
15 359 conditional to being informed by global research on the topic.

16 360
17 361 *“If the research or it's already proven in other countries, 'so this is a risk factor it is a good idea*
18 362 *to add' but [before adding anything], I think some data or there should be some routine*
19 363 *surveillance or monitoring system should be there. ... even within the medical circle, people*
20 364 *may not be aware like how much is the contribution of this, the climate change to the heart*
21 365 *disease or for any disease for that case... I don't think our administrators or even our clinicians*
22 366 *are that much thinking about the impact of climate change, and this one.” #3, Medical*
23 367 *doctor/academic.*

368 *Scepticism and low awareness on non-conventional health impacts of climate change*

369 As alluded to previously, health impacts of climate change are often not explicit, making it a
370 challenge to research or focus the research agenda on for several reasons. One participant
371 described how the slow pace of climate impacts leads people to think it will not immediately
372 affect health, unless the impacts are drastic.

373 *“...The problem has to become so severe, like you have air pollution in Delhi, then people will*
374 *act. So this climate change affects the life slowly it's not a drastic...that is one of the reasons I*
375 *feel. And slowly if you get some data and keep on generating awareness not only among the*
376 *public, but also within the scientific community, then slowly things will be better.”#3, Medical*
377 *doctor/academic.*

378
379 For researchers, an additional challenge of convincing funders or collaborators on the health
380 impacts of climate change also emerged. One participant described the difficulty researchers
381 had separating environmental risks from other common health risk factors. Scepticism when
382 attempting to research health impacts of climate change was also encountered. Confounding
383 from other risk factors and potential ecological bias was seen as the roots of this uncertainty.

384 *“Maybe for six, seven years, I have been trying to do some work on climate change and*
385 *environmental health. Every time I write a proposal I'm criticized largely telling that "how is it*
386 *going to work?... And one other problem I see with the research with climate change or any*

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3 387 *environmental thing, it's ecological effects. So people ask "how can you attribute this to only*
4 388 *this, why not to this?", " Why not to lifestyle, why only to climate change?" So this direct*
5 389 *relationship is not there." #4, Medical doctor/ academic.*
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8 390 Diseases such as malaria, with historical links to stagnant water as breeding grounds, have
9 391 been etched into public knowledge and further perpetrated through mass awareness
10 392 campaigns, intervention programs and research. The slow developing nature of CVDs and the
11 393 prevalent categorization of CVDs as solely lifestyle diseases was mentioned by many
12 394 participants as potential barriers to research. The multifactorial nature of CVDs was thought
13 395 to add to the difficulty of identifying climate attributable impacts, with most of the focus
14 396 being on evident lifestyle contributions.
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19 398 *"Non-communicable diseases, because we are not quantifying that and because of the long*
20 399 *latent period of the incident, you're not able to quantify directly to environment or climate*
21 400 *change. So definitely, hypertension, cardiovascular disease, all these probably diabetes also*
22 401 *because of the changing food pattern, but I don't think -you cannot separate climate change*
23 402 *from any of the health effects or any of the non-communicable diseases. Also related to stress*
24 403 *caused by climate change." #2, Medical doctor/ academic.*
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28 404
29 405 Another participant described how clinicians especially do not see the need to focus on
30 406 environmental risk factors for CVDs, believing it ineffective in reducing the overall burden.
31 407 One participant described how CVDs are commonly reduced to lifestyle diseases with the
32 408 onus of risk management on the individual rather than a *"willingness to see the invisible*
33 409 *factors"*. A few participants expressed belief and hope that the temperature-CVD association
34 410 was an upcoming topic of interest for the government and public both.
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39 412 *"I'm just giving my opinion. See, this heart attack and cardiovascular diseases, whatever is a*
40 413 *well-known thing, even a common person knows that, but this climate change aspect of it,*
41 414 *even the officials or the administrators wouldn't know because-so, there comes the gap...So,*
42 415 *maybe in another five years, people would really relate these two." #9, Environmentalist.*
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45 416 The need for regional studies was also stressed upon as there seemed likely to be a disconnect
46 417 in comparing national or global level problems with health impacts of climate change on a
47 418 local level. Participants described the attitude of *"this does not affect us"* among the public
48 419 when it came to climate change especially.
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52 421 **Technical barriers to research**

53 422 *Insufficient resources and workforce dedicated to research*

54 423 Resource allocation, especially financial, for climate change-health research was described as
55 424 a barrier. Along with inconsistent funding from the government, one of the problems
56 425 mentioned was lack of adequate trained personnel. This was partially linked to the need to
57 426 relieve the research expectations from already over-burdened doctors. There was also a need
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3 427 to have trained personnel for digitalization and categorization of health data in order to
4 428 create a digital state-level health database.

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7 429 *“The UT of Puducherry, we do not have much data. So we need to focus and we need*
8 430 *manpower. We do not have the funding also it’s a problem now. Sometimes they provide*
9 431 *funds; sometimes they do not give that adequate funds.” #1, Practicing physician/policy*
11 432 *advisor.*

13 433 Some participants, referred to the low percentage of the annual budget of India allocated to
14 434 health along with the need to increase this. One participant described funds earmarked for
15 435 climate change-health research institutionally, along with optimism that this would lead to
17 436 future research opportunities.

19 437 *“Yes, for recent years even ICMR (Indian Council of Medical Research) has called for proposals*
20 438 *on this environment related, uh, this one. ICMR is one of the largest body which is for the*
22 439 *research organization as well as for the academic institutes like us. So, clearly, they are given*
23 440 *a separate block of funding for climate change and this one. That means the funds are*
25 441 *available.”#3, Medical doctor/academic.*

27 442 However, this was countered by the notion that most of the funds are directed to Central
28 443 government institutes as opposed to smaller research institutes. A participant also alluded to
29 444 misappropriation of research funding at an institutional level. Another participant spoke
31 445 about the need to involve university students in research along with concern that most
32 446 students do not get access to funding or research opportunities. There was a feeling that most
34 447 students remain unaware of opportunities for funding or that funds do not ultimately reach
35 448 the students aiming to conduct research. Another participant also described the prioritization
37 449 of more immediate health burdens and curative research as opposed to preventative
38 450 research for the directing of funds or resources. This was supported by the opinion expressed
39 451 by an environmentalist on climate change being viewed as a problem for the future as
41 452 opposed to the present.

43 453 *“So though we focus on vaccination and other things, but still, the budget still flows more for*
44 454 *the curative aspects rather than the preventive part. So for instance, the climate change is*
46 455 *more of like, you prevent this- the future heart attacks or some other diseases. You have to*
47 456 *focus on the prevention.” #3, Medical doctor/academic.*

49 457 *Underdeveloped transdisciplinary research capacity*

50 458 Alongside education, the need to build more technical capacity among researchers was also
51 459 mentioned as one of the biggest challenges by participants. Despite a potential interest and
53 460 willingness from researchers, the lack of training and expertise in climate change-health
55 461 research was strongly expressed. This was tied in with the expressed desire for mentorship,
56 462 both to facilitate increased awareness among the scientific and medical community as well as
57 463 increased regional research on health impacts of climate change.

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3 464 *"Yeah, more than research, I would tell it as people are aware and willing to do it, but here is*
4 *more of capacity building...Let's say if I want to work on vector borne disease, I know who to*
5 465 *approach...but when it comes to climate change, that linking is absent. ...So actually, even if*
6 466 *I'm interested and I want to work on it, there are a lot of hurdles which has to be crossed...So*
7 467 *I have to be given an opportunity to work on it, or I feel somebody has to mentor me to work*
8 468 *on it. So what we call as, starting trouble, you know is there. Once I think somebody starts, we*
9 469 *will be going into it..." #4, Medical doctor/ academic.*
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14 471 Some participants had the belief that larger research institutes or relevant ministries could be
15 472 drafted to provide training to the smaller educational institutes or local government bodies.
16 473 There was a sense of "duty" attached to studying all aspects of climate change impacts for
17 474 the environmentalists in Puducherry tied in with a search for a starting point.

475 *Research slowed by unavailability and limited access to quality data*

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21 476 Participants described critical gaps in monitoring, surveillance and database development, all
22 477 of which were perceived to hamper research conduction, especially for health data. First,
23 478 merging health data from the many healthcare facilities within Puducherry was seen as a
24 479 challenge. There was an expressed need to bring together health data for the entire UT in a
25 480 single system, including public and private healthcare facilities.

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29 481 *"Puducherry as so many medical colleges, but all of them do not supply data to the*
30 482 *government. They may have their own data. That's the problem: actually we have to integrate*
31 483 *everyone" #1, Practicing physician/policy advisor.*

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34 484 Second, some participants mentioned the state-level government health-monitoring
35 485 database. However, participants described this as being limited to selected diseases from all
36 486 the government run primary healthcare centres, with limited information on the private
37 487 sector or secondary and tertiary care hospitals. A few participants described the lack of
38 488 disease-specific categorization of health outcomes, making it an added challenge in
39 489 conducting health related research.

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44 491 *"Cases are reported but not categorized into these sectors...And as you said, this co- morbid*
45 492 *or cardiovascular, those kind of things we do not have any data... They have a very*
46 493 *comprehensive data. They put all the data together, (but) they don't categorize it. Maybe now*
47 494 *if we are very much interested in those data, we can go, collect all their data and categories*
48 495 *for our use...They don't have a ready data." #9, Environmentalist.*

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52 497 Third, participants also perceived private medical colleges and healthcare facilities as
53 498 reluctant to share data with the government, with a felt need to enhance governmental
54 499 efforts to work on the state wide database. Fourth, on a related note, concerns about data
55 500 quality were mentioned by several participants. Part of the reason for an unwillingness to
56 501 share data by healthcare facilities was thought to be due to potentially inaccurate or poor
57 502 quality data.

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5 504 *“They're all afraid of like somebody will find a fault with that. So because they don't have*
6 505 *manpower to look at the accurate or clean the data, okay, so somebody shares and later they*
7 506 *find their mistake, and they will be answerable to the higher authority. So that's the usual*
8 507 *reason we do not to share the data, the insecurity.” #3, Medical doctor/academic.*

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11 509 Another challenge shared was the slow, ongoing effort to digitalize the data. Participants
12 510 described as feeling unmotivated to start research at the cost of manually sorting through
13 511 thousands of paper records, unless there was a way to guarantee research output. This was
14 512 also relate to a challenge of medical professionals being overburdened with work.

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17 513 *“There is not even a digitalization...Many hospital doesn't have digitalized MRD [medical*
18 514 *records department]. For example, I was doing a study, retrospective study, collecting infective*
19 515 *endocarditis data for past 10 years, there are more than 1000 files. How can I go through the*
20 516 *1000 files? It's not possible.” #13, Practicing physician.*

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24 517 Surveillance of diseases was mentioned as ongoing work. Diabetes, hypertension, cervical
25 518 cancer and other ‘notifiable’ diseases like infectious diseases were described as being under
26 519 surveillance.

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521 **DISCUSSION**

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31 522 This research examined mainly barriers faced in conducting climate change and health
32 523 research. While we focused on Puducherry, the findings relatively remain relevant for India
33 524 and can be extrapolated to other LMIC settings [33].

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36 525 In recent years, there have been a lot of strides taken in the Indian policy space with
37 526 pertaining to climate change and health, such as the addition of the Health Pillar to the NAPCC
38 527 and the subsequent development of the NAPCCHH and mandates for the development of the
39 528 State level action plans for climate change and health [17, 18]. Although the Health Pillar is a
40 529 relatively recent addition (2015), we still found a substantial lack of awareness on the NAPCC
41 530 as well as the health mission in general, which we present as a key area for strengthening.
42 531 Knowledge of such policies, especially if they can provide a framework to support related
43 532 research, is a useful tool to advance the research agenda on climate change and health [34,
44 533 35]. Health system vulnerabilities are already being seen in Puducherry and active knowledge
45 534 of such policies can also be utilized by relevant stakeholders to develop resilience focused
46 535 interventions. This includes communicating the severity of the problem to the policy makers,
47 536 who generally lack the political will to divert resources to non-apparent problems, alluded to
48 537 by the participants in this study [36, 37].

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53 538 Most political efforts are thought to be focused on mitigation measures such as air pollution
54 539 control, with little importance given to health adaptation and healthcare resilience. The
55 540 participants believed that the health impacts of climate change were not a political priority
56 541 or seen as urgent. Similar findings have been elucidated in other studies which also found
57 542 public health leadership on climate change to be fragmented [25, 38]. Further efforts to

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3 543 inform the decision makers on the importance of health adaptation might contribute to more
4 544 evidence informed climate change and health policies [39, 40]. As an added justification for
5 545 health co-benefits of mitigation can be introduced through multiple pathways, including air
6 546 pollution, lifestyle modification, health surveillance or research programs in development or
7 547 related policies [41, 42].

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10 548 We found almost unanimous support for a separate inter-sectoral body focused specifically
11 549 on climate change and health. Methodological challenges in the light of limited technical
12 550 knowledge and adequate inter-sectorial coordination and support for transdisciplinary
13 551 capacity that we found have also been reported elsewhere [43, 44]. A recent study on the
14 552 knowledge, attitudes and practices related to climate change and health among the Indian
15 553 health workforce found intermediate or delayed health impacts of climate change less
16 554 commonly identified [26]. This could also support the development of regional, national or
17 555 even international research networks facilitating knowledge sharing and transfer, including
18 556 research methodology support [44].

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23 557 The compartmentalization of work within institutes or sectors was seen as a research barrier,
24 558 partially due to the unclear division of responsibilities and fragmented institutional focus, as
25 559 also seen in other studies [38, 44, 45]. A study examining the challenges for the Californian
26 560 public health sector in climate change found the compartmentalization and lack of inter-
27 561 sectorial coordination to limit work on inter-sectoral issues such as climate change and health
28 562 [25]. These findings point to the need to have regular national level conferences or improved
29 563 science dissemination systems to communicate climate adaptation related research or plans
30 564 between and across sectors.

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34 565 Our respondents had varied views regarding education on climate change or its health
35 566 impacts; however, the need to improve this was clearly described. The need for strengthening
36 567 capacity and education has been a common finding in several other global studies. Globally,
37 568 there is a critical gap and scope for improvement in the education on health impacts of
38 569 climate change, especially for medical practitioners [25, 46-54]. A study comparing medical
39 570 curriculums across the world found inconsistencies between environmental changes, health
40 571 and community needs, with Indian and Chinese students especially having a gap in the
41 572 inclusion of planetary health in medical schools [50]. The inclusion of planetary health from
42 573 an early stage for medical students leads to a more active role of physicians in educating their
43 574 patients about climate risks [50, 55]. However, there is a need to validate the results in future
44 575 studies given the inconsistencies in the views we found on climate change-health education.
45 576 The emphasis on cure rather than prevention, which has also been shown to reduce long term
46 577 healthcare costs, implying a need for Puducherry to focus on the preventative aspects, largely
47 578 through education and awareness [24]. As also found in our study, these health impacts are
48 579 viewed as 'invisible' compared to more conventional or immediate impacts, such as air
49 580 pollution or extreme events [56]. This is also a commonly identified challenge to climate
50 581 change and health research, accompanied by insufficient education about climate systems
51 582 during the course of school or university education [26, 56].

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58 583 Data barriers remain common challenges in public health research, despite efforts to facilitate
59 584 improvements [57, 58]. As Puducherry has the advantage of a relatively small size and well-

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3 585 connected healthcare facilities, efforts need to be taken to improve a central, disease specific
4 586 data collection system, incorporating all the healthcare facilities in the State [59]. Facilitating
5 587 training to build local data analysis expertise would contribute to more region specific
6 588 research on the topic [60]. As was also made apparent during the interviews, health impacts
7 589 of climate change are a relatively new concept and not inherently associated with climate,
8 590 potentially explaining the uncertainties and scepticism expressed, especially for diseases that
9 591 do not warrant a visit to the doctor [61, 62]. On the positive side, the expressed desire of
10 592 participants to learn more about it and make changes to the healthcare system and policies
11 593 based on robust, conclusive evidence implies a willingness to adapt and implement changes
12 594 in how the region tackles health impacts of climate change [49, 63]. Resource and funding
13 595 constraints are one of the most common barriers to public health research, especially in LMICs
14 596 and there remains a critical need to address this gap [64].

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19 597 At present, little is known on CVD impacts of climate change in India. Our related study from
20 598 Puducherry found a high attributable burden of non-optimal temperature to CVD mortality,
21 599 suggesting a need for similar studies from around the country [65, 66]. The CVD specific
22 600 challenges we identified here are comparable to the general health challenges. Awareness
23 601 among the medical community on the environmental risk factors of CVDs will be instrumental
24 602 in furthering this research agenda, while awareness among policy makers will help raise the
25 603 political prioritization of CVD impacts of climate change [24, 67, 68].

26 604 Limitations

27 605 This study had a few limitations. First, the sample was restricted to Puducherry district and
28 606 not representative of the entire Union Territory of Puducherry, much less India as a whole,
29 607 although the projected population for Puducherry is 1.25 million in 2021, comparable to a
30 608 few smaller countries or global regions [69]. The results might thus only reflect the studied
31 609 context and participants. Secondly, while we chose to focus on the medical community and
32 610 DSTE representatives working on climate change, we could not include the experiences and
33 611 perspectives of other public health professionals or stakeholders. Third, we do not highlight
34 612 the opportunities for increasing research on climate change and health as many of these are
35 613 very often interconnected with barriers. However, we do discuss potential recommendations
36 614 given by stakeholders. Finally, our sample size was also limited by the ongoing COVID-19
37 615 measures. Nonetheless, the results of this study could be useful for the research community
38 616 and policy makers alike to strengthen climate change and health research and engagement.

39 617 Conclusion

40 618 There is a great need to fill the gap in research on the impacts of climate change on various
41 619 health outcomes in India, especially in light of the vulnerabilities it faces. By highlighting some
42 620 crucial barriers to environmental health research faced by relevant professionals, we present
43 621 potential intervention points for consideration. Insufficient awareness on health impacts of
44 622 climate change and perceived need to improve research capacity through collaborative work;
45 623 and challenges in data availability emerged as the largest barriers to conducting research on
46 624 this topic in Puducherry. We outlined the gaps and scope for addressing these through
47 625 improved policy awareness; informed leadership and evidence informed climate change and
48 626 health policies; research capacity strengthening and transdisciplinary research and

627 communication network; improved education on climate change and health on all levels; and
628 addressing data barriers in climate change through improved monitoring and evaluation
629 systems. The key findings could contribute to supporting and strengthening evidence-
630 informed climate resilient healthcare systems. In addition, it would also serve to inform and
631 strengthen the research and institutional support for environmental health research in the
632 future both in India and globally.

633 **Figure legends**

634 *Figure 1: A framework for health adaptation action in the context of climate change based on*
635 *level of knowledge, perceived health risks, policy and institutional support and public*
636 *engagement. The circled part highlights the thematic areas we focus on in this work, namely*
637 *institutional determinants and its challenges.*

638 **DECLARATIONS**

639 **Competing interests**

640 The authors declare that they have no competing interests.

641 **Author contributions**

642 S.S, M.R, M.A.D, J.U and G.C conceptualized and planned the study. S.S and R.L acquired and
643 provided access to the data. R.L facilitated the interviews. S.M and S.S designed the study. T.L
644 validated the codes and codebook. O.C, S.S and S.M conceptualized and structured the
645 framework. S.S wrote the main manuscript with inputs from all authors. The final manuscript
646 has been revised by all authors.

647 **Informed consent**

648 This study was approved by the Institute Ethics Committee (Human Studies) of the Indira
649 Gandhi Medical College and Research Institute (A Government of Puducherry Institution); No.
650 318/IEC-31/IGM&RI/PP/2021 and by the Ethics Committee Northwest and Central
651 Switzerland (EKNZ); Statement ID- AO_2020_00034. The methodology used in this project
652 abided by the principles laid out in the Declaration of Helsinki and the COREQ checklist.

653 All participants were verbally explained the project and its objectives as well as being provided
654 information sheets. All participants were made aware of their right to refuse participation at
655 any point prior to publication of the study. Signed informed consent was obtained from all
656 participants prior to the interviews, with participants retaining one copy.

657 **Acknowledgements**

658 The authors would like to extend their sincere gratitude to all the participants who made this
659 study possible.

660 **Funding sources**

661 S.S has received funding from the European Union's Horizon 2020 research and innovation
662 programme under the Marie Skłodowska-Curie grant agreement No 801076, through the
663 SSPH+ Global PhD Fellowship Programme in Public Health Sciences (GlobalP3HS) of the Swiss

664 School of Public Health and from the Joint South Africa and Swiss Chair in Global
665 Environmental Health.

666 O.C has been funded by the Swiss Government Excellence Scholarship (ESKAS) Id. 2020 0742.

667 Data availability statement

668 All relevant data from this study has been included in the Supplementary material. As this is
669 a qualitative study with a small number of key informants, making the full dataset and
670 interview transcripts available to a wider audience could potentially breach the confidentiality
671 commitment made to the participants during the process of obtaining informed consent as
672 well as to the ethics committees that approved this study. Therefore, this data will not be
673 made available.

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675 References

- 676 1. Rocque, R.J., et al., *Health effects of climate change: an overview of systematic reviews*. BMJ
677 open, 2021. **11**(6): p. e046333.
- 678 2. Cissé, G., R. McLeman, H. Adams, P. Aldunce, K. Bowen, D. Campbell-Lendrum, S. Clayton,
679 K.L. Ebi, J. Hess, C. Huang, Q. Liu, G. McGregor, J. Semenza, and M.C. Tirado, *Health,
680 Wellbeing, and the Changing Structure of Communities*, in *Climate Change 2022:
681 Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth
682 Assessment Report of the Intergovernmental Panel on Climate Change* D.C.R. H-O. Pörtner,
683 M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Lösckke, V.
684 Möller, A. Okem, B. Rama, Editor. 2022, IPCC: Cambridge, UK and New York, NY, USA. p.
685 1041-1170.
- 686 3. WHO. *Climate change and health*. Fact sheets 2021; Available from:
687 <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>.
- 688 4. Patz, J.A., et al., *Impact of regional climate change on human health*. Nature, 2005.
689 **438**(7066): p. 310-7.
- 690 5. Watts, N., et al., *The 2020 report of the Lancet Countdown on health and climate change:
691 responding to converging crises*. Lancet, 2021. **397**(10269): p. 129-170.
- 692 6. Cisse, G., *Food-borne and water-borne diseases under climate change in low- and middle-
693 income countries: Further efforts needed for reducing environmental health exposure risks*.
694 Acta Trop, 2019. **194**: p. 181-188.
- 695 7. Rocha, J., et al., *Climate change and its impacts on health, environment and economy*, in *One
696 Health*. 2022, Elsevier. p. 253-279.
- 697 8. Wise, R.M., et al., *Reconceptualising adaptation to climate change as part of pathways of
698 change and response*. Global environmental change, 2014. **28**: p. 325-336.
- 699 9. Haines, A., et al., *Health risks of climate change: act now or pay later*. Lancet, 2014.
700 **384**(9948): p. 1073-5.
- 701 10. Kjellstrom, T., *Climate change, direct heat exposure, health and well-being in low and
702 middle-income countries*. Glob Health Action, 2009. **2**.
- 703 11. Scheelbeek, P.F.D., et al., *The effects on public health of climate change adaptation
704 responses: a systematic review of evidence from low- and middle-income countries*. Environ
705 Res Lett, 2021. **16**(7): p. 073001.
- 706 12. Ebi, K.L., R.S. Kovats, and B. Menne, *An approach for assessing human health vulnerability
707 and public health interventions to adapt to climate change*. Environmental health
708 perspectives, 2006. **114**(12): p. 1930-1934.

- 1
2
3 709 13. Gioli, G., T. Khan, and J. Scheffran, *Climatic and environmental change in the Karakoram: making sense of community perceptions and adaptation strategies*. Regional Environmental Change, 2014. **14**(3): p. 1151-1162.
- 4 710
5 711
6 712 14. Tripathi, V., R. Akhtar, and G.S. Preetha, *Perceptions Regarding Climate Change and its Health Impact: Reflections from a Community-Based Study in India*. Indian Journal of Community Medicine, 2021. **46**(2): p. 206-209.
- 7 713
8 714
9 715 15. Nayak, S., Takemi, T, *Assessing the Impact of Climate Change on Temperature and Precipitation Over India.*, in *Wadi Flash Floods. Natural Disaster Science and Mitigation Engineering: DPRI reports.*, T. Sumi, Kantoush, S.A., Saber, M. , Editor. 2022: Singapore.
- 10 716
11 717
12 718 16. Dagdeviren, H., A. Elangovan, and R. Parimalavalli, *Climate change, monsoon failures and inequality of impacts in South India*. Journal of Environmental Management, 2021. **299**.
- 13 719
14 720 17. GOI, *National Action Plan for Climate Change and Human Health*, G.o.I. Ministry of Health and Family Welfare, Editor. 2018.
- 15 721
16 722 18. GOI, G.o.I., *India's National Action Plan on Climate Change*. 2009.
- 17 723 19. Bush, K.F., et al., *Impacts of climate change on public health in India: future research directions*. Environmental Health Perspectives, 2011. **119**(6): p. 765-770.
- 18 724
19 725 20. Singh, P.K. and R.C. Dhiman, *Climate change and human health: Indian context*. Journal of vector borne diseases, 2012. **49**(2): p. 55.
- 20 726
21 727 21. Gill, M. and R. Stott, *Health professionals must act to tackle climate change*. Lancet, 2009. **374**(9706): p. 1953-1955.
- 22 728
23 729 22. Roberts, I., R. Stott, and C.H. Council, *Doctors and climate change*. British Medical Journal, 2010. **341**.
- 24 730
25 731 23. Moser, A.M., F.L. Stigler, and B. Haditsch, *Physicians' responsibility for planetary health*. Lancet Planetary Health, 2017. **1**(2): p. E56-E56.
- 26 732
27 733 24. Sainsbury, P., et al., *Climate change is a health issue: what can doctors do?* Internal Medicine Journal, 2019. **49**(8): p. 1044-1048.
- 28 734
29 735 25. Gould, S. and L. Rudolph, *Challenges and Opportunities for Advancing Work on Climate Change and Public Health*. Int J Environ Res Public Health, 2015. **12**(12): p. 15649-72.
- 30 736
31 737 26. Vishvaja Sambath, S.N., Punita Kumar, Pooja Kumar, Adithya Pradyumna, *Knowledge, attitudes and practices related to climate change and its health aspects among the healthcare workforce in India – A cross-sectional study*. The Journal of Climate Change and Health, 2022. **6**.
- 32 738
33 739
34 740 27. Shrikhande, S.S., et al., *Climate change and health?: Knowledge and perceptions among key stakeholders in Puducherry, India*. medRxiv, 2023: p. 2023.01.17.23284663.
- 35 741
36 742 28. GOI, *Census of India- Puducherry*. 2011, Government of India.
- 37 743
38 744 29. DTEE. *Puducherry Climate Change Cell*. Available from: https://dste.py.gov.in/PCCC/PCCC_Projects.html.
- 39 745
40 746 30. Gale, N.K., et al., *Using the framework method for the analysis of qualitative data in multi-disciplinary health research*. BMC Medical Research Methodology, 2013. **13**.
- 41 747
42 748 31. van Eck, C.W., B.C. Mulder, and S. van der Linden, *Climate Change Risk Perceptions of Audiences in the Climate Change Blogosphere*. Sustainability, 2020. **12**(19).
- 43 749
44 750 32. Rudolph, L. and S. Gould, *Climate Change and Health Inequities: A Framework for Action*. Ann Glob Health, 2015. **81**(3): p. 432-44.
- 45 751
46 752 33. Mallen, E., et al., *Overcoming Barriers to Successful Climate and Health Adaptation Practice: Notes from the Field*. International Journal of Environmental Research and Public Health, 2022. **19**(12): p. 7169.
- 47 753
48 754 34. Crouzat, E., et al., *Researchers must be aware of their roles at the interface of ecosystem services science and policy*. Ambio, 2018. **47**(1): p. 97-105.
- 49 755
50 756 35. van Valkengoed, A.M., G. Perlaviciute, and L. Steg, *Relationships between climate change perceptions and climate adaptation actions: policy support, information seeking, and behaviour*. Climatic Change, 2022. **171**(1-2).
- 51 757
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41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 760 36. Hussey, L.K. and G. Arku, *Conceptualizations of climate-related health risks among health*
761 *experts and the public in Ghana*. *Social Science & Medicine*, 2019. **223**: p. 40-50.
- 762 37. Austin, S.E., et al., *Enabling local public health adaptation to climate change*. *Social Science*
763 *& Medicine*, 2019. **220**: p. 236-244.
- 764 38. Robbert Biesbroek, J.K., Catrien Termeer, and Pavel Kabat, *Barriers to climate change*
765 *adaptation in the Netherlands*. *Climate Law*, 2011. **2**(2): p. 181-199.
- 766 39. Oxman, A.D., et al., *SUPPORT Tools for evidence-informed health Policymaking (STP) 15:*
767 *Engaging the public in evidence-informed policymaking*. *Health research policy and systems*,
768 2009. **7**(1): p. 1-9.
- 769 40. Uzochukwu, B., et al., *The challenge of bridging the gap between researchers and policy*
770 *makers: experiences of a Health Policy Research Group in engaging policy makers to support*
771 *evidence informed policy making in Nigeria*. *Globalization and health*, 2016. **12**(1): p. 1-15.
- 772 41. Haines, A., *Health co-benefits of climate action*. *Lancet Planet Health*, 2017. **1**(1): p. e4-e5.
- 773 42. Haines, A., et al., *Public health benefits of strategies to reduce greenhouse-gas emissions:*
774 *overview and implications for policy makers*. *Lancet*, 2009. **374**(9707): p. 2104-2114.
- 775 43. Xun, W.W., et al., *Climate change epidemiology: methodological challenges*. *International*
776 *Journal of Public Health*, 2010. **55**(2): p. 85-96.
- 777 44. Leal Filho, W., et al., *Implementing climate change research at universities: Barriers,*
778 *potential and actions*. *Journal of Cleaner Production*, 2018. **170**: p. 269-277.
- 779 45. Eisenack, K., et al., *Explaining and overcoming barriers to climate change adaptation*. *Nature*
780 *Climate Change*, 2014. **4**(10): p. 867-872.
- 781 46. Yang, L., et al., *Associations between Knowledge of the Causes and Perceived Impacts of*
782 *Climate Change: A Cross-Sectional Survey of Medical, Public Health and Nursing Students in*
783 *Universities in China*. *Int J Environ Res Public Health*, 2018. **15**(12).
- 784 47. Hathaway, J. and E.W. Maibach, *Health Implications of Climate Change: a Review of the*
785 *Literature About the Perception of the Public and Health Professionals*. *Curr Environ Health*
786 *Rep*, 2018. **5**(1): p. 197-204.
- 787 48. Kotcher, J., et al., *Views of health professionals on climate change and health: a*
788 *multinational survey study*. *Lancet Planet Health*, 2021. **5**(5): p. e316-e323.
- 789 49. Corner, A., *PSYCHOLOGY Science literacy and climate views*. *Nature Climate Change*, 2012.
790 **2**(10): p. 710-711.
- 791 50. Omrani, O.E., et al., *Envisioning planetary health in every medical curriculum: An*
792 *international medical student organization's perspective*. *Med Teach*, 2020. **42**(10): p. 1107-
793 1111.
- 794 51. Whitley, C.T., et al., *Sustainability behaviors among college students: an application of the*
795 *VBN theory*. *Environmental Education Research*, 2018. **24**(2): p. 245-262.
- 796 52. Chaplin, G. and P. Wyton, *Student engagement with sustainability: understanding the value-*
797 *action gap*. *International Journal of Sustainability in Higher Education*, 2014. **15**(4): p. 404-
798 417.
- 799 53. Andersen, J.G., et al., *Perspectives of Local Community Leaders, Health Care Workers,*
800 *Volunteers, Policy Makers and Academia on Climate Change Related Health Risks in Mukuru*
801 *Informal Settlement in Nairobi, Kenya-A Qualitative Study*. *International Journal of*
802 *Environmental Research and Public Health*, 2021. **18**(22).
- 803 54. Eagle, L., et al., *Attitudes of undergraduate business students toward sustainability issues*.
804 *International Journal of Sustainability in Higher Education*, 2015. **16**(5): p. 650-668.
- 805 55. Shaman, J. and K. Knowlton, *The Need for Climate and Health Education*. *Am J Public Health*,
806 2018. **108**(S2): p. S66-S67.
- 807 56. McMichael, A.J., *Impediments to comprehensive research on climate change and health*. *Int J*
808 *Environ Res Public Health*, 2013. **10**(11): p. 6096-105.
- 809 57. van Panhuis, W.G., et al., *A systematic review of barriers to data sharing in public health*.
810 *Bmc Public Health*, 2014. **14**.

- 1
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3 811 58. Lazem, M. and A. Sheikhtaheri, *Barriers and facilitators for disease registry systems: a mixed-*
4 812 *method study*. BMC Medical Informatics and Decision Making, 2022. **22**(1).
5 813 59. Lakshmanasamy Ravivarman, P.K. *A10 Medically certified causes of death and risk factors in*
6 814 *mortality, Puducherry district, India, 2016-19*. 2020. BMC Proc 15 (Suppl 11).
7 815 60. Levison, M.M., et al., *Development of a Climate Change Vulnerability Assessment Using a*
8 816 *Public Health Lens to Determine Local Health Vulnerabilities: An Ontario Health Unit*
9 817 *Experience*. International Journal of Environmental Research and Public Health, 2018. **15**(10).
10 817 61. Valois, P., et al., *The Health Impacts of Climate Change: A Continuing Medical Education*
11 818 *Needs Assessment Framework*. J Contin Educ Health Prof, 2016. **36**(3): p. 218-25.
12 819 62. Herrmann, A. and R. Sauerborn, *General Practitioners' Perceptions of Heat Health Impacts on*
13 820 *the Elderly in the Face of Climate Change A Qualitative Study in Baden-Wurtemberg,*
14 821 *Germany*. International Journal of Environmental Research and Public Health, 2018. **15**(5).
15 822 63. Paterson, J., et al., *Health Care Facilities Resilient to Climate Change Impacts*. International
16 823 *Journal of Environmental Research and Public Health*, 2014. **11**(12): p. 13097-13116.
17 824 64. Shumba CS, L.A., *Not enough traction: Barriers that aspiring researchers from low- and*
18 825 *middle-income countries face in global health research*. Journal of Global Health Economics
19 826 *and Policy*, 2021. **1**.
20 827 65. Shrikhande, S., Pedder, H., Roosli, M., Dalvie, MA., Lakshmanasamy. R., Gasparrini, A.,
21 828 Utzinger, J., Cisse. G, *Non-optimal apparent temperature and cardiovascular mortality: the*
22 829 *association in Puducherry, India between 2010 and 2020*. Research Square 2022.
23 830 66. Bhatia, M., et al., *Impending epidemic of cardiovascular diseases among lower*
24 831 *socioeconomic groups in India*. The Lancet Healthy Longevity, 2021. **2**(6): p. e314-e315.
25 832 67. Sheffield, P.E., et al., *Emerging Roles of Health Care Providers to Mitigate Climate Change*
26 833 *Impacts: A Perspective from East Harlem, New York*. Health and Human Rights, 2014. **16**(1):
27 834 p. 113-121.
28 835 68. Dupraz, J. and B. Burnand, *Role of Health Professionals Regarding the Impact of Climate*
29 836 *Change on Health-An Exploratory Review*. International Journal of Environmental Research
30 837 *and Public Health*, 2021. **18**(6).
31 838 69. GovernmentOfPuducherry. *About Puducherry District*. 2022 25/03/2022]; Available from:
32 839 <https://puducherry-dt.gov.in/history/>.
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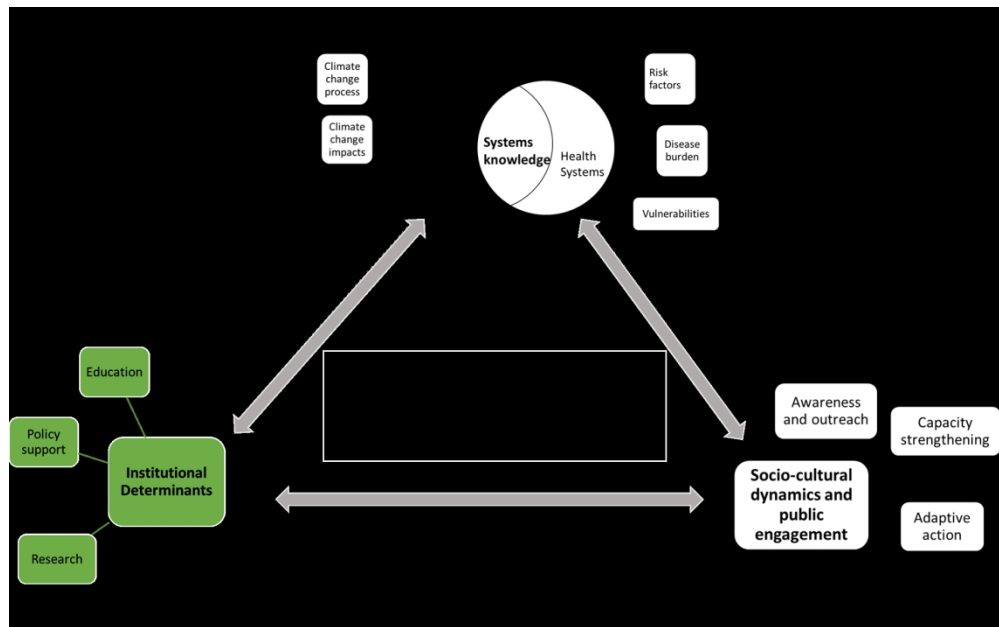


Figure 1: A framework for health adaptation action in the context of climate change based on level of knowledge, perceived health risks, policy and institutional support and public engagement. The circled part highlights the thematic areas we focus on in this work, namely institutional determinants and its challenges.

848x528mm (59 x 59 DPI)

Supplementary material

1. Interview questions guide for medical professionals and members of the Department of Science, Technology and Environment (DSTE) working on the Puducherry State Adaptation plan

COMMON QUESTIONS

Target group	Themes	Aims	Questions
COMMON	Participant information	To get the basic demographic and professional information about the participant	<ol style="list-style-type: none"> 1. Age 2. Nationality 3. Place of residence 4. Educational background and speciality 5. Occupation 6. Years in occupation 7. Professional experience related to climate change and/or health
	Background knowledge- climate change	To establish level of knowledge about climate change with 'warm up' questions	<ol style="list-style-type: none"> 1. What comes to mind when you think of climate change? 2. What do you think are physical manifestations of climate change? 3. Have you experienced or been aware of any climate change events in the past few years? 4. What, according you, are the most common consequences of climate change?- Which aspects of life do they affect most severely?
	Climate change and health, climate change and CVDs	To establish knowledge/ awareness about climate change and health and climate change and CVDs	<ol style="list-style-type: none"> 1. Have you ever thought about the health impacts of climate change? 2. What aspects of human health do you think climate change will have the biggest impact on? 3. Are you aware about the impacts of climate change on NCDs such as cardiovascular diseases? <ol style="list-style-type: none"> 3.1. If yes to above question, what do you know about it? How do you know about it (eg through research or

			through professional experience?)
	Policies and plans	To establish knowledge and awareness levels about policies and plans on the issue of climate change and health	<ol style="list-style-type: none"> 1. Are you aware or have you been part of any policies/plans/programs on the issue of climate change and health? 2. If yes, what were/are they?-What diseases or health topic did it focus on? What was the work done (aim)? Do you think it was successful and beneficial? 3. Do you know any plans/programs specifically targeting climate change and heart diseases? (can be from any sector). 4. Do you know about the national/state climate change adaptation plan? 5. If yes, do you know of the role health plays in it?
	Challenges and outlook	To understand challenged faced, potential solutions and planned changes	<ol style="list-style-type: none"> 1. Are you aware of any upcoming or recent changes to the health adaptation plans or any other relevant policy that target climate change and health? 2. Do you know any policies which can be used to increase awareness and research on the impact of climate change on CVDs in India? 3. According to you, what are the biggest drawbacks and challenges faced- why do you think health or NCD impacts of climate change are not a priority? 4. What can be done to change that? 5. Can you think of some measures to mitigate the impacts of climate change? <ul style="list-style-type: none"> - Your contribution to mitigating the impact, whether it's individual or you think it should be more at a governmental level?

			<ul style="list-style-type: none"> - Examples can be green healthcare facilities etc
<p>Medical Professionals</p>	<p>Climate change and health-medical experience</p>	<p>To understand perceptions on the extent to which climate/temperature affects patient health</p>	<ol style="list-style-type: none"> 1. Do you think climate, especially temperature affects health based on hospital admissions and mortality? 2. Can you explain what you have observed (eg, more patients on particularly hot days). 3. Which diseases have you observed to be the most sensitive to climate/temperature? 4. Based on your day to day observations, do you see an association between temperature and CVDs? 5. Do you think we will see an increase in the CVD deaths attributable to temperature in the future?
	<p>Population vulnerability</p>	<p>To understand views on how different people are affected based on demography</p>	<ol style="list-style-type: none"> 1. Which people have you observed to be the most vulnerable to temperature? (eg, age, gender, occupation, SE status etc) 2. Do you see a big gender difference in CVD patients with and without the influence on external temperatures? 3. Have you observed an association between age/gender and temperatures? For example, are a certain group of people more susceptible to heat or cold? 4. Do the public and private sectors work together during disasters? <ul style="list-style-type: none"> - How is the communication, facility and equipment sharing?
	<p>Education and training</p>	<p>To understand level of training and awareness among doctors on climate sensitive diseases</p>	<ol style="list-style-type: none"> 1. Have you ever been explicitly trained, either during medical school or professionally, on climate sensitive diseases?

			<ol style="list-style-type: none"> 2. If yes, where did the course take place (India or abroad, college or professional) and what did it cover (broadly) 3. If yes, did the course include CVDs? 4. Did it include gender differences in terms of symptoms? 5. Do you think such a course is needed or would be beneficial?
	Measures to be taken	To discuss possible measures to be taken to increase awareness and preparedness on climate sensitive diseases	<ol style="list-style-type: none"> 1. Assuming that we will be seeing an increase in CVD mortalities attributable to temperature in the future, what measures do you think can be taken to prepare and adapt to it? <ul style="list-style-type: none"> - In hospitals, in medical schools, - Give an example..early warning systems, emergency cardio bays in hospitals, awareness drives etc 2. What policy measures do you feel would benefit with the issue of climate sensitive diseases? For CVDs?
Health department (policy makers, ministerial representatives)	Current policies	To understand current health policies and whether climate change is included in them- include CVD policies and training	<ol style="list-style-type: none"> 1. Do any of the current health policies include climate change? 2. Are there any specific policies on climate sensitive diseases? <ul style="list-style-type: none"> - Guidelines for disasters - Guidelines for heat 3. If yes, do any policies include NCDs or CVDs specifically?
	Challenges and outlook	To understand current challenges and future plans	<ol style="list-style-type: none"> 1. The national adaptation plan recently added health as one of its climate change missions- why do you think this was not always a priority? 2. FOR PUDUCHERRY- Why is there no health

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			<p>mission in the state adaptation plan? Are there plans to include it? If yes, what diseases will be focused on?</p> <ol style="list-style-type: none"> 3. Are any activities being planned around climate sensitive diseases especially CVDs? <ul style="list-style-type: none"> - Awareness programs - Education and training in medical schools? 4. Are there any plans to develop and expand heat action plans nationally? (eg. Ahmedabad heat action plan) 5. Which diseases will be a priority area for climate sensitivity in terms of policy and research? 6. Is there any research or study being conducted on the health impacts of climate change? Are there any plans to do so? 7. CVD effects and most other effects of climate change affect vulnerable populations most-how do you plan to address some of these challenges? <ul style="list-style-type: none"> - Rural vs urban exposures and requirements differ. Are there plans that specifically target different populations? - What about different communities? Do you feel different communities have different needs to protect themselves against the climate? Can you elaborate? - What about different SE groups?
<p>Department of Science, Technology and Environment</p>	<p>Current policies</p>	<p>To understand the development process of the adaptation plan and how health is included in current policies</p>	<ol style="list-style-type: none"> 1. The adaptation plan has recently added a health mission, but it does not have a comprehensive list and guidelines for climate sensitive disease management?

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			<p>2. The adaptation plan is an intersectional plan with involvement from many departments. Does the steering committee have regular meetings to review and stay prepared, if so how often?</p> <ul style="list-style-type: none"> - Review meetings? - Do you make changes to the plan based on new evidence or incidences? <p>3. Is there a reason that NCDs such as CVDs, despite having a huge burden of disease are not explicitly included and researched in terms of climate attributable burden?</p> <p>4. What plans/programs/campaigns are presently ongoing that deal with climate-health adaptation? Are there any specific to CVDs?</p> <p>5. Can you tell me about any plans or policies that have been previously implemented on the topic of climate sensitive diseases?</p> <ul style="list-style-type: none"> - Were they successful and effective? - What is the present status of these? - What were the biggest challenges faced? <p>6. CVD effects and most other effects of climate change affect vulnerable populations most-how do you plan to address some of these challenges?</p> <ul style="list-style-type: none"> - Rural vs urban exposures and requirements differ. Are there plans that specifically target different populations? - What about different communities? Do you
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			<p>feel different communities have different needs to protect themselves against the climate? Can you elaborate?</p> <ul style="list-style-type: none"> - What about different SE groups?
	Challenges and outlook	To understand challenges faced and future plans	<ol style="list-style-type: none"> 1. What is the biggest challenge in formulating and implementing climate sensitive disease policies or policies related to climate impacts on health? 2. Are there any plans to include NCDs and CVDs as a separate component of climate sensitive diseases? 3. Are there research projects planned on this topic to inform priority setting and policy formulation? 4. What measures do you think need to be taken to help formulate better , more comprehensive climate change policies that are informed by health research?
			<p>The adaptation plan is an intersectional plan with involvement from many departments. Does the steering committee have regular meetings to review and stay perpared, if so how often?</p> <ol style="list-style-type: none"> 1. Review meetings? 2. Do you make changes to the plan based on new evidence or incidences? 3.
EDUCATION- either department or medical college educators	Current practices	To understand current medical curriculum and whether climate change is included in it	<ol style="list-style-type: none"> 4. Does the current medical school curriculum include climate change with respect to diseases that are sensitive to it? 5. Do you feel this needs to be taught? 6. Do you think temperature affects diseases?

			<p>7. What diseases do you think are most sensitive to climate change that need to be included in the curriculum?</p> <p>8. If yes to above questions, does it include gender differences?</p>
	Challenges and outlook	To understand challenges in teaching students about climate change and plans for future along with suggestions	<p>1. Are there any plans to include climate sensitive diseases in the curriculum?</p> <p>2. What other measures do you think can be taken with respect to the training of medical workers to reduce the burden of climate sensitive diseases?</p> <ul style="list-style-type: none"> - Ex, emergency bays, more ambulances or staff during days of particular temperature etc

Table S1: Interview guideline for key-informant interviews

2. Participants profile

Sector/background	<i>n</i>	Females	Males	Age range (Years)	Range of experience (Years)
Medicine (in-practice)	8	0	8	32-51	3-20
Medicine (research/academic)	3	1	2	40-44	11-20
Environment/governmental	5	2	3	28-53	4-30
Total	16	3	13	28-53	3-30

Table S2: Profile of the participants interviewed in this study.

3. Framework with themes and relevant categories

Theme	Sub-theme	Categories
Climate change and health: systems knowledge and perceptions	Climate change as an acute and growing problem for India	

	Domino effect on impacts of climate change ultimately converges at health	
Role of institutions	Political and institutional barriers	Limited knowledge and awareness on climate change and health related policies
		Disengaged leadership and low political prioritization of climate change and health
		Weak inter-departmental integration and co-ordination for climate change and health
	Educational and informational barriers	Gaps in climate change and health in higher education curricula
		Need to strengthen inter-sectoral information dissemination
		Scepticism and low awareness on non-conventional health impacts of climate change
	Technical barriers to research	Insufficient resources and workforce dedicated to research
		Underdeveloped transdisciplinary research capacity
		Research slowed by availability and access to quality data
	Socio-cultural dynamics, outreach and engagement	Need for alternate solutions, targeted campaigns and programs at all levels
Role of experts and famous personalities in awareness building		
Climate informed health policies and seasonal workplace guidelines		
Integrating climate change in the curriculum and		

	continuing educational courses	
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Table S3: Structural codes and framework matrix

4. Additional supporting quotes

- i. Institutional Knowledge and perceptions: Limited knowledge and awareness on climate change and health related policies

“Priority areas means, uh, for example, climate change in the health department, there is no clear cut guidelines is there. There is no clear cut guidelines, there is no clear cut programs are not there regarding climate and health.”#16, Practicing physician

- ii. Institutional barriers: Disengaged leadership and climate change not seen as immediate health concern

“When we practice medicine, because we are more concerned with treating the patient rather than you know, going and finding out the cause and prevent the incident in happening. So there the problem is a disconnect between, uh, what is happening (and) the preventive aspects, we were not able to quantify, especially in our setup here in India.” #2, Medical doctor/academic

- iii. Institutional barriers: Integration of climate change-health as a separate, inter-departmental body

“Because one thing is, it is not about criticizing some other officer, it is like they have to do their work, not other department's work. So then the head should accept that they have to spare their times [for] this climate change work.. It depends on who the nodal officer is, who the higher officer is, and who the head of the bureaucracy is. So when people are okay with working on this, things would be fine. But people don't care things will be the other way. So, in short, I would say that it has to come from the top down approach.”#9, Environmentalist

- iv. Technical barriers: Availability and access to quality data slowing down research progress

“The state government has the, uh, database. We may not have a line list. So without line list we cannot call it as database, but they will have each primary health center how many patients with NCDs, diabetes, hypertension, stroke,

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3 they have the data. So that is there. But, uh, I think last two to three years only
4 they started screening households for diabetes, hypertension and cervical
5 cancer, but not specifically targeting high risk groups. For the private side, we
6 don't have the database on how many are-It's not like a tuberculosis program.
7 We have the line list, total line list of whether they are part of the public health
8 program or the private. So there we will have a database of patients but not
9 for the non-communicable diseases." #3, Medical doctor/academic
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- 14 v. Technical barriers: Need for more resources and workforce dedicated to
15 research
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19 "One is like, if you know, India should actually allocate more funds from the
20 GDP towards the health sector. Actually, if you speak, there is not much of
21 research work going on. Probably in the last like three to four years, it might
22 have picked up... Most of the Indian government funding is going to the Central
23 Institutes. For example, if you go to any government, hospital, state run
24 government hospital, they don't have any separate data entry and don't have
25 any separate research. You should bringing the students into the studies, which
26 are happening only in the institutions not in the state run hospitals. Because
27 they actually- many funds are- see now also funds are coming to state. They're
28 giving directly to the institutes. But no one knows where the fund goes.
29 Ultimately, it doesn't reach the students. It disappears at the level of
30 consultants." #14, Practicing cardiologist
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37 "Definitely they will select the more burden because the more causing
38 immediately they will put a resource on that. So that climate change part,
39 maybe they are giving a least preference. That's why it's not that much
40 implemented." #16, Practicing physician
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- 45 vi. Technical barriers: Scepticism and low awareness on non-explicit health
46 impacts of climate change
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48 "When it comes to non communicable disease, one is this relationship it's also
49 is not synced into us...Once people know that this is going to happen, then
50 actually there's a percolation of knowledge that 'climate change is affecting
51 this, and you have to look for it.' But as of now, if I go and tell a clinician that
52 climate change is affecting NCDs, or cardiovascular disease, they will be
53 laughing at me. They tell it's the lifestyle diseases, which is affecting them. So
54 I'll be a fool actually for talking to them...Even if I work on it and show, if I don't
55 have expertise, they're going to snub me off tell that "no, it's only a remote, it
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3 *could be this, it could be a confounding, it could be a bias.” #4, Medical*
4 *doctor/academic*
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8 vii. Technical barriers: Need for transdisciplinary research capacity

9 *“One important thing that I would like to register is we ourselves need to*
10 *participate in certain workshops which are done by certain other people, for*
11 *example, DST [Department of Science and Technology] from New Delhi. For*
12 *example, in the last two years, the only technical work that we've done for our*
13 *city, is like this vulnerability assessment. But...we in our cell, or even officials*
14 *here, we are not pre-sensitized with all these things. So only when we take up*
15 *learnings from outside, we can execute that for our city, for our state.” #9,*
16 *Environmentalist*
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24 viii. Specific challenges in studying the cardiovascular impacts of climate change

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27 *“In hospitals, even this point of you know, we are expecting more of even*
28 *this trend of increased changing of our climate and (that) has to be made*
29 *aware to people. (When we were discussing on the topic of climate change)*
30 *when it went to the clinicians, they're like, "how is it going to help me? It's not*
31 *going to help me". They are very careful with the infectious disease...”#4,*
32 *Medical doctor/academic*
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36 *“But non communicable disease, like cardiovascular disease, no one tells*
37 *complaints noone also correlates all those things. They just think of diabetes,*
38 *hypertension, cholesterol, and all these things maybe because of the elevated*
39 *sugar, and the BP it might have got the ,uh, cardiac complaint. Now one*
40 *doesn't correlates all the things since he has gone in the rainy-rain or since he*
41 *has got the cold. Noone correlates. And I think we should also think about all*
42 *those things.” #13, Practicing physician*
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COREQ (CONsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
<i>Personal characteristics</i>			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	
Occupation	3	What was their occupation at the time of the study?	
Gender	4	Was the researcher male or female?	
Experience and training	5	What experience or training did the researcher have?	
<i>Relationship with participants</i>			
Relationship established	6	Was a relationship established prior to study commencement?	
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	
Interviewer characteristics	8	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	
Domain 2: Study design			
<i>Theoretical framework</i>			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	
<i>Participant selection</i>			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	
Sample size	12	How many participants were in the study?	
Non-participation	13	How many people refused to participate or dropped out? Reasons?	
<i>Setting</i>			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	
<i>Data collection</i>			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	
Repeat interviews	18	Were repeat interviews carried out? If yes, how many?	
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	
Field notes	20	Were field notes made during and/or after the interview or focus group?	
Duration	21	What was the duration of the interviews or focus group?	
Data saturation	22	Was data saturation discussed?	
Transcripts returned	23	Were transcripts returned to participants for comment and/or	

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
<i>Data analysis</i>			
Number of data coders	24	How many data coders coded the data?	
Description of the coding tree	25	Did authors provide a description of the coding tree?	
Derivation of themes	26	Were themes identified in advance or derived from the data?	
Software	27	What software, if applicable, was used to manage the data?	
Participant checking	28	Did participants provide feedback on the findings?	
<i>Reporting</i>			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	
Data and findings consistent	30	Was there consistency between the data presented and the findings?	
Clarity of major themes	31	Were major themes clearly presented in the findings?	
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	

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Barriers to climate change and health research in India: A qualitative study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2023-073381.R1
Article Type:	Original research
Date Submitted by the Author:	28-Jul-2023
Complete List of Authors:	Shrikhande, Shreya; Swiss Tropical and Public Health Institute, Epidemiology and Public Health; University of Basel Merten, Sonja; Swiss Tropical and Public Health Institute, Epidemiology and Public Health; University of Basel Cambaco, Olga; Swiss Tropical and Public Health Institute, Epidemiology and Public Health; University of Basel Lee, Tristan T; Swiss Tropical and Public Health Institute; University of Basel Lakshmanasamy, Ravivarman; Govt of Puducherry, Department of Health and Family Welfare Services; World Health Organisation Country Office for India, NCD Team Röösli, Martin; Swiss Tropical and Public Health Institute; University of Basel, Dalvie, Mohammad; University of Cape Town, Centre for Environmental and Occupational Health Research Utzinger, Jürg; Schweizerisches Tropen- und Public Health-Institut; University of Basel Cissé, Guéladio ; Swiss Tropical and Public Health Institute; University of Basel
Primary Subject Heading:	Public health
Secondary Subject Heading:	Global health, Qualitative research
Keywords:	PUBLIC HEALTH, QUALITATIVE RESEARCH, EPIDEMIOLOGY

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1 Barriers to climate change and health research in India: A qualitative 2 study

3
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17 Word count: 6684

18 Keywords: Climate change; health; research barriers; environmental health; qualitative study;
19 stakeholder perspectives; India; LMIC

Abstract

Objectives: Almost a quarter of the global burden of disease and mortalities is attributable to environmental causes, the magnitude of which is projected to increase in the near future. However, in many low- and middle-income settings, there remains a large gap in the synthesis of evidence on climate-sensitive health outcomes. In India, now the world's most populous country, little remains known about the impacts of climate change on various health outcomes. The objective of this study is to understand the challenges faced in conducting climate change and health research in Puducherry, India.

Design and setting: In this study, we employed key informant interviews to understand the perceived research barriers in Puducherry. The findings were analysed using data driven qualitative thematic analysis to elaborate the major perceived barriers to conducting environmental health research.

Participants: This study was conducted amongst 16 public health professionals, including medical researchers, and professionals involved in environmental policies and planning in Puducherry.

Results: We identify three key barriers faced by public health professionals as key stakeholders, namely: (i) political and institutional barriers; (ii) education and awareness barriers; and (iii) technical research barriers. We show there is a need, from the professionals' perspective, to improve community and political awareness on climate change and health; strengthen technical research capacity and collaboration amongst researchers; and strengthen health surveillance, resource allocation and access to health data for research.

Conclusion: Evidence informed policies and interventions are a key element in the adaptation response for countries. In the context of the paucity of data on environmental health from India, despite recognised climate change related health vulnerabilities, these findings could contribute to the development and improvement of relevant interventions conducive to a strong research environment.

Strengths and limitations of this study:

- This study identifies crucial challenges faced in conducting environmental health research by public health professionals for the first time.
- The findings draw on the experiences of highly relevant experts, well placed in the climate change and health sphere.
- The sample was restricted to Puducherry district and not representative of the entire Union Territory of Puducherry, much less India as a whole.
- The sample is restricted to the opinions of a selected group of experts and we could not include the experiences and perspectives of other public health professionals or stakeholders.

73 INTRODUCTION

74 An ever-growing body of research has irrefutably shown the global health impacts of climate
75 change through both direct and indirect exposure pathways [1, 2]. Multiple risk and
76 vulnerability factors determine the population resilience and adaptive capacity, from socio-
77 political, demographic and biological factors to infrastructure, urban planning, health
78 information systems and health workforce [2, 3]. Given the regional variations in climate
79 systems, the health impacts of climate change differ between and within countries and
80 communities, mediated by interconnected socio-economic and environmental determinants
81 of health [4, 5]. Non-communicable diseases (NCDs), such as respiratory diseases,
82 cardiovascular diseases (CVDs), mental health conditions, have been recognized as growing
83 climate-sensitive health outcomes, in addition to other communicable diseases like vector-
84 and water-borne diseases and malnutrition [3, 6].

85 With the rapid pace of climate change, the health impacts attributable to it are also projected
86 to increase [7]. Strengthening the adaptive capacity of countries is therefore an essential
87 component of the climate change response [8]. Timely public health interventions can do
88 much to protect population health from the potential adverse health impacts of climate
89 change [9]. Low- and middle-income countries (LMICs), such as India, remain
90 disproportionately affected by climate impacts, with a critical need to strengthen the
91 healthcare response to climate impacts [10, 11]. One of the key steps in the regional or local
92 adaptation response is assessing the true burden of the health impacts within the population
93 of that location [12]. However, owing to the complexity of the relationship between climate
94 change and health, identifying and estimating this association remains one of the biggest
95 global and environmental health challenges, especially in LMICs [11].

96 In India, the existing health and social disparities within the population make it one of the
97 most vulnerable to climate change impacts, compounded by climatic diversity [13-16]. There
98 have been recent efforts from the Government of India to focus on climate change and health,
99 as evinced by the recent addition of a health mission to the National Action Plan on Climate
100 Change (NAPCC). This led to the formulation of the National Action Plan on Climate Change
101 and Human Health (NAPCCHH) and the drive for State Action Plans for Climate Change and
102 Human Health (SAPCCHH) [17, 18]. The government recognizes several diseases as climate-
103 sensitive in these official document., However, public health engagement, action and
104 research on health impacts of climate change are limited in India, especially given the
105 magnitude of climate impacts to which it is vulnerable [19, 20].

106 Medical and public health professionals, hereafter referred to as health professionals, play an
107 important role in researching, managing and responding to climate change impacts on health.
108 Along with being considered credible sources of information, these groups of professionals
109 also have the capacity for scientific inquiries into the climate change attributable impacts of
110 health [21-24]. Globally, there is an acknowledged need to train health professionals to
111 engage in, study and manage health impacts of climate change. There are few studies
112 assessing stakeholder perceptions on climate change and health [14, 25, 26], and even fewer

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3 113 studies looking at specific barriers to research on this topic [27, 28]. Given the present gaps
4 114 in this domain, especially in LMICs, it is particularly important to understand what research
5 115 barriers and needs are perceived by health professionals [25-27, 29].
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8 116 The aim of this study is to understand some of the contextual barriers to environmental health
9 117 action and research amongst two relevant professional groups in Puducherry, India. We
10 118 focused our study on: (i) medical professionals, both in active research and practicing; and (ii)
11 119 members of the Department of Science, Technology and Environment working on climate
12 120 change in Puducherry. As this study is a part of a larger project on CVDs and climate change
13 121 in India, we also highlighted the specific challenges and barriers to conducting research on
14 122 CVDs.
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18 123 **METHODS**

19 124 **Study setting**

20 125 This study employed key informant interviews following a semi-structured interview guide.
21 126 The methods have been described in detail elsewhere. Briefly, the focus of our study was
22 127 Puducherry district, which lies on the south-eastern coast of India, with a population of
23 128 950,289, as per the Government of India 2011 Census [30]. Puducherry has one main State
24 129 government run tertiary care hospital and medical college, along with several private clinics
25 130 and primary care health centres. It is also home to the Central Government Jawaharlal
26 131 Institute of Postgraduate Medical Education and Research (JIPMER), an 'Institute of National
27 132 Importance' and tertiary care referral hospital. Within the Department of Science, Technology
28 133 and Environment (DSTE), there also exists a specialized Puducherry Climate Change Cell with
29 134 the aim to integrate knowledge about climate change and facilitate the NAPCC
30 135 implementation, including the state specific Action Plan [31].
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37 136 **Data collection and analysis**

38 137 16 semi-structured interviews were conducted between January and March 2022 with
39 138 participants from Puducherry. 14 interviews were conducted in-person and 2 were conducted
40 139 virtually over Zoom. Using purposive sampling based on prior connections followed by
41 140 snowball sampling, we invited medical professionals (research or practicing) and DSTE staff
42 141 working on the Puducherry State Action Plan for Climate Change (hereon referred to as
43 142 environmentalists). Interviews continued until information saturation was reached in the
44 143 interviews or we had interviewed all the relevant target participants, as in the case of the
45 144 DSTE staff. The full interview guide and framework with the main categories has been given
46 145 in the Supplementary Table S1.
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51 146 Eleven of the participants had a medical background and were working as either practicing
52 147 physicians or researchers. Within the doctors, we mainly targeted cardiologists, emergency
53 148 medicine or general medicine physicians who were involved in areas relevant to our study.
54 149 The majority of the participants was male, with only three females, out of which only one had
55 150 a medical background. Half of the participants were practicing physicians while the other half
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151 were researchers. The participant profile is presented in the Table 1 and further described in
152 [32].

153

154 *Table 1: Profile of participants interviewed in this study.*

Sector/background	<i>n</i>	Females (<i>n</i>)	Males (<i>n</i>)	Age range (Years)	Range of experience (Years)
Medicine (in-practice)	8	0	8	32-51	3-20
Research (Medical)	3	1	2	40-44	11-20
Research (Environment/governmental)	5	2	3	28-53	4-30

164 The interviews, conducted by S.S, lasted between 15 to 50 minutes and were audio recorded
165 with informed consent using a voice recorder. Field notes taken to optimize the interview
166 guide and note key topics. R.L was a passive observer and facilitator for 3 interviews. We used
167 an *a priori* developed interview guide with broad and open-ended questions to allow
168 participants to freely bring up and discuss relevant topics. All interview recordings were
169 assigned a number prior to transcription to ensure anonymity throughout the analysis
170 process. Verbatim transcription and analysis was done using the MaxQDA software version
171 2018.1 (VERBI Software, Berlin, Germany) by S.S.

172 For the analysis, a combination of deductive and inductive thematic analysis was used as
173 described by Gale et al [33]. Broad themes were developed based on the aim, framework and
174 interview guide, as discussed below. During analysis, major themes were inductively
175 developed for emerging topics, which we then clearly defined. After familiarization with the
176 transcripts, an initial codebook was developed from coding the three interviews with the
177 richest data; the remaining interviews were indexed and coded further. The codes were
178 classified into categories, sub-themes and themes. The final analytical matrix included three
179 themes. S.S. and T.L. independently validated the codebook with the 3 main interviews and
180 agreed on the final framework matrix that considered all relevant codes. The matrix was then
181 used to chart relevant quotes supporting our findings and draw comparisons between
182 participants.

183 The conceptual framework for climate change risk perceptions developed by van Eck *et al*
184 [34] and the framework for health inequalities proposed by Rudolph *et al* [35] were used as a
185 base for our analytical framework, shown in Figure 1. While there are three major themes,

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2
3 186 this paper focuses only on the theme of 'Institutional determinants'. The findings from the
4 187 two other themes have been elaborated elsewhere. Within the context of this paper,
5 188 'institution' is used as a broad term covering all governmental structures including policy,
6 189 education, and occupation. We identify how these determinants can be perceived as barriers
7 190 to environmental health research. The framework matrix with relevant themes and categories
8 191 has been provided in Supplementary Table S2. Additional supporting quotes have also been
9 192 provided in the Supplementary material.

193 Ethical consideration

194 There was no prior relationship between the researcher and participant. Before the interview,
195 the researcher went over the informed consent form, which was then signed by both parties.
196 S.S, the main researcher is an Indian PhD candidate supervised by a team of international
197 experts based mainly in Switzerland. R.L is also Indian national based in Puducherry.
198 Additionally, all the quotes presented in this analysis have been assigned only by serial
199 number to ensure anonymity.

200 This study was approved by the Institute Ethics Committee (Human Studies) of the Indira
201 Gandhi Medical College and Research Institute (A Govt. of Puducherry Institution); No.
202 318/IEC-31/IGM&RI/PP/2021 and by the Ethics Committee Northwest and Central
203 Switzerland (EKNZ); Statement ID- AO_2020_00034. The methodology used in this project
204 abided by the principles laid out in the Declaration of Helsinki and the COREQ checklist.

205 Patient and public involvement

206 As we employed a combination of purposive and snowball sampling, some participants were
207 involved in helping us identify suitable participants to interview. Beyond that, no members of
208 the public were involved in the design, conduct, reporting or dissemination plan of our
209 research.

211 RESULTS

212 Overall, there are 4 main themes that emerged from this research, which are presented in
213 Figure 2. We first report participants' knowledge regarding climate change and health
214 policies, followed by their perceived institutional barriers to research, namely political,
215 educational and technical barriers. As this study is part of a larger study examining climate
216 change impacts on CVDs, we also highlight barriers specific to climate change and CVD
217 research.

219 1. Institutional framework: knowledge on policies

220 1.1. Limited knowledge and awareness on climate change and health related policies

221 We found limited awareness among the participants about climate change and health related
222 policies, such as the NAPCC, NAPCCHH and SAPCCHH. Aside from the environmentalists, who
223 worked on it, only three medical professionals who worked on one of the Action Plans were
224 aware of it. Four participants expressed belief about the non-inclusion of climate change in

225 disease specific policies and the lack of integrated climate change and health policies and
226 guidelines.

227 *“Our country has different policy, environmental policy, health policy. But I have doubt
228 whether health policy has any component of climate change. So, it needs to be incorporated
229 in a health policy of national importance as well as the state, but currently, this element is not
230 in place, that is my feeling.” #8, Environmentalist.*

231 One of the environmentalist also mentioned challenges in integrating climate change in
232 development plans. These were thought to be made primarily from a socio-economic
233 development perspective, although there were ongoing efforts to include the economic co-
234 benefits of climate change adaptation in the development plans.

235 *“The challenge is that the government sectoral officers are not aware of how the climate
236 adaptations need to be integrated into their developmental plans. Because they, whenever
237 they plan for a project, they plan it from the socio economic development perspective.” #7,
238 Environmentalist.*

239 2. Political and institutional barriers

240 2.1. Disengaged leadership and low political prioritization of climate change and health

241 Political leadership that did not consider health impacts of climate change as a pressing
242 matter was perceived as one of the barriers to conducting research on the topic. Several
243 participants mentioned how climate change was seen as future concern by policy makers and
244 the general public, rather than viewed as a cause for immediate concern. A few participants
245 also mentioned the slim likelihood of decision makers actually being aware of it. One
246 participant described the issue as being *“not mainstream enough”* to warrant focused work,
247 contributing to the perceived low priority assigned to environmental health research.

248 Many participants felt that the governmental focus was inclined towards non-health impacts
249 of climate change. The most pressing climate change impacts, which also influence research
250 focus, were thought to be pollution, coastal sensitivity and natural resource depletion and
251 degradation, especially in the context of Puducherry as a coastal region. Additionally, existing
252 sectoral programs already running were seen as a hindrance to focusing on climate change
253 related programs by one participant.

254 *“The problem is everybody has to understand at the level of the minister or the secretaries. So
255 many programs are there. Not only about climate change, other programs are there so they
256 do not focus much on (climate change) programs... Actually, what I have seen for the past 2-
257 3 years, they don’t care much about climate.” #1, Practicing physician/policy advisor.*

258 Despite climate change being recognized as a health risk factor, there was a clear disconnect
259 between on-paper government plans and practice when it came to environmental health
260 research. The challenges India faces from other vulnerabilities, including unmet nutritional
261 and economic needs were perceived to outrank climate risks to health..

262 *“I’m an adviser to government of India on health related research. We did discuss a lot of
263 things but we also touched upon climate and the effects of climate on health...That was*

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3 264 *considered as an important topic, but we didn't dwell much upon how to take it forward*
4 *because there are more pressing problems.” #15, Practicing physician/academic.*
5

6 266 *2.2. Weak inter-departmental integration and co-ordination for climate change and health*

7 267 The compartmentalization of topics within institutes or sectors was seen as a barrier to
8 conducting inter-disciplinary research by the participants. One participant discussed the
9 newly formed Puducherry Climate Change and Health Action Plan (2022), which aims to bring
10 together a multi- sectoral team, under the leadership of the health ministry, to focus on
11 health impacts of climate change.
12 270
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14
15 272 However, apart from one participant, most others voiced a perceived need for an
16 independent, coordinating body focused on environmental health, incorporating a research
17 agenda. Partially, this was due to climate change being thought of an added responsibility for
18 health professionals and vice versa for environmentalists, especially for those working in the
19 government. As highlighted by a few participants, officials were likely to prioritize their
20 primary work profile over the added responsibility of climate change and health research.
21 276
22 277 Another concern in the existing scenario was inter-sectoral, collaborative research being
23 dependant on higher officials being receptive to their junior employees researching a topic
24 not entirely within the scope of their respective department.
25 280

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28 281 *“Especially government departments, they are loaded with a lot of work. Today, an officer*
29 *comes in, he has to do his own work, not the work that other departments asks us to do...” #9,*
30 *Environmentalist.*
31 283

32 284
33 285 Several participants mentioned the Puducherry Climate Change cell created in response to
34 address climate change impacts. However, despite that, one medical researcher mentioned
35 the current difficulties in collaborating on climate change and health. Several participants also
36 mentioned the need to improving coordination between the sectors, with a dedicated head
37 of climate change and health.
38 289

39
40
41 290 *“Intersectoral body and there should be one decision maker. So now, everybody is like the*
42 *leader in the particular sector, but if they need the support from other one, that coordination*
43 *may be lacking...There won't be any one dedicated person for the climate change. So they will*
44 *be in charge of multiple departments. For example, somebody's going to be in charge of*
45 *immunization or the child health. So their priority will be child health obviously.” #3, Medical*
46 *doctor/academic.*
47 294
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49 296 *3. Educational and informational barriers*

50 297 *3.1. Gaps in climate change and health in higher education curricula*

51 298 One of the strongest emergent themes, referred to by most participants, was the need for
52 environmental health education, either by incorporating climate change in the health
53 curriculum or health impacts of climate change in the environmental curriculum in
54 universities and schools. The prevalent feeling was the source of climate change and health
55 literacy needs to be from multiple sources, with formal education being the most important
56 one. Most participants also felt that at present there was a disconnect between
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304 environmental and health education, as a result of which there was a relatively low level of
305 awareness on climate change impacts on health.

306 *“Education system need to be addressed from beginning...Even the medical college students
307 who are completing five years courses, I do not see any syllabus which contains impact on
308 health by the climate change even though it is very important...my son is studying medical-
309 medicine, but I guess I just go through the syllabus, but nothing is there.” #8, Environmentalist.*

310 All the environmentalists professed to never having specifically studied health impacts of
311 climate change during the course of their education. On the other hand, the health
312 professionals expressed incongruent views on climate change-health education. While one
313 mentioned having studied climate sensitive diseases in medical school, another denied ever
314 having been taught the link between climate change and various diseases.

315 Continuing education courses specific for health impacts of climate change were suggested
316 by a few participants as potential options to bridge the gap between the environment and
317 health. Two participants also suggested including short courses on this topic for all people
318 working on topics related to climate change, health, adaptation and resilience.

319 *3.2. Weakness in inter-sectoral information dissemination*

320 Many of the participants mentioned having little to no awareness on climate change-health
321 related research unless actively searching for it, pointing to the scope for improving related
322 education and science dissemination, especially among the scientific community.
323 Environmental risk factors were not commonly associated with health inherently, partially
324 attributed the low scientific exposure on the topic.

325
326
327 CVDs were seen as a ‘silent’ disease, with many people are not trained to look for symptoms,
328 much less correlate them to weather conditions, all suggesting the need for improved CVD
329 literacy and awareness on the topic. On the other hand, many participants were open to
330 changing their current schools of thought on risk factors for health to include climate change,
331 conditional to being informed by global research on the topic.

332
333 *“If there is research or it's already proven in other countries, 'so this is a risk factor it is a good
334 idea to add' but [before adding anything], I think some data or there should be some routine
335 surveillance or monitoring system should be there. ... even within the medical circle, people
336 may not be aware how much is the contribution of climate change to the heart disease or for
337 any disease for that case... I don't think our administrators or even our clinicians are that much
338 thinking about the impact of climate change, and [heart disease].” #3, Medical
339 doctor/academic.*

340

3.3. Scepticism and low awareness on non-conventional health impacts of climate change

As alluded to previously, health impacts of climate change are often not explicit, making it a challenge to research or focus the research agenda on for several reasons. One participant described how the slow pace of climate impacts leads people to think it will not immediately affect health, unless the impacts are drastic.

"...The problem has to become so severe, like you have air pollution in Delhi, then people will act. Climate change affects the life slowly it's not drastic...that is one of the reasons I feel. And slowly if you get some data and keep on generating awareness not only among the public, but also within the scientific community, then slowly things will be better."#3, Medical doctor/academic.

For researchers, an additional challenge of convincing funders or collaborators on the health impacts of climate change also emerged. One participant described the difficulty researchers had separating environmental risks from other common health risk factors. Scepticism when attempting to research health impacts of climate change was also encountered. Confounding from other risk factors and potential ecological bias was seen as the roots of this uncertainty.

"Maybe for six, seven years, I have been trying to do some work on climate change and environmental health. Every time I write a proposal I'm criticized largely telling that "how is it going to work?... And one other problem I see with the research with climate change or any environmental thing, it's ecological effects. So people ask "how can you attribute this to only this, why not to this?", " Why not to lifestyle, why only to climate change?" So this direct relationship is not there." #4, Medical doctor/ academic.

Diseases such as malaria, with historical links to stagnant water as breeding grounds, have been etched into public knowledge and further perpetrated through mass awareness campaigns, intervention programs and research. The slow developing nature of CVDs and the prevalent categorization of CVDs as solely lifestyle diseases was mentioned by many participants as potential barriers to research. One participant described how CVDs are commonly reduced to lifestyle diseases with the onus of risk management on the individual rather than a "willingness to see the invisible factors". The multifactorial nature of CVDs was thought to add to the difficulty of identifying climate attributable impacts. Another participant described how clinicians especially do not see the need to focus on environmental risk factors for CVDs, believing it ineffective in reducing the overall burden.

"Non-communicable diseases, because we are not quantifying that and because of the long latent period of the incident, you're not able to quantify directly to environment or climate change. So definitely, hypertension, cardiovascular disease, all these probably diabetes also because of the changing food pattern, but I don't think -you cannot separate climate change from any of the health effects or any of the non-communicable diseases. Also related to stress caused by climate change." #2, Medical doctor/ academic.

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3 381 The need for regional studies was also stressed upon as there seemed likely to be a disconnect
4 382 in comparing national or global level problems with health impacts of climate change on a
5 383 local level. Participants described the attitude of *“this does not affect us”* among the public
6 384 when it came to climate change especially. A few participants expressed belief and hope that
7 385 the temperature-CVD association was an upcoming topic of interest for the government and
8 386 public both.
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13 388 4. Technical barriers to research

14 389 4.1. *Insufficient resources and workforce dedicated to research*

15 390 Resource allocation, especially financial, for climate change-health research was described as
16 391 a barrier, especially by researchers. Along with inconsistent funding from the government,
17 392 one of the problems mentioned was lack of adequate trained personnel. This was partially
18 393 linked to the need to relieve the research expectations from already over-burdened doctors.
19 394 There was also a need to have trained personnel for digitalization and categorization of health
20 395 data in order to create a digital state-level health database.
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25 396 Some participants, referred to the low percentage of the annual budget of India allocated to
26 397 health along with the need to increase this. One participant described funds earmarked for
27 398 climate change-health research institutionally, along with optimism that this would lead to
28 399 future research opportunities.
29
30

31 400 *“Yes, for recent years even ICMR (Indian Council of Medical Research) has called for proposals*
32 401 *on this environment related, uh, this one. ICMR is one of the largest body which is for the*
33 402 *research organization as well as for the academic institutes like us. So, clearly, they are given*
34 403 *a separate block of funding for climate change and [health]. That means the funds are*
35 404 *available.”#3, Medical doctor/academic.*

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39 405 However, this was countered by the notion that most of the funds are directed to Central
40 406 government institutes as opposed to smaller research institutes. A participant also alluded to
41 407 misappropriation of research funding at an institutional level. Another participant spoke
42 408 about the need to involve university students in research along with concern that most
43 409 students do not get access to funding or research opportunities. There was a feeling that most
44 410 students remain unaware of opportunities for funding or that funds do not ultimately reach
45 411 the students aiming to conduct research. Another participant also described the prioritization
46 412 of more immediate health burdens and curative research as opposed to preventative
47 413 research for the directing of funds or resources. This was supported by the opinion expressed
48 414 by an environmentalist on climate change being viewed as a problem for the future as
49 415 opposed to the present.
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55 416 *“So though we focus on vaccination and other things, but still, the budget still flows more for*
56 417 *the curative aspects rather than the preventive part. So for instance, the climate change is*
57 418 *more of like, you prevent this- the future heart attacks or some other diseases. You have to*
58 419 *focus on the prevention.” #3, Medical doctor/academic.*

4.2. Underdeveloped transdisciplinary research capacity

Alongside education, the need to build more technical capacity among researchers was also mentioned as one of the biggest challenges by participants. Despite a potential interest and willingness from researchers, the lack of training and expertise in climate change-health research was strongly expressed. This was tied in with the expressed desire for mentorship, both to facilitate increased awareness among the scientific and medical community as well as increased regional research on health impacts of climate change.

“Yeah, more than research, I would tell it as people are aware and willing to do it, but here is more of capacity building...Let's say if I want to work on vector borne disease, I know who to approach...but when it comes to climate change, that linking is absent. ...So actually, even if I'm interested and I want to work on it, there are a lot of hurdles which has to be crossed...So I have to be given an opportunity to work on it, or I feel somebody has to mentor me to work on it. So what we call as, starting trouble, you know is there. Once I think somebody starts, we will be going into it...” #4, Medical doctor/ academic.

Some participants had the belief that larger research institutes or relevant ministries could be drafted to provide training to the smaller educational institutes or local government bodies. There was a sense of “duty” attached to studying all aspects of climate change impacts for the environmentalists in Puducherry tied in with a search for a starting point.

4.3. Research slowed by unavailability and limited access to quality data

Participants described critical gaps in monitoring, surveillance and database development, all of which were perceived to hamper research conduction, especially for health data. First, merging health data from the many healthcare facilities within Puducherry was seen as a challenge. There was an expressed need to bring together health data for the entire UT in a single system, including public and private healthcare facilities.

Second, some participants mentioned the state-level government health-monitoring database. However, participants described this as being limited to selected diseases from all the government run primary healthcare centres, with limited information on the private sector or secondary and tertiary care hospitals. A few participants described the lack of disease-specific categorization of health outcomes, making it an added challenge in conducting health related research.

Third, participants also perceived private medical colleges and healthcare facilities as reluctant to share data with the government, with a felt need to enhance governmental efforts to work on the state wide database. Fourth, on a related note, concerns about data quality were mentioned by several participants. Part of the reason for an unwillingness to share data by healthcare facilities was thought to be due to potentially inaccurate or poor quality data.

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3 458 *“They're all afraid of like somebody will find a fault with that. So because they don't have*
4 459 *manpower to look at the accurate or clean the data, okay, so somebody shares and later they*
5 460 *find their mistake, and they will be answerable to the higher authority. So that's the usual*
6 461 *reason we do not to share the data, the insecurity.” #3, Medical doctor/academic.*
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10 463 Another challenge shared was the slow, ongoing effort to digitalize the data. Participants
11 464 described as feeling unmotivated to start research at the cost of manually sorting through
12 465 thousands of paper records, unless there was a way to guarantee research output. This was
13 466 also relate to a challenge of medical professionals being overburdened with work.

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16 467 *“There is not even a digitalization...Many hospital doesn't have digitalized MRD [medical*
17 468 *records department]. For example, I was doing a study, retrospective study, collecting infective*
18 469 *endocarditis data for past 10 years, there are more than 1000 files. How can I go through the*
19 470 *1000 files? It's not possible.” #13, Practicing physician.*
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23 471 Surveillance of diseases was mentioned as ongoing work. Diabetes, hypertension, cervical
24 472 cancer and other ‘notifiable’ diseases like infectious diseases were described as being under
25 473 surveillance.
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28 475 **DISCUSSION**

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30 476 This research examined barriers faced in conducting climate change and health research by
31 477 key stakeholders in Puducherry. The localized findings relatively remain relevant for India and
32 478 can be extrapolated to other LMIC settings [28]. Four main themes emerged from this
33 479 research, which are discussed below.

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36 480 First, we found limited knowledge of relevant policies, especially amongst the participants
37 481 with a medical background. In recent years, there have been a lot of strides taken in the Indian
38 482 policy space with pertaining to climate change and health, such as the addition of the Health
39 483 Pillar to the NAPCC and the subsequent development of the NAPCCHH and mandates for the
40 484 development of the State level action plans for climate change and health [17, 18]. Although
41 485 the Health Pillar is a relatively recent addition (2015), there was still a substantial lack of
42 486 awareness on the NAPCC as well as the health mission in general, which we present as a key
43 487 area for strengthening. Knowledge of such policies, especially if they can provide a framework
44 488 to support related research, is a useful tool to advance the research agenda on climate change
45 489 and health [36, 37] . Health system vulnerabilities are already being seen in Puducherry and
46 490 active knowledge of such policies can also be utilized by relevant stakeholders to develop
47 491 resilience focused interventions. This includes communicating the severity of the problem to
48 492 the policy makers, who generally lack the political will to divert resources to non-apparent
49 493 problems, alluded to by the participants in this study and identified in other studies [38, 39].

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52 494 Second, participants perceived climate change and health as a topic lacking political support
53 495 and prioritization. Most political efforts are thought to be focused on mitigation measures
54 496 such as air pollution control, with little importance given to health adaptation and healthcare
55 497 resilience. The participants believed that the health impacts of climate change were not a
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3 498 political priority or seen as urgent. Similar findings have been elucidated in other studies
4 499 which also found public health leadership on climate change to be fragmented [27, 40].
5 500 Further efforts to inform the decision makers on the importance of health adaptation might
6 501 contribute to more evidence informed climate change and health policies [41, 42]. As an
7 502 added justification for health co-benefits of mitigation can be introduced through multiple
8 503 pathways, including air pollution, lifestyle modification, health surveillance or research
9 504 programs in development or related policies [43, 44].

13 505 Participants also highlighted weaknesses in inter-departmental co-ordination for working on
14 506 climate change and health. We found almost unanimous support for a separate inter-sectoral
15 507 body focused specifically on climate change and health. Methodological challenges in the light
16 508 of limited technical knowledge and adequate inter-sectorial coordination and support for
17 509 transdisciplinary capacity that we found have also been reported elsewhere [29, 45]. A recent
18 510 study on the knowledge, attitudes and practices related to climate change and health among
19 511 the Indian health workforce found intermediate or delayed health impacts of climate change
20 512 less commonly identified [26]. This could also support the development of regional, national
21 513 or even international research networks facilitating knowledge sharing and transfer, including
22 514 research methodology support [29].

27 515 The siloed operations of 'health' and 'climate change' was also seen as a research barrier. This
28 516 was partially due to the unclear division of responsibilities and fragmented institutional focus,
29 517 as also seen in other studies [29, 40, 46]. A study examining the challenges for the Californian
30 518 public health sector in climate change found the compartmentalization and lack of inter-
31 519 sectorial coordination to limit work on inter-sectoral issues such as climate change and health
32 520 [27]. Our findings point to the need to have regular national level conferences or improved
33 521 science dissemination systems to communicate climate adaptation related research or plans
34 522 between and across sectors.

38 523 Third, participants perceived gaps in formal education and training on climate change and
39 524 health. Our respondents had varied views regarding education on climate change or its health
40 525 impacts; however, the need to improve this was clearly described by participants in this study.
41 526 The need for strengthening capacity and education has been a common finding in several
42 527 other global studies. Globally, there is a critical gap and scope for improvement in the
43 528 education on health impacts of climate change, especially for medical practitioners [25, 27,
44 529 47-54]. A study comparing medical curriculums across the world found inconsistencies
45 530 between environmental changes, health and community needs, with Indian and Chinese
46 531 students especially having a gap in the inclusion of planetary health in medical schools [50].
47 532 The inclusion of planetary health from an early stage for medical students leads to a more
48 533 active role of physicians in educating their patients about climate risks [50, 55]. However,
49 534 there is a need to validate the results in future studies given the inconsistencies in the views
50 535 we found on climate change-health education. The emphasis on cure rather than prevention,
51 536 which has shown to reduce long term healthcare costs, could support the need for
52 537 Puducherry to focus on the preventative aspects, largely through education and awareness
53 538 [24]. We also found scepticism and low awareness on the non-conventional health impacts
54 539 of climate change, such as CVDs. These health impacts were thought to be viewed as 'invisible'
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3 540 compared to more conventional or immediate impacts, such as air pollution or extreme
4 541 events. This is also a commonly identified challenge to climate change and health research,
5 542 accompanied by insufficient education about climate systems during the course of school or
6 543 university education [26, 56].
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9 544 Fourth, technical research barriers we found included insufficient data, capacity, human and
10 545 financial resources. Data barriers remain common challenges in public health research,
11 546 despite efforts to facilitate improvements [57, 58]. As Puducherry has the advantage of a
12 547 relatively small size and well-connected healthcare facilities, efforts need to be taken to
13 548 improve a central, disease specific data collection system, incorporating all the healthcare
14 549 facilities in the State [59]. Facilitating training to build local data analysis expertise and
15 550 capacity would contribute to more region specific research on the topic [60]. As was also
16 551 made apparent in this study, other studies have shown that health impacts of climate change
17 552 are a relatively new concept and not inherently associated with climate, potentially explaining
18 553 the uncertainties and scepticism expressed by our participants, especially for diseases that do
19 554 not warrant a visit to the doctor [61, 62]. On the positive side, the expressed desire of
20 555 participants to learn more about it and make changes to the healthcare system and policies
21 556 based on robust, conclusive evidence implies a willingness to adapt and implement changes
22 557 in how the region tackles health impacts of climate change [49, 63]. Resource and funding
23 558 constraints are one of the most common barriers to public health research, especially in LMICs
24 559 and there remains a critical need to address this gap [64].
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31 560 At present, little is known on CVD impacts of climate change in India. Our related study from
32 561 Puducherry found a high attributable burden of non-optimal temperature to CVD mortality,
33 562 suggesting a need for similar studies from around the country [65, 66]. The CVD specific
34 563 challenges we identified here are comparable to the general health challenges. Awareness
35 564 among the medical community on the environmental risk factors of CVDs will be instrumental
36 565 in furthering this research agenda, while awareness among policy makers will help raise the
37 566 political prioritization of CVD impacts of climate change [24, 67, 68].
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41 567 Limitations

42 568 First, the sample was restricted to Puducherry district and not representative of the entire
43 569 Union Territory of Puducherry, much less India as a whole, although the projected population
44 570 for Puducherry is 1.25 million in 2021, comparable to a few smaller countries or global regions
45 571 [69]. The results might thus only reflect the studied context and participants. Secondly, while
46 572 we chose to focus on the medical community and DSTE representatives working on climate
47 573 change, we did not include the experiences and perspectives of other public health
48 574 professionals or stakeholders. Third, we do not highlight the opportunities for increasing
49 575 research on climate change and health as many of these are very often interconnected with
50 576 barriers. However, we do discuss potential recommendations given by stakeholders.
51 577 Nonetheless, the results of this study could be useful for the research community and policy
52 578 makers alike to strengthen climate change and health research and engagement.
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57 579 Conclusion

58 580 There is a great need to fill the gap in research on the impacts of climate change on various
59 581 health outcomes in India, especially in light of the vulnerabilities it faces. By highlighting some
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3 582 crucial barriers to environmental health research faced by relevant professionals, we present
4 583 potential intervention points for consideration. Insufficient awareness on health impacts of
5 584 climate change and perceived need to improve research capacity through collaborative work;
6 585 and challenges in data availability emerged as the largest barriers to conducting research on
7 586 this topic in Puducherry. We outlined the gaps and scope for addressing these through
8 587 improved policy awareness; informed leadership and evidence informed climate change and
9 588 health policies; research capacity strengthening and transdisciplinary research and
10 589 communication network; improved education on climate change and health on all levels; and
11 590 addressing data barriers in climate change through improved monitoring and evaluation
12 591 systems. The key findings could contribute to supporting and strengthening evidence-
13 592 informed climate resilient healthcare systems. In addition, it would also serve to inform and
14 593 strengthen the research and institutional support for environmental health research in the
15 594 future both in India and globally.

21 595 **Figure legends**

22 596 *Figure 1:* A framework for health adaptation action in the context of climate change based on
23 597 level of knowledge, perceived health risks, policy and institutional support and public
24 598 engagement. The circled part highlights the thematic areas we focus on in this work, namely
25 599 institutional determinants and its challenges.

26 600 *Figure 2:* An overview of the thematic framework and salient findings for the four themes
27 601 explored in this paper. The four main themes are: (i) Institutional framework: knowledge on
28 602 policies; (ii) Political and institutional; (iii) Educational and informational; and (iv) Technical
29 603 research barriers.

30 604 **DECLARATIONS**

31 605 **Competing interests**

32 606 The authors declare that they have no competing interests.

33 607 **Author contributions**

34 608 S.S, M.R, M.A.D, J.U and G.C conceptualized and planned the study. S.S and R.L acquired and
35 609 provided access to the data. R.L facilitated the interviews. S.M and S.S designed the study. T.L
36 610 validated the codes and codebook. O.C, S.S and S.M conceptualized and structured the
37 611 framework. S.S wrote the main manuscript with inputs from all authors. The final manuscript
38 612 has been revised by all authors.

39 613 **Ethics approval statement**

40 614 This study was approved by the Institute Ethics Committee (Human Studies) of the Indira
41 615 Gandhi Medical College and Research Institute (A Government of Puducherry Institution); No.
42 616 318/IEC-31/IGM&RI/PP/2021 and by the Ethics Committee Northwest and Central
43 617 Switzerland (EKNZ); Statement ID- AO_2020_00034. The methodology used in this project
44 618 abided by the principles laid out in the Declaration of Helsinki and the COREQ checklist.

45 619 All participants were verbally explained the project and its objectives as well as being provided
46 620 information sheets. All participants were made aware of their right to refuse participation at

any point prior to publication of the study. Signed informed consent was obtained from all participants prior to the interviews, with participants retaining one copy.

Acknowledgements

The authors would like to extend their sincere gratitude to all the participants who made this study possible.

Funding sources

S.S has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 801076, through the SSPH+ Global PhD Fellowship Programme in Public Health Sciences (GlobalP3HS) of the Swiss School of Public Health and from the Joint South Africa and Swiss Chair in Global Environmental Health.

O.C has been funded by the Swiss Government Excellence Scholarship (ESKAS) Id. 2020 0742.

Data availability statement

All relevant data from this study has been included in the Supplementary material. As this is a qualitative study with a small number of key informants, making the full dataset and interview transcripts available to a wider audience could potentially breach the confidentiality commitment made to the participants during the process of obtaining informed consent as well as to the ethics committees that approved this study. Therefore, this data will not be made available.

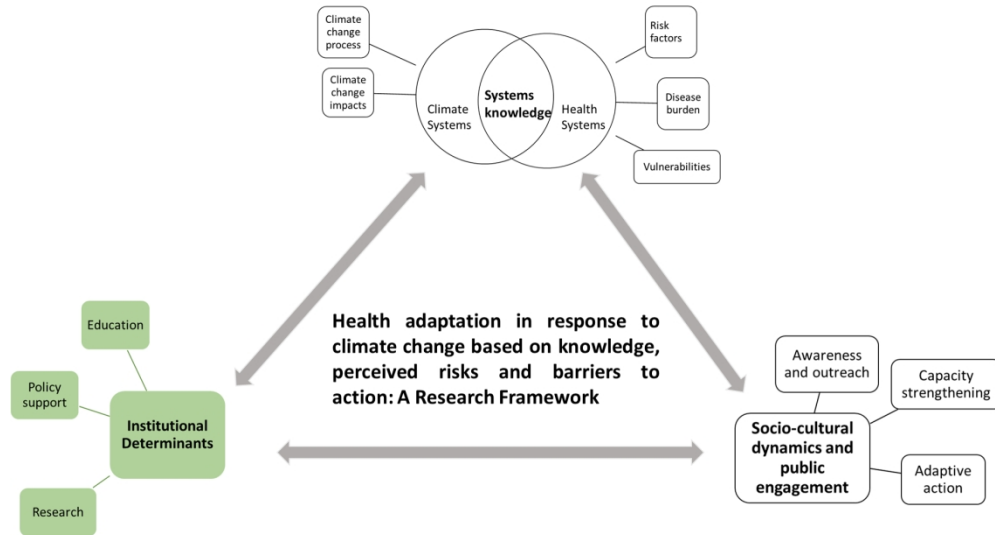
References

1. Rocque, R.J., et al., *Health effects of climate change: an overview of systematic reviews*. BMJ open, 2021. **11**(6): p. e046333.
2. Cissé, G., R. McLeman, H. Adams, P. Aldunce, K. Bowen, D. Campbell-Lendrum, S. Clayton, K.L. Ebi, J. Hess, C. Huang, Q. Liu, G. McGregor, J. Semenza, and M.C. Tirado, *Health, Wellbeing, and the Changing Structure of Communities*, in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* D.C.R. H-O. Pörtner, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama, Editor. 2022, IPCC: Cambridge, UK and New York, NY, USA. p. 1041-1170.
3. WHO. *Climate change and health*. Fact sheets 2021; Available from: <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>.
4. Patz, J.A., et al., *Impact of regional climate change on human health*. Nature, 2005. **438**(7066): p. 310-7.
5. Watts, N., et al., *The 2020 report of the Lancet Countdown on health and climate change: responding to converging crises*. Lancet, 2021. **397**(10269): p. 129-170.
6. Cisse, G., *Food-borne and water-borne diseases under climate change in low- and middle-income countries: Further efforts needed for reducing environmental health exposure risks*. Acta Trop, 2019. **194**: p. 181-188.
7. Rocha, J., et al., *Climate change and its impacts on health, environment and economy*, in *One Health*. 2022, Elsevier. p. 253-279.

- 1
- 2
- 3 663 8. Wise, R.M., et al., *Reconceptualising adaptation to climate change as part of pathways of*
- 4 664 *change and response*. Global environmental change, 2014. **28**: p. 325-336.
- 5 665 9. Haines, A., et al., *Health risks of climate change: act now or pay later*. Lancet, 2014.
- 6 666 **384**(9948): p. 1073-5.
- 7 667 10. Kjellstrom, T., *Climate change, direct heat exposure, health and well-being in low and*
- 8 668 *middle-income countries*. Glob Health Action, 2009. **2**.
- 9 669 11. Scheelbeek, P.F.D., et al., *The effects on public health of climate change adaptation*
- 10 670 *responses: a systematic review of evidence from low- and middle-income countries*. Environ
- 11 671 Res Lett, 2021. **16**(7): p. 073001.
- 12 672 12. Ebi, K.L., R.S. Kovats, and B. Menne, *An approach for assessing human health vulnerability*
- 13 673 *and public health interventions to adapt to climate change*. Environmental health
- 14 674 perspectives, 2006. **114**(12): p. 1930-1934.
- 15 675 13. Gioli, G., T. Khan, and J. Scheffran, *Climatic and environmental change in the Karakoram:*
- 16 676 *making sense of community perceptions and adaptation strategies*. Regional Environmental
- 17 677 Change, 2014. **14**(3): p. 1151-1162.
- 18 678 14. Tripathi, V., R. Akhtar, and G.S. Preetha, *Perceptions Regarding Climate Change and its*
- 19 679 *Health Impact: Reflections from a Community-Based Study in India*. Indian Journal of
- 20 680 Community Medicine, 2021. **46**(2): p. 206-209.
- 21 681 15. Nayak, S., Takemi, T, *Assessing the Impact of Climate Change on Temperature and*
- 22 682 *Precipitation Over India.*, in *Wadi Flash Floods. Natural Disaster Science and Mitigation*
- 23 683 *Engineering: DPRI reports.*, T. Sumi, Kantoush, S.A., Saber, M. , Editor. 2022: Singapore.
- 24 684 16. Dagdeviren, H., A. Elangovan, and R. Parimalavalli, *Climate change, monsoon failures and*
- 25 685 *inequality of impacts in South India*. Journal of Environmental Management, 2021. **299**.
- 26 686 17. GOI, *National Action Plan for Climate Change and Human Health*, G.o.I. Ministry of Health
- 27 687 and Family Welfare, Editor. 2018.
- 28 688 18. GOI, G.o.I., *India's National Action Plan on Climate Change*. 2009.
- 29 689 19. Bush, K.F., et al., *Impacts of climate change on public health in India: future research*
- 30 690 *directions*. Environmental Health Perspectives, 2011. **119**(6): p. 765-770.
- 31 691 20. Singh, P.K. and R.C. Dhiman, *Climate change and human health: Indian context*. Journal of
- 32 692 vector borne diseases, 2012. **49**(2): p. 55.
- 33 693 21. Gill, M. and R. Stott, *Health professionals must act to tackle climate change*. Lancet, 2009.
- 34 694 **374**(9706): p. 1953-1955.
- 35 695 22. Roberts, I., R. Stott, and C.H. Council, *Doctors and climate change*. British Medical Journal,
- 36 696 2010. **341**.
- 37 697 23. Moser, A.M., F.L. Stigler, and B. Haditsch, *Physicians' responsibility for planetary health*.
- 38 698 Lancet Planetary Health, 2017. **1**(2): p. E56-E56.
- 39 699 24. Sainsbury, P., et al., *Climate change is a health issue: what can doctors do?* Internal Medicine
- 40 700 Journal, 2019. **49**(8): p. 1044-1048.
- 41 701 25. Hathaway, J. and E.W. Maibach, *Health Implications of Climate Change: a Review of the*
- 42 702 *Literature About the Perception of the Public and Health Professionals*. Curr Environ Health
- 43 703 Rep, 2018. **5**(1): p. 197-204.
- 44 704 26. Vishvaja Sambath, S.N., Punita Kumar, Pooja Kumar, Adithya Pradyumna, *Knowledge,*
- 45 705 *attitudes and practices related to climate change and its health aspects among the*
- 46 706 *healthcare workforce in India – A cross-sectional study*. The Journal of Climate Change and
- 47 707 Health, 2022. **6**.
- 48 708 27. Gould, S. and L. Rudolph, *Challenges and Opportunities for Advancing Work on Climate*
- 49 709 *Change and Public Health*. Int J Environ Res Public Health, 2015. **12**(12): p. 15649-72.
- 50 710 28. Mallen, E., et al., *Overcoming Barriers to Successful Climate and Health Adaptation Practice:*
- 51 711 *Notes from the Field*. International Journal of Environmental Research and Public Health,
- 52 712 2022. **19**(12): p. 7169.
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1
2
3 713 29. Leal Filho, W., et al., *Implementing climate change research at universities: Barriers,*
4 714 *potential and actions.* Journal of Cleaner Production, 2018. **170**: p. 269-277.
- 5 715 30. GOI, *Census of India- Puducherry.* 2011, Government of India.
- 6 716 31. DTEE. *Puducherry Climate Change Cell.* Available from:
7 717 https://dste.py.gov.in/PCCC/PCCC_Projects.html.
- 8 718 32. Shrikhande, S.S., et al., *"Climate Change and Health?": Knowledge and Perceptions among*
9 719 *Key Stakeholders in Puducherry, India.* International Journal of Environmental Research and
10 720 Public Health, 2023. **20**(6): p. 4703.
- 11 721 33. Gale, N.K., et al., *Using the framework method for the analysis of qualitative data in multi-*
12 722 *disciplinary health research.* BMC Medical Research Methodology, 2013. **13**.
- 13 723 34. van Eck, C.W., B.C. Mulder, and S. van der Linden, *Climate Change Risk Perceptions of*
14 724 *Audiences in the Climate Change Blogosphere.* Sustainability, 2020. **12**(19).
- 15 725 35. Rudolph, L. and S. Gould, *Climate Change and Health Inequities: A Framework for Action.*
16 726 *Ann Glob Health,* 2015. **81**(3): p. 432-44.
- 17 727 36. Crouzat, E., et al., *Researchers must be aware of their roles at the interface of ecosystem*
18 728 *services science and policy.* Ambio, 2018. **47**(1): p. 97-105.
- 19 729 37. van Valkengoed, A.M., G. Perlaviciute, and L. Steg, *Relationships between climate change*
20 730 *perceptions and climate adaptation actions: policy support, information seeking, and*
21 731 *behaviour.* Climatic Change, 2022. **171**(1-2).
- 22 732 38. Hussey, L.K. and G. Arku, *Conceptualizations of climate-related health risks among health*
23 733 *experts and the public in Ghana.* Social Science & Medicine, 2019. **223**: p. 40-50.
- 24 734 39. Austin, S.E., et al., *Enabling local public health adaptation to climate change.* Social Science
25 735 & Medicine, 2019. **220**: p. 236-244.
- 26 736 40. Robbert Biesbroek, J.K., Catrien Termeer, and Pavel Kabat, *Barriers to climate change*
27 737 *adaptation in the Netherlands.* Climate Law, 2011. **2**(2): p. 181-199.
- 28 738 41. Oxman, A.D., et al., *SUPPORT Tools for evidence-informed health Policymaking (STP) 15:*
29 739 *Engaging the public in evidence-informed policymaking.* Health research policy and systems,
30 740 2009. **7**(1): p. 1-9.
- 31 741 42. Uzochukwu, B., et al., *The challenge of bridging the gap between researchers and policy*
32 742 *makers: experiences of a Health Policy Research Group in engaging policy makers to support*
33 743 *evidence informed policy making in Nigeria.* Globalization and health, 2016. **12**(1): p. 1-15.
- 34 744 43. Haines, A., *Health co-benefits of climate action.* Lancet Planet Health, 2017. **1**(1): p. e4-e5.
- 35 745 44. Haines, A., et al., *Public health benefits of strategies to reduce greenhouse-gas emissions:*
36 746 *overview and implications for policy makers.* Lancet, 2009. **374**(9707): p. 2104-2114.
- 37 747 45. Xun, W.W., et al., *Climate change epidemiology: methodological challenges.* International
38 748 Journal of Public Health, 2010. **55**(2): p. 85-96.
- 39 749 46. Eisenack, K., et al., *Explaining and overcoming barriers to climate change adaptation.* Nature
40 750 Climate Change, 2014. **4**(10): p. 867-872.
- 41 751 47. Yang, L., et al., *Associations between Knowledge of the Causes and Perceived Impacts of*
42 752 *Climate Change: A Cross-Sectional Survey of Medical, Public Health and Nursing Students in*
43 753 *Universities in China.* Int J Environ Res Public Health, 2018. **15**(12).
- 44 754 48. Kotcher, J., et al., *Views of health professionals on climate change and health: a*
45 755 *multinational survey study.* Lancet Planet Health, 2021. **5**(5): p. e316-e323.
- 46 756 49. Corner, A., *PSYCHOLOGY Science literacy and climate views.* Nature Climate Change, 2012.
47 757 **2**(10): p. 710-711.
- 48 758 50. Omrani, O.E., et al., *Envisioning planetary health in every medical curriculum: An*
49 759 *international medical student organization's perspective.* Med Teach, 2020. **42**(10): p. 1107-
50 760 1111.
- 51 761 51. Whitley, C.T., et al., *Sustainability behaviors among college students: an application of the*
52 762 *VBN theory.* Environmental Education Research, 2018. **24**(2): p. 245-262.
- 53
54
55
56
57
58
59
60

- 1
2
3 763 52. Chaplin, G. and P. Wyton, *Student engagement with sustainability: understanding the value-*
4 764 *action gap*. International Journal of Sustainability in Higher Education, 2014. **15**(4): p. 404-
5 765 417.
- 6 766 53. Andersen, J.G., et al., *Perspectives of Local Community Leaders, Health Care Workers,*
7 767 *Volunteers, Policy Makers and Academia on Climate Change Related Health Risks in Mukuru*
8 768 *Informal Settlement in Nairobi, Kenya-A Qualitative Study*. International Journal of
9 769 Environmental Research and Public Health, 2021. **18**(22).
- 10 770 54. Eagle, L., et al., *Attitudes of undergraduate business students toward sustainability issues*.
11 771 International Journal of Sustainability in Higher Education, 2015. **16**(5): p. 650-668.
- 12 772 55. Shaman, J. and K. Knowlton, *The Need for Climate and Health Education*. Am J Public Health,
13 773 2018. **108**(S2): p. S66-S67.
- 14 774 56. McMichael, A.J., *Impediments to comprehensive research on climate change and health*. Int J
15 775 Environ Res Public Health, 2013. **10**(11): p. 6096-105.
- 16 776 57. van Panhuis, W.G., et al., *A systematic review of barriers to data sharing in public health*.
17 777 BMC Public Health, 2014. **14**.
- 18 778 58. Lazem, M. and A. Sheikhtaheri, *Barriers and facilitators for disease registry systems: a mixed-*
19 779 *method study*. BMC Medical Informatics and Decision Making, 2022. **22**(1).
- 20 780 59. Lakshmanasamy Ravivarman, P.K. *A10 Medically certified causes of death and risk factors in*
21 781 *mortality, Puducherry district, India, 2016-19*. 2020. BMC Proc 15 (Suppl 11).
- 22 782 60. Levison, M.M., et al., *Development of a Climate Change Vulnerability Assessment Using a*
23 783 *Public Health Lens to Determine Local Health Vulnerabilities: An Ontario Health Unit*
24 784 *Experience*. International Journal of Environmental Research and Public Health, 2018. **15**(10).
- 25 785 61. Valois, P., et al., *The Health Impacts of Climate Change: A Continuing Medical Education*
26 786 *Needs Assessment Framework*. J Contin Educ Health Prof, 2016. **36**(3): p. 218-25.
- 27 787 62. Herrmann, A. and R. Sauerborn, *General Practitioners' Perceptions of Heat Health Impacts on*
28 788 *the Elderly in the Face of Climate Change A Qualitative Study in Baden-Wurttemberg,*
29 789 *Germany*. International Journal of Environmental Research and Public Health, 2018. **15**(5).
- 30 790 63. Paterson, J., et al., *Health Care Facilities Resilient to Climate Change Impacts*. International
31 791 Journal of Environmental Research and Public Health, 2014. **11**(12): p. 13097-13116.
- 32 792 64. Shumba CS, L.A., *Not enough traction: Barriers that aspiring researchers from low- and*
33 793 *middle-income countries face in global health research*. Journal of Global Health Economics
34 794 and Policy, 2021. **1**.
- 35 795 65. Shrikhande, S., Pedder, H., Roosli, M., Dalvie, MA., Lakshmanasamy. R., Gasparrini, A.,
36 796 Utzinger, J., Cisse. G, *Non-optimal apparent temperature and cardiovascular mortality: the*
37 797 *association in Puducherry, India between 2010 and 2020*. Research Square 2022.
- 38 798 66. Bhatia, M., et al., *Impending epidemic of cardiovascular diseases among lower*
39 799 *socioeconomic groups in India*. The Lancet Healthy Longevity, 2021. **2**(6): p. e314-e315.
- 40 800 67. Sheffield, P.E., et al., *Emerging Roles of Health Care Providers to Mitigate Climate Change*
41 801 *Impacts: A Perspective from East Harlem, New York*. Health and Human Rights, 2014. **16**(1):
42 802 p. 113-121.
- 43 803 68. Dupraz, J. and B. Burnand, *Role of Health Professionals Regarding the Impact of Climate*
44 804 *Change on Health-An Exploratory Review*. International Journal of Environmental Research
45 805 and Public Health, 2021. **18**(6).
- 46 806 69. GovernmentOfPuducherry. *About Puducherry District*. 2022 25/03/2022]; Available from:
47 807 <https://puducherry-dt.gov.in/history/>.
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A framework for health adaptation action in the context of climate change based on level of knowledge, perceived health risks, policy and institutional support and public engagement. The circled part highlights the thematic areas we focus on in this work, namely institutional determinants and its challenges.

333x207mm (150 x 150 DPI)

Institutional framework: knowledge on policies	<ul style="list-style-type: none"> • Limited knowledge and awareness on climate change and health related policies
Political and institutional barriers	<ul style="list-style-type: none"> • Disengaged leadership and low political prioritization of climate change and health • Weak inter-departmental integration and co-ordination for climate change and health
Educational and informational barriers	<ul style="list-style-type: none"> • Gaps in higher education curricula • Weakness in inter-sectoral knowledge • Scepticism and low awareness on non-conventional health impacts of climate change
Technical barriers and research	<ul style="list-style-type: none"> • Insufficient resources and workforce dedicated to research • Underdeveloped transdisciplinary research capacity • Unavailability and limited access to quality data

An overview of the thematic framework and salient findings for the four themes explored in this paper. The four main themes are: (i) Institutional framework: knowledge on policies; (ii) Political and institutional; (iii) Educational and informational; and (iv) Technical research barriers.

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Supplementary material

1. Interview questions guide for medical professionals and members of the Department of Science, Technology and Environment (DSTE) working on the Puducherry State Adaptation plan

COMMON QUESTIONS

Table S1: Common interview question guide based on the participant group.

Target group	Themes	Aims	Questions
COMMON	Participant information	To get the basic demographic and professional information about the participant	<ol style="list-style-type: none"> 1. Age 2. Nationality 3. Place of residence 4. Educational background and speciality 5. Occupation 6. Years in occupation 7. Professional experience related to climate change and/or health
	Background knowledge- climate change	To establish level of knowledge about climate change with 'warm up' questions	<ol style="list-style-type: none"> 1. What comes to mind when you think of climate change? 2. What do you think are physical manifestations of climate change? 3. Have you experienced or been aware of any climate change events in the past few years? 4. What, according you, are the most common consequences of climate change?- Which aspects of life do they affect most severely?
	Climate change and health, climate change and CVDs	To establish knowledge/ awareness about climate change and health and climate change and CVDs	<ol style="list-style-type: none"> 1. Have you ever thought about the health impacts of climate change? 2. What aspects of human health do you think climate change will have the biggest impact on? 3. Are you aware about the impacts of climate change on NCDs such as cardiovascular diseases? <ol style="list-style-type: none"> 3.1. If yes to above question, what do you know about it? How do you know about it (eg

			through research or through professional experience?)
	Policies and plans	To establish knowledge and awareness levels about policies and plans on the issue of climate change and health	<ol style="list-style-type: none"> 1. Are you aware or have you been part of any policies/plans/programs on the issue of climate change and health? 2. If yes, what were/are they?-What diseases or health topic did it focus on? What was the work done (aim)? Do you think it was successful and beneficial? 3. Do you know any plans/programs specifically targeting climate change and heart diseases? (can be from any sector). 4. Do you know about the national/state climate change adaptation plan? 5. If yes, do you know of the role health plays in it?
	Challenges and outlook	To understand challenged faced, potential solutions and planned changes	<ol style="list-style-type: none"> 1. Are you aware of any upcoming or recent changes to the health adaptation plans or any other relevant policy that target climate change and health? 2. Do you know any policies which can be used to increase awareness and research on the impact of climate change on CVDs in India? 3. According to you, what are the biggest drawbacks and challenges faced- why do you think health or NCD impacts of climate change are not a priority? 4. What can be done to change that? 5. Can you think of some measures to mitigate the impacts of climate change? <ul style="list-style-type: none"> - Your contribution to mitigating the impact, whether it's individual or you think it should

			<p>be more at a governmental level?</p> <ul style="list-style-type: none"> - Examples can be green healthcare facilities etc
<p>Medical Professionals</p>	<p>Climate change and health-medical experience</p>	<p>To understand perceptions on the extent to which climate/temperature affects patient health</p>	<ol style="list-style-type: none"> 1. Do you think climate, especially temperature affects health based on hospital admissions and mortality? 2. Can you explain what you have observed (eg, more patients on particularly hot days). 3. Which diseases have you observed to be the most sensitive to climate/temperature? 4. Based on your day to day observations, do you see an association between temperature and CVDs? 5. Do you think we will see an increase in the CVD deaths attributable to temperature in the future?
	<p>Population vulnerability</p>	<p>To understand views on how different people are affected based on demography</p>	<ol style="list-style-type: none"> 1. Which people have you observed to be the most vulnerable to temperature? (eg, age, gender, occupation, SE status etc) 2. Do you see a big gender difference in CVD patients with and without the influence on external temperatures? 3. Have you observed an association between age/gender and temperatures? For example, are a certain group of people more susceptible to heat or cold? 4. Do the public and private sectors work together during disasters? <ul style="list-style-type: none"> - How is the communication, facility and equipment sharing?
	<p>Education and training</p>	<p>To understand level of training and awareness among</p>	<ol style="list-style-type: none"> 1. Have you ever been explicitly trained, either during medical school or

		doctors on climate sensitive diseases	<p>professionally, on climate sensitive diseases?</p> <ol style="list-style-type: none"> If yes, where did the course take place (India or abroad, college or professional) and what did it cover (broadly) If yes, did the course include CVDs? Did it include gender differences in terms of symptoms? Do you think such a course is needed or would be beneficial?
	Measures to be taken	To discuss possible measures to be taken to increase awareness and preparedness on climate sensitive diseases	<ol style="list-style-type: none"> Assuming that we will be seeing an increase in CVD mortalities attributable to temperature in the future, what measures do you think can be taken to prepare and adapt to it? <ul style="list-style-type: none"> In hospitals, in medical schools, Give an example..early warning systems, emergency cardio bays in hospitals, awareness drives etc What policy measures do you feel would benefit with the issue of climate sensitive diseases? For CVDs?
Health department (policy makers, ministerial representatives)	Current policies	To understand current health policies and whether climate change is included in them- include CVD policies and training	<ol style="list-style-type: none"> Do any of the current health policies include climate change? Are there any specific policies on climate sensitive diseases? <ul style="list-style-type: none"> Guidelines for disasters Guidelines for heat If yes, do any policies include NCDs or CVDs specifically?
	Challenges and outlook	To understand current challenges and future plans	<ol style="list-style-type: none"> The national adaptation plan recently added health as one of its climate change missions- why do you think this was not always a priority?

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			<ol style="list-style-type: none"> 2. FOR PUDUCHERRY- Why is there no health mission in the state adaptation plan? Are there plans to include it? If yes, what diseases will be focused on? 3. Are any activities being planned around climate sensitive diseases especially CVDs? <ul style="list-style-type: none"> - Awareness programs - Education and training in medical schools? 4. Are there any plans to develop and expand heat action plans nationally? (eg. Ahmedabad heat action plan) 5. Which diseases will be a priority area for climate sensitivity in terms of policy and research? 6. Is there any research or study being conducted on the health impacts of climate change? Are there any plans to do so? 7. CVD effects and most other effects of climate change affect vulnerable populations most-how do you plan to address some of these challenges? <ul style="list-style-type: none"> - Rural vs urban exposures and requirements differ. Are there plans that specifically target different populations? - What about different communities? Do you feel different communities have different needs to protect themselves against the climate? Can you elaborate? - What about different SE groups?
<p>Department of Science, Technology and Environment</p>	<p>Current policies</p>	<p>To understand the development process of the adaptation plan and how health is</p>	<ol style="list-style-type: none"> 1. The adaptation plan has recently added a health mission, but it does not have a comprehensive list and guidelines for climate

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		included in current policies	<p>sensitive disease management?</p> <ol style="list-style-type: none"> 2. The adaptation plan is an intersectional plan with involvement from many departments. Does the steering committee have regular meetings to review and stay prepared, if so how often? <ul style="list-style-type: none"> - Review meetings? - Do you make changes to the plan based on new evidence or incidences? 3. Is there a reason that NCDs such as CVDs, despite having a huge burden of disease are not explicitly included and researched in terms of climate attributable burden? 4. What plans/programs/campaigns are presently ongoing that deal with climate-health adaptation? Are there any specific to CVDs? 5. Can you tell me about any plans or policies that have been previously implemented on the topic of climate sensitive diseases? <ul style="list-style-type: none"> - Were they successful and effective? - What is the present status of these? - What were the biggest challenges faced? 6. CVD effects and most other effects of climate change affect vulnerable populations most-how do you plan to address some of these challenges? <ul style="list-style-type: none"> - Rural vs urban exposures and requirements differ. Are there plans that specifically target different populations?
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			<ul style="list-style-type: none"> - What about different communities? Do you feel different communities have different needs to protect themselves against the climate? Can you elaborate? - What about different SE groups?
	Challenges and outlook	To understand challenges faced and future plans	<ol style="list-style-type: none"> 1. What is the biggest challenge in formulating and implementing climate sensitive disease policies or policies related to climate impacts on health? 2. Are there any plans to include NCDs and CVDs as a separate component of climate sensitive diseases? 3. Are there research projects planned on this topic to inform priority setting and policy formulation? 4. What measures do you think need to be taken to help formulate better , more comprehensive climate change policies that are informed by health research?
			<p>The adaptation plan is an intersectional plan with involvement from many departments. Does the steering committee have regular meetings to review and stay perpared, if so how often?</p> <ol style="list-style-type: none"> 1. Review meetings? 2. Do you make changes to the plan based on new evidence or incidences? 3.
EDUCATION- either department or medical college educators	Current practices	To understand current medical curriculum and whether climate change is included in it	<ol style="list-style-type: none"> 4. Does the current medical school curriculum include climate change with respect to diseases that are sensitive to it? 5. Do you feel this needs to be taught?

			<p>6. Do you think temperature affects diseases?</p> <p>7. What diseases do you think are most sensitive to climate change that need to be included in the curriculum?</p> <p>8. If yes to above questions, does it include gender differences?</p>
	Challenges and outlook	To understand challenges in teaching students about climate change and plans for future along with suggestions	<p>1. Are there any plans to include climate sensitive diseases in the curriculum?</p> <p>2. What other measures do you think can be taken with respect to the training of medical workers to reduce the burden of climate sensitive diseases?</p> <ul style="list-style-type: none"> - Ex, emergency bays, more ambulances or staff during days of particular temperature etc

2. Framework with themes and relevant categories

Table S2: Structural codes and framework matrix

Theme	Sub-theme	Categories
Climate change and health: systems knowledge and perceptions	Climate change as an acute and growing problem for India	
	Domino effect on impacts of climate change ultimately converges at health	
Role of institutions	Political and institutional barriers	Limited knowledge and awareness on climate change and health related policies
		Disengaged leadership and low political prioritization of climate change and health
		Weak inter-departmental integration and co-ordination for climate change and health

	Educational and informational barriers	Gaps in climate change and health in higher education curricula
		Need to strengthen inter-sectoral information dissemination
		Scepticism and low awareness on non-conventional health impacts of climate change
	Technical barriers to research	Insufficient resources and workforce dedicated to research
		Underdeveloped transdisciplinary research capacity
		Research slowed by availability and access to quality data
Socio-cultural dynamics, outreach and engagement	Need for alternate solutions, targeted campaigns and programs at all levels	
	Role of experts and famous personalities in awareness building	
	Climate informed health policies and seasonal workplace guidelines	
	Integrating climate change in the curriculum and continuing educational courses	

3. Additional supporting quotes

- i. Institutional framework: Limited knowledge and awareness on climate change and health related policies

“Priority areas means, uh, for example, climate change in the health department, there is no clear cut guidelines is there. There is no clear cut guidelines, there is no clear cut programs are not there regarding climate and health.”#16, Practicing physician

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3 ii. Institutional barriers: Disengaged leadership and climate change not seen as
4 immediate health concern
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7 *“When we practice medicine, because we are more concerned with treating*
8 *the patient rather than you know, going and finding out the cause and prevent*
9 *the incident in happening. So there the problem is a disconnect between, uh,*
10 *what is happening (and) the preventive aspects, we were not able to quantify,*
11 *especially in our setup here in India.” #2, Medical doctor/academic*
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16 iii. Institutional barriers: Integration of climate change-health as a separate, inter-
17 departmental body
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20 *“Because one thing is, it is not about criticizing some other officer, it is like they*
21 *have to do their work, not other department's work. So then the head should*
22 *accept that they have to spare their times [for] this climate change work.. It*
23 *depends on who the nodal officer is, who the higher officer is, and who the head*
24 *of the bureaucracy is. So when people are okay with working on this, things*
25 *would be fine. But people don't care things will be the other way. So, in short, I*
26 *would say that it has to come from the top down approach.”#9,*
27 *Environmentalist*
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34 iv. Technical barriers: Insufficient resources and workforce dedicated to research
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37 *““The UT of Puducherry, we do not have much data. So we need to focus and*
38 *we need manpower. We do not have the funding also it's a problem now.*
39 *Sometimes they provide funds; sometimes they do not give that adequate*
40 *funds.” #1, Practicing physician/policy advisor.*
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44 v. Technical barriers: Availability and access to quality data slowing down
45 research progress
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48 *“The state government has the, uh, database. We may not have a line list. So*
49 *without line list we cannot call it as database, but they will have each primary*
50 *health center how many patients with NCDs, diabetes, hypertension, stroke,*
51 *they have the data. So that is there. But, uh, I think last two to three years only*
52 *they started screening households for diabetes, hypertension and cervical*
53 *cancer, but not specifically targeting high risk groups. For the private side, we*
54 *don't have the database on how many are-It's not like a tuberculosis program.*
55 *We have the line list, total line list of whether they are part of the public health*
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program or the private. So there we will have a database of patients but not for the non-communicable diseases.” #3, Medical doctor/academic

“Puducherry as so many medical colleges, but all of them do not supply data to the government. They may have their own data. That’s the problem: actually we have to integrate everyone” #1, Practicing physician/policy advisor.

- vi. Technical barriers: Need for more resources and workforce dedicated to research

“One is like, if you know, India should actually allocate more funds from the GDP towards the health sector. Actually, if you speak, there is not much of research work going on. Probably in the last like three to four years, it might have picked up... Most of the Indian government funding is going to the Central Institutes. For example, if you go to any government, hospital, state run government hospital, they don't have any separate data entry and don't have any separate research. You should bringing the students into the studies, which are happening only in the institutions not in the state run hospitals. Because they actually- many funds are- see now also funds are coming to state. They're giving directly to the institutes. But no one knows where the fund goes. Ultimately, it doesn't reach the students. It disappears at the level of consultants.”#14, Practicing cardiologist

- vii. Technical barriers: Scepticism and low awareness on non-explicit health impacts of climate change

“When it comes to non communicable disease, one is this relationship it's also is not synced into us...Once people know that this is going to happen, then actually there's a percolation of knowledge that 'climate change is affecting this, and you have to look for it.' But as of now, if I go and tell a clinician that climate change is affecting NCDs, or cardiovascular disease, they will be laughing at me. They tell it's the lifestyle diseases, which is affecting them. So I'll be a fool actually for talking to them...Even if I work on it and show, if I don't have expertise, they're going to snub me off tell that "no, it's only a remote, it could be this, it could be a confounding, it could be a bias.” #4, Medical doctor/academic

- viii. Technical barriers: Need for transdisciplinary research capacity

“One important thing that I would like to register is we ourselves need to participate in certain workshops which are done by certain other people, for

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3 *example, DST [Department of Science and Technology] from New Delhi. For*
4 *example, in the last two years, the only technical work that we've done for our*
5 *city, is like this vulnerability assessment. But...we in our cell, or even officials*
6 *here, we are not pre-sensitized with all these things. So only when we take up*
7 *learnings from outside, we can execute that for our city, for our state.” #9,*
8 *Environmentalist*

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16 ix. Specific challenges in studying the cardiovascular impacts of climate change

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18 *“But non communicable disease, like cardiovascular disease, no one tells*
19 *complaints noone also correlates all those things. They just think of diabetes,*
20 *hypertension, cholesterol, and all these things maybe because of the elevated*
21 *sugar, and the BP it might have got the ,uh, cardiac complaint. Now one*
22 *doesn't correlates all the things since he has gone in the rainy-rain or since he*
23 *has got the cold. Noone correlates. And I think we should also think about all*
24 *those things.” #13, Practicing physician*

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26 *“In hospitals, even this point of you know, we are expecting more of even this*
27 *trend of increased changing of our climate and (that) has to be made aware*
28 *to people. (When we were discussing on the topic of climate change) when it*
29 *went to the clinicians, they're like, "how is it going to help me? It's not going*
30 *to help me". They are very careful with the infectious disease...”#4, Medical*
31 *doctor/academic*

COREQ (CONsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
<i>Personal characteristics</i>			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	
Occupation	3	What was their occupation at the time of the study?	
Gender	4	Was the researcher male or female?	
Experience and training	5	What experience or training did the researcher have?	
<i>Relationship with participants</i>			
Relationship established	6	Was a relationship established prior to study commencement?	
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	
Interviewer characteristics	8	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	
Domain 2: Study design			
<i>Theoretical framework</i>			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	
<i>Participant selection</i>			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	
Sample size	12	How many participants were in the study?	
Non-participation	13	How many people refused to participate or dropped out? Reasons?	
<i>Setting</i>			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	
<i>Data collection</i>			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	
Repeat interviews	18	Were repeat interviews carried out? If yes, how many?	
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	
Field notes	20	Were field notes made during and/or after the interview or focus group?	
Duration	21	What was the duration of the interviews or focus group?	
Data saturation	22	Was data saturation discussed?	
Transcripts returned	23	Were transcripts returned to participants for comment and/or	

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
<i>Data analysis</i>			
Number of data coders	24	How many data coders coded the data?	
Description of the coding tree	25	Did authors provide a description of the coding tree?	
Derivation of themes	26	Were themes identified in advance or derived from the data?	
Software	27	What software, if applicable, was used to manage the data?	
Participant checking	28	Did participants provide feedback on the findings?	
<i>Reporting</i>			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	
Data and findings consistent	30	Was there consistency between the data presented and the findings?	
Clarity of major themes	31	Were major themes clearly presented in the findings?	
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

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