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CHAPTER

MAPPING LOW-RESOURCE CONTEXTS TO PREPARE FOR LUNG HEALTH INTERVENTIONS IN FOUR COUNTRIES – A MIXED- METHOD FRESH AIR STUDY

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SUMMARY

Background Effectiveness of health programmes can be undermined when the implementation misaligns with local beliefs and behaviours. To design context-driven implementation strategies, we explored beliefs and behaviours regarding chronic respiratory disease (CRD) in diverse low-resource settings.

Methods This observational mixed-method study was conducted in Africa (Uganda), Asia (Kyrgyzstan and Vietnam) and Europe (rural Greece and a Roma camp). We systematically mapped beliefs and behaviours using the SETTING-tool. Multiple qualitative methods among purposively selected community members, health-care professionals, and key informants were triangulated with a quantitative survey among a representative group of community members and health-care professionals. We used thematic analysis and descriptive statistics.

Findings We included qualitative data from 340 informants (77 interviews, 45 focus group discussions, 83 observations of community members' households and health-care professionals' consultations) and quantitative data from 1037 community members and 204 health-care professionals. We identified three key themes across the settings; namely, (1) perceived CRD identity (community members in all settings except the rural Greek strongly attributed long-lasting respiratory symptoms to infection, predominantly tuberculosis); (2) beliefs about causes (682 [65.8%] of 1037 community members strongly agreed that tobacco smoking causes symptoms, this number was 198 [19.1%] for household air pollution; typical perceived causes ranged from witchcraft [Uganda] to a hot-cold disbalance [Vietnam]); and (3) norms and social structures (eg, real men smoke [Kyrgyzstan and Vietnam]).

Interpretation When designing context-driven implementation strategies for CRD-related interventions across these global settings, three consistent themes should be addressed, each with common and context-specific beliefs and behaviours. Context-driven strategies can reduce the risk of implementation failure, thereby optimising resource use to benefit health outcomes.

Funding European Commission Horizon 2020.

RESEARCH IN CONTEXT

Evidence before this study

To reduce the risk of implementation failure, implementation strategies need to align with locally prevailing health beliefs and behaviours. Therefore, local beliefs and behaviours should be thoroughly understood. We searched PubMed and Google Scholar for original articles and systematic reviews published up to May 6, 2021, that focused on beliefs and behaviours regarding chronic respiratory diseases in low-resource settings, with no language restrictions. We used synonyms of “beliefs” or “behaviours”, and “chronic respiratory disease” (including “COPD” or “asthma”). Evidence was highly fragmented, and studies were mostly confined to one low-resource setting, in a high-income country. Studies were generally limited to either patients’ knowledge about their disease (often in relation to adherence to inhalers or disease control), or to health-care professionals’ knowledge and adherence to guidelines, or to specific interventions (smoking cessation). Only one qualitative study and three international, quantitative studies focused on COPD-related or asthma-related beliefs in general. Overall, the available evidence demonstrated that knowledge about COPD and asthma among patients and health-care professionals was poor. The studies did not provide insights about themes that consistently played a role in low-resource communities’ beliefs and behaviours. Therefore, it is hard to determine what aspects to explore and address in implementation strategies of future lung health interventions.

Added value of this study

To address this knowledge gap, international, national academic, and community researchers teamed up to explore local beliefs and behaviours regarding chronic respiratory disease. We collected qualitative data from 340 informants in more than 200 interviews, focus groups and observations, and triangulated findings with a survey. We consistently applied the same mixed-method approach across three continents in six highly diverse settings, thereby enhancing comparability of the findings. Across slums in Uganda, highland and lowland Kyrgyzstan, rapidly developing Vietnam, austerity-impacted Greece, and an off-the-grid Roma camp we identified three common themes: (1) perceived disease identity (eg, the strong attribution of chronic symptoms to infection); (2) beliefs about causes (ranging from witchcraft in Uganda to a hot–cold disbalance in Vietnam); and (3) norms and social structures (eg, that real men smoke in Kyrgyzstan and Vietnam). We illustrated how findings were used to design context-driven implementation strategies for subsequent lung health interventions to improve their uptake. Furthermore, we provided an overview of the main characteristics per setting with their prevailing beliefs and behaviours about respiratory health to serve implementers globally; in settings with similar characteristics, implementers could be vigilant for similar beliefs and behaviours.

Implications of all the available evidence

Awareness of chronic respiratory disease is poor among low-resource communities and their health-care professionals, and leads to avoidable morbidity and mortality. This poor knowledge should be targeted by context-driven interventions that address the common and context-specific traits within the three identified themes. Future research should assess further generalisability of these themes to other settings. Furthermore, as we have learnt from the COVID-19 pandemic, there is a role for international collaboration to improve respiratory health literacy and address myths. This should be done by using a clear narrative about the identity of chronic as well as infectious disease and about their causes. Primary care is embedded in local communities and understands the local norms and social structures. Therefore, primary care has a large potential to deliver messages that align with these norms and structures, or challenge these, as required.

INTRODUCTION

WHO, global health funders, and other institutions have urged for more and better implementation research.^{1–4} Implementation failure can drain scarce resources and seriously undermine the effect of health programmes.⁵ Research is most needed for low-income and middle-income countries (LMICs), where the burden of disease is highest, health systems are weakest, and implementation evidence is scarcest.⁶

Implementation success depends on numerous factors. Critical is the compatibility between the programme, implementation strategy, and the local context, of which local health beliefs and behaviours are key dimensions.^{2,7,8} Leading theoretical models are built on the concept that health behaviour is shaped by health beliefs.^{9–11} To illustrate, three billion people still burn solid fuels (eg, wood or animal dung) daily. The resulting household air pollution (HAP) causes 3 million deaths and 86 million disability-adjusted life-years per year.¹² Improved cookstoves that generate less smoke would be a promising solution, yet for decades their adoption by local communities has been poor. Failure to understand the households' beliefs and needs, and hence failure of the stoves to meet those beliefs and needs has been a major barrier to successful implementation of the stove programmes. Discrepancy between the perceived and actual harm of HAP is another common barrier.¹³ Implementation research must explore such local beliefs and related behaviours to optimise uptake of promising interventions and enable those to enter routine practice.

Of particular interest are health beliefs and behaviours related to chronic respiratory disease (CRD) in low-resource settings; chronic obstructive pulmonary disease (COPD) is the third leading cause of death worldwide, with 90% of deaths occurring in LMICs. Also, most

asthma-related deaths occur in LMICs.^{14,15} Evidence-based interventions exist, such as cleaner cooking solutions, smoking cessation, and pulmonary rehabilitation. To increase implementation success of such interventions, strategies are needed that are aligned with the health beliefs and behaviours. Therefore, in this study we aimed to map local beliefs and behaviours regarding CRD (COPD and asthma) in diverse low-resource settings.

METHODS

This study was part of the FRESHAIR implementation research project (Free Respiratory Evaluation and Smoke-exposure reduction by primary Health cAre Integrated gRoups, NTR5759), targeting the prevention, diagnosis, and treatment of CRDs in low-resource settings.¹⁶ Reporting adheres to the STROBE statement for observational studies¹⁷ and COREQ guidelines for qualitative research.¹⁸ A scientific advisory committee supervised the quality of the design and conduct of the study (appendix 4 p 15). The methods are provided here in brief. For additional details, see our methods article,¹⁹ study protocol (available online), and appendix 4.

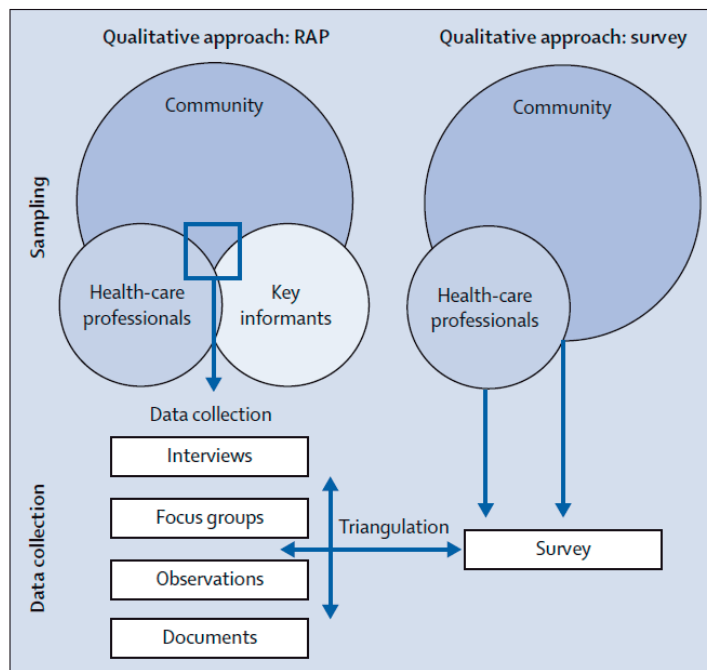


FIGURE 1: The mixed-method study design

RAP=rapid assessment process. Reproduced from Brakema and colleagues.¹⁹

Study design

We conducted a cross-sectional, mixed-method study between April 5, 2016, and Jan 27, 2017 (figure 1). Following the context-mapping method of the SETTING tool, we engaged local stakeholders and co-set study priorities; used a mixed-method design (a qualitative rapid assessment process [RAP] including in-depth interviews, focus groups, and observations of households and health-care consultations, combined with a quantitative survey); used context-sensitive materials with high validity; collected data with a trained, diverse team including community researchers; analysed the data pragmatically and in-depth; and continuously disseminated findings to relevant stakeholders to promote data use.¹⁹

A theoretical framework guided our study design and analyses. This Beliefs and Behaviours Framework was based on three well-established health behavioural models, the Theory of Explanatory Models of Illness, the Theory of Planned Behaviour, and the Health Belief Model (appendix 4 pp 2–3).^{9–11} It consisted of factors leading to (intention to conduct) CRD-related behaviour, such as the locally perceived identity of CRDs, perceived susceptibility to CRD, or barriers to change CRD-related behaviour. CRD-related behaviour included risk behaviour (eg, tobacco smoking), help-seeking behaviour by community members, and helping behaviour by health-care professionals.¹⁹

Development of our research materials¹⁹ (topic lists, observation forms, questionnaires) was also guided by the theoretical framework. Because we expected a low awareness of CRDs and their implications,²⁰ we used a syndromic approach focusing on symptoms rather than disease. To avoid potential stigmatisation for tuberculosis we used a vignette²¹ describing a relatively young woman with symptoms typical for solid fuel use-related COPD (appendix 4 pp 2–3).²² We then asked questions such as, “Are there people with a similar situation in your community?” and “What, according to you, is the cause of the situation?”. We adapted the materials to each local setting. The quantitative questionnaires included demographic questions and were a compilation of existing validated questionnaires (the revised brief-Illness Perception Questionnaire, community member risk behaviour regarding cooking or heating and tobacco use, and health-care professional treatment behaviour).^{23–27} The questionnaires for community members and health-care professionals were tailored according to our preliminary qualitative findings and pilot-tested in each setting.¹⁹

Participants provided written, informed consent. Participants who were unable to read or write provided audio-recorded, verbal consent instead. The study was approved by the coordinating centre and each local research ethical review board; namely, the Leiden University Medical Center Medical Ethical Committee (P16.063;04/15/2016), Mulago Research and Ethics Committee (933;03/31/2016), National Center of Cardiology and Internal Medicine in Bishkek Ethics

Committee (5/03/03/2016), Ho Chi Minh City University of Medicine and Pharmacy (188/DHYD-HD;06/27/2016), and 7th Health Region of Crete (6951;05/27/2016).

Setting

We purposively selected six rural low-resource settings in Uganda, Kyrgyzstan (two settings), Vietnam, and Greece (two settings) to represent diversity in geography, culture, risk factor exposure, and health-care and political system.¹⁹ We conveniently preferred sites where the research team or our engaged stakeholders had already well-established relationships with the communities. These were the Jinja district in Uganda, and the Ben Luc and Can Giuoc districts in Vietnam. In Kyrgyzstan, we selected a mountainous (Naryn) and a lowland (Chui) setting, because these differed substantially in lifestyle and risk exposure.²⁸ In Greece, we selected a Roma camp and rural areas affected by the recent economic crisis in the Heraklion region (Crete; appendix 4 pp 4–10).

Study population and sampling

Our study population comprised three groups; namely, health-care professionals, defined as any worker medically addressing CRD within the community boundaries (eg, medical doctors, nurses, and clinical officers); community members aged at least 18 years; and key informants (people with either in-depth knowledge or an overall overview of community beliefs and behaviours; eg, religious leaders, pharmacists, and traditional healers). Any person physically or mentally unable to participate was excluded. For the RAP, participants were selected purposively to represent diversity in sex, age, background, and profession, and based on snowball sampling and opportunity. The engaged stakeholders helped to identify participants. Sample size was determined by the principle of a priori and inductive thematic saturation (appendix 4 pp 4–10), which we expected to be achieved with ten to 15 health-care professional interviews, ten to 15 consultation observations, ten to 15 key informant interviews, two to three community member focus groups, and ten to 15 household observations per setting. For the quantitative survey, we randomly selected health-care professionals and community members using a three-stage sampling approach suitable for rural areas. Following the WHO Expanded Program of Immunization,^{29,30} we targeted a sample size of 210 community members per setting, from which we pragmatically derived a targeted sample of 40 health-care professionals. The rationale and randomisation process are detailed in appendix 4 (pp 11–14) and our previously published methods article.¹⁹

Procedures

First, we conducted the RAP. This is a team-based applied technique to develop an insider's perspective of a situation within a short period of time.³¹ The research team situated in local community settings collected data using multiple methods. We explored CRD-related beliefs and perceptions during focus group discussions and semi-structured interviews. We studied

community members' risk behaviours (tobacco smoking, and cooking and heating on solid fuels) during structured household observations, and health-care professional's helping behaviour during observations of respiratory consultations. Additionally, we used qualitative questionnaires and conveniently collected relevant documents, such as CRD-related elements of medical curricula.³² All team members conducted the diverse qualitative methods. To ensure data collection was driven by local needs and developments, and to work towards thematic saturation, the team conducted preliminary analyses daily.³¹ Accordingly, we iteratively adapted the data collection strategy, and identified new informants or adapted our topic lists. We audio-recorded qualitative field activities and took fieldnotes.¹⁹ Second, we conducted a survey to triangulate the qualitative findings (figure 1). The survey questionnaires were researcher administered in the local language.

Data handling and analysis

Audio recordings were transcribed verbatim, anonymised, and translated into English. Qualitative data were thematically analysed using the Framework Method.³³ Data were coded inductively and deductively, guided by the theoretical framework (Atlas.ti, version 7.5.15; appendix 4 pp 2–3). Quantitative data were analysed by descriptive statistics on the frequencies of reported beliefs and behaviours (SPSS version 25; IBM, Armonk, NY, USA). These data were used to quantify the qualitative findings (eg, to find out how many people indicated that they believed in stress as a cause for CRD). Additional information (including reflexivity) has been previously reported.¹⁹

Role of the funding source

The funders had no role in study design, data collection, analysis, interpretation, or writing of the report.

RESULTS

We included 340 qualitative informants (Uganda n=68, Kyrgyz highlands n=42, Kyrgyz lowlands n=61, Vietnam n=74, rural Greece n=73, Roma n=22). We conducted 77 interviews and 45 focus groups comprising three to eight participants, which we triangulated with observations of 61 community member households and consultations of 22 health-care professionals (appendix 4 pp 4–10). Informants had diverse ages, sex, and backgrounds. Health-care professionals ranged from physicians to medical students, and key informants from traditional healers to chairs of communal committees.

Next, we enrolled 1037 community members in the survey (Uganda n=207, Kyrgyz highlands n=210, Kyrgyz lowlands n=210, Vietnam n=210, Greece n=200; table 1; appendix 4 pp 11–14 details inclusion). Of note, no survey was conducted in the Roma camp as the qualitative data

collection pointed out that this would be unfeasible within our budget and timeframe. The overall mean age was 48.8 years (SD 16.0), with the youngest population in Uganda (41.8 years [15.3]) and the oldest in Greece (56.9 years [19.0]). More females (623 [60.1%]) than males (414 [39.9%]) participated. Of all respondents, 472 (45.5%) did not have paid work, of whom 260 (25.1% of the total) looked after the home and family (appendix 4 pp 11–14). Over one-fifth (22.2%) of the respondents reported to have similar symptoms to those described in the vignette, and one tenth (10.3%) reported to have a CRD diagnosis.

Additionally, we administered 204 questionnaires among health-care professionals (Uganda n=41, Kyrgyz highlands n=42, Kyrgyz lowlands n=40, Vietnam n=40, Greece n=41; table 2). The type of health-care professional who treated respiratory patients in Uganda varied, whereas in Kyrgyzstan most were nurses (highlands 85.7%, lowlands 80.0%), and in Vietnam and Greece most were general practitioners (Vietnam 82.5% and Greece 97.6%). Median years of practice was highest in the Kyrgyz highlands (27.5 years [IQR 16.3–36.8]) and lowest in Uganda (10.0 years [4.3–20.0]). Three key themes across the settings were identified from our qualitative data, which were then triangulated and complemented with quantitative data. Results are displayed in table 3, including the country characteristics in which they were embedded (appendix 4 pp 16–32). Additional quotes are provided in appendix 4 (pp 33–35).

Theme 1 was the locally perceived identity of chronic respiratory disease. Community members typically associated chronic respiratory symptoms with acute, communicable diseases. Although the vignette detailed a story of a person suffering from symptoms for more than 3 years, during the focus groups, the community members mostly held infections accountable. Also in the survey, community member frequently reported infections (eg, tuberculosis, flu, or a cold) to cause the symptoms (61.0% of all classifiable answers; figure 2). Meanwhile, 697 (67.2%) community members felt they understood the condition in the vignette fairly well or very well.

Community members predominantly related the symptoms to tuberculosis in both the qualitative and quantitative data (296 [28.5%] of all 1037 community members named tuberculosis as a diagnosis in the survey, totalling 70.1% of their 422 responses classifiable as infectious diagnoses).

“Coughing these days is like of three different types; some people cough as a result of HIV; others cough and even turn dark because of tuberculosis.”

Uganda, focus group with women (aged ≥30 years; focus group [FG] 5)

Non-communicable diagnoses for long-lasting symptoms were mentioned less frequently (272 [39.3%] of 692 classifiable answers in the survey). The term COPD was typically completely unknown.

	Uganda (n=207)	Kyrgyz highlands (n=210)	Kyrgyz lowlands (n=210)	Vietnam (n=210)	Greece (n=200)	Total (n=1037)
Sex						
Female	143 (69.1%)	116 (55.2%)	119 (56.7%)	138 (65.7%)	107 (53.5%)	623 (60.1%)
Male	64 (30.9%)	94 (44.8%)	91 (43.3%)	72 (34.3%)	93 (46.5%)	414 (39.9%)
Age, years	42.0 (28.0–53.0)	45.0 (36.0–56.0)	48.5 (36.0–58.0)	52.0 (40.0–62.0)	60.0 (41.0–72.0)	49.0 (36.0–60.0)
Education, years	8.4 (4.0)	11.6 (2.1)	12.1 (2.1)	6.4 (3.8)	9.7 (4.3)	9.7 (4.0)
Occupational sector						
None	54 (26.1%)	114 (54.3%)	112 (58.1%)	68 (32.4%)	114 (57.0%)	472 (45.5%)
Primary	84 (40.6%)	77 (36.7%)	35 (16.7%)	66 (31.4%)	28 (14.0%)	290 (28.0%)
Secondary	17 (8.2%)	0	15 (7.1%)	14 (6.7%)	18 (9.0%)	64 (6.2%)
Tertiary	39 (18.8%)	18 (8.6%)	38 (34.3%)	44 (21.0%)	35 (17.5%)	174 (16.8%)
Other*	10 (4.8%)	0	0	2 (1.0%)	5 (2.5%)	18 (1.7%)
Has vignette-like symptoms	38 (18.4%)	59 (28.1%)	9 (4.3%)	52 (24.8%)	72 (36.0%)	230 (22.2%)
CRD diagnosis	8 (3.9%)	31 (14.8%)	9 (4.3%)	5 (2.4%)	54 (27.0%)	107 (10.3%)

Data are n (%), median (IQR), or mean (SD). CRD=chronic respiratory disease. *Mostly students. Values were missing for age (n=4 Uganda, n=1 Greece), occupation (n=3 Uganda, n=16 Vietnam), symptoms (n=1 Vietnam), and CRD diagnosis (n=2 Uganda).

Table 1: Demographics of survey participants for community members

	Uganda (n=41)	Kyrgyz highlands (n=42)	Kyrgyz lowlands (n=40)	Vietnam (n=40)	Greece (n=41)	Total (n=204)
Sex						
Female	23 (56.1%)	40 (95.2%)	40 (100%)	27 (67.5%)	19 (46.3%)	149 (73.0%)
Male	18 (43.9%)	2 (4.8%)	0	13 (32.5%)	22 (53.7%)	55 (27.0%)
Age, years	39.5 (31.0–46.8)	46.0 (40.8–50.3)	55.0 (48.5–59.9)	42.0 (38.0–51.0)	47.0 (43.0–51.0)	47.0 (40.0–53.0)
Type						
Nurse	14 (34.1%)*	36 (85.7%)*	32 (80.0%)*	3 (7.5%)	0	85 (41.7%)*
Midwife	7 (17.1%)	2 (4.8%)	0	0	0	9 (4.4%)
General practitioner	6 (14.6%)	4 (9.5%)	8 (20.0%)	33 (82.5%)	40 (97.6%)	91 (44.6%)
Other	6 (14.6%)†	0	0	2 (5.0%)	1 (2.4%)	9 (4.4%)
Years of practice	10.0 (4.3–20.0)	22.0 (14.0–29.0)	27.5 (16.3–36.8)	16.0 (7.8–25.5)	15.0 (11.0–20.0)	17.0 (10.5–27.0)

Data are n (%), median (IQR). *27 of whom were physician assistants: n=1 Uganda (senior clinical officer), n=10 Kyrgyz highlands (feldshers), n=16 Kyrgyz lowlands (feldshers). †Five of whom were nurse assistants. Values were missing for age (n=5 Uganda, n=1 Vietnam), type of health-care professional (n=2 Uganda, n=2 Vietnam), years of practice (n=1 Uganda, n=2 Vietnam).

Table 2: Demographics of survey participants for health-care professionals



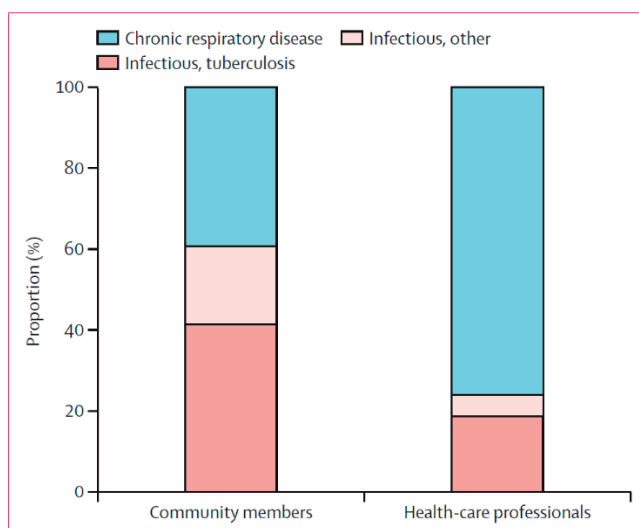


FIGURE 2: Disease to which chronic respiratory symptoms were attributed

Perceived diagnosis related to the vignette (progressive respiratory symptoms lasting for >3 years). Data include all classifiable survey responses, totalling 692 answers of community members and 242 of health-care professionals (eg, respiratory disease is not regarded classifiable). Open question; multiple answers could be given.

Interviewer: “Have you heard of COPD?”

Woman: “This is the first time I have heard of it [laughs].”

Kyrgyz lowlands, focus group with women (aged 18–30 years; FG 5)

Most Vietnamese participants, including patients with COPD and their health-care professionals, used the local word for asthma for both asthma and COPD. Even if the word COPD was recognised when probed for, its implications, symptoms, causes, and consequences were unknown.

“I have heard of COPD from the media, but I do not know the cause of the disease. I do not know if COPD is caused by smoking or not.”

Vietnam, focus group with men (aged ≥60 years; FG 7)

Community members usually recognised the terms asthma and chronic bronchitis when probed for, and sometimes mentioned them spontaneously; however, the meanings attached to the terms differed from medical connotations. For example, the non-communicable and chronic nature of the diseases were not mentioned, also not when probed for. Greek community members were an exception. They almost never mentioned tuberculosis during the qualitative field activities, and only twice in the survey (appendix 4 pp 36–38). Their awareness of CRD was higher; the term COPD was known by most community members and all health-care professionals. However, community members would not spontaneously use the word COPD,

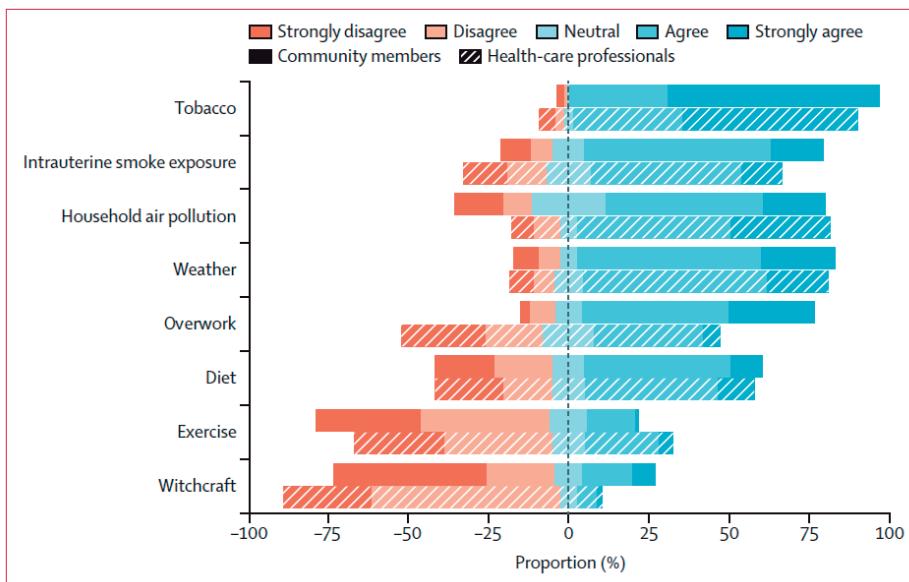


FIGURE 3: Perceived causes for chronic respiratory symptoms

The extent to which survey participants ($n=1037$ community members and $n=204$ health-care professionals) agreed with each factor as a cause. Missing values intrauterine smoke exposure $n=2$ community members; household air pollution $n=2$ community members, $n=1$ health-care professional; the weather $n=1$ health-care professional; overwork $n=1$ health-care professional; diet $n=2$ health-care professionals; exercise $n=4$ community members, $n=1$ health-care professional; witchcraft $n=1$ community member.

but speak of a respiratory condition instead. Understanding of COPD, such as its cause and consequences, was also poor among Greek community members.

Most surveyed health-care professionals across the settings indicated that they had seen a case similar to the vignette in the past 12 months (159 [77.9%] of 204). They attributed the chronic respiratory symptoms in the vignette much more to non-communicable diagnoses than the community members (192 [79.3%] of all 242 classifiable answers in the survey; figure 2, appendix 4 pp 36–38). However, tuberculosis was still a commonly perceived diagnosis. 39 (19.1%) of 204 health-care professionals named tuberculosis as a diagnosis, totaling 78.0% of all their 50 responses classifiable as infectious diagnoses. Similarly, all eight interviewed Ugandan health-care professionals considered tuberculosis the most likely diagnosis for the vignette. When the interviewer added that a tuberculosis test was negative, the health-care professionals considered a false-negative result more likely than an alternative diagnosis. The occurrence of post-tuberculosis lung damage was never mentioned. Two health-care professionals mentioned that untreated tuberculosis lasting for 3 years would be unusual.

Uganda		Kyrgyzstan (highlands)	Kyrgyzstan (lowlands)	Vietnam	Greece (rural)	Greece (Roma)
Contextual information (secondary sources)						
Country's income level*	Low	Lower middle	Lower middle	Lower middle	High	High
CRD prevalence†	COPD 6.1–16.2%; asthma 4.4%	COPD 36.7%; asthma 3.7%	COPD 10.4%; asthma 3.7%	COPD 33–9.4%; asthma 3.8%	COPD 3.5–10.6%; asthma 5.10%	Higher than for non-Roma‡
Tuberculosis incidence (per 100 000)†	200 (117–303)	110 (84–127)	110 (84–127)	176 (112–255)	4.3 (3.7–5.0)	4.3 (3.7–5.0)
Tobacco use and household air pollution (this study, quantitative data)						
Survey participants	207	210	210	210	200	No survey
Tobacco use (daily)	3 (1.4%)	38 (18.1%)	46 (21.9%)	53 (25.2%)	52 (26.0%)	NA
Female	0	0	2 (4.3%)	5 (9.4%)	33 (36.5%)	NA
Male	3 (100%)	38 (100%)	44 (95.7%)	48 (90.6%)	19 (63.5%)	NA
Age of onset, years	27.0 (13.7)	18.1 (3.5)	20.4 (7.4)	23.7 (12.1)	18.8 (4.5)	NA
Daily number of cigarettes	5 (0)	14.5 (9.5)	16.5 (9.5)	13.6 (9.2)	18.0 (12.8)	NA
Exposing others to smoke	2 (66.7%)	25 (65.8%)	27 (58.7%)	43 (81.1%)	36 (69.2%)	NA
Desire to stop	3 (100%)	36 (94.7%)	41 (89.1%)	38 (71.7%)	39 (75.0%)	NA
Stop attempt past 12 months	1 (33.3%)	28 (73.7%)	26 (56.5%)	30 (56.6%)	16 (30.8%)	NA
Household air pollution						
Cooking practices						
Open or surrounded fire	110 (53.1%)	25 (11.9%)	7 (3.3%)	79 (37.6%)	9 (4.5%)	NA
Daily solid fuel use (winter)	198 (95.7%)	201 (95.7%)	127 (60.5%)	89 (42.4%)	29 (14.5%)	NA
Daily clean fuel use (winter)	7 (3.4%)	18 (8.6%)	153 (72.9%)	193 (91.9%)	196 (98.0%)	NA
Location (most common)	Separate room or building	Room used for living or sleeping	Separate room or building	Separate room	Separate room	NA
Ventilation (most common)	Open window or door	Open window or door or chimney	Open window or door or chimney	Open window or door	Open window or door or hood	NA

Heating practices						
Use of heating	22 (10.6%)	210 (100.0%)	210 (100.0%)	0	200 (100.0%)	NA
Same stove as cookstove	13 (6.3%)	201 (95.7%)	130 (61.9%)	NA	3 (1.5%)	NA
Central heating	0	1 (0.5%)	0	NA	100 (50.0%)	NA
Solid fuel use	21 (95.5%)	210 (100.0%)	203 (96.7%)	NA	122 (61.0%)	NA
Clean fuel use	0	0	10 (4.8%)	NA	66 (33.0%)	NA
CRD-related themes (this study, qualitative data)						
Community members attributed chronic respiratory symptoms	To a low extent to CRD, to a high extent to infection, to a very high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to a high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to a high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to some extent to tuberculosis	To a high extent to CRD, to a high extent to infection	To a low extent to CRD, to a high extent to infection, to some extent to tuberculosis
Health-care professionals attributed chronic respiratory symptoms	To a low extent to CRD, to a high extent to infection, to a very high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to a high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to a high extent to tuberculosis	To a low extent to CRD, to a high extent to infection, to some extent to tuberculosis	To a high extent to CRD, to a low extent to infection	To a high extent to CRD, to a low extent to infection
Perceived causes	Cold weather, dust, stress, smoking, witchcraft or spiritual, underlying HIV/AIDS	Cold weather, stress, smoking, Evil eye (witchcraft or spiritual)	Cold weather, stress, smoking, Evil eye (witchcraft or spiritual)	Hot-cold disbalance, overwork, smoking, tidal wave	Cold weather, humidity, stress, smoking	Cold weather, smoking, household air pollution
Social factors related to health-keeping and health-seeking	One should not believe in spiritual powers (although others do)	Real men smoke, women should not. This proud nomad nation is self-reliant and does not seek medical help	Real men smoke, women should not	Real men smoke, women should not refuse an offered cigarette. Mother and newborn should undergo coal-burning ritual	Filotimo; one should support those around you (including patients in need)	A common distrust to seek help for symptoms outside the community

Data are n, n (%), or mean (SD), unless otherwise specified. CRD=chronic obstructive pulmonary disease. COPD=chronic obstructive pulmonary disease. NA=not applicable. * As classified by the World Bank (accessed May, 2020). †Data are as specific to the setting as possible. See appendix 4 (pp 16–32) for data sources. ‡No data were identified for Roma in Greece specifically; two large European reports indicated that CRD prevalence was higher for Roma than for non-Roma. Values were missing for tobacco use (n=1 Uganda), age of onset (n=1 Greece), daily cigarettes (n=2 Uganda, n=2 Vietnam, n=1 Greece), location cooking area (n=2 Greece). For the themes in the table not elaborated in the text, see appendix 4 (pp 33–35) for supporting quotations.

Table 3: Simplified overview of relevant setting characteristics for implementing CRD-related interventions

“As far as I know, if it was tuberculosis it would have intensified more than that, to that extent, it wouldn’t have stayed there for 3 years.”

Uganda, interview with nurse (health-care professional 11)

In eight out of 41 observed respiratory consultations among 11 Ugandan health-care professionals, sputum was checked for tuberculosis, whereas none of the consultations included (diagnostic) questions directed towards asthma or COPD. Health-care professionals in Uganda, Kyrgyzstan, and Vietnam were also almost exclusively visited for acute symptoms, rather than for follow-up of chronic symptoms. None but the Greek health centres were equipped with a spirometer (after inquiring, a nurse in the Kyrgyz highland confirmed to have one and demonstrated a peak flow meter). In Greece, health-care professionals were also visited for chronic symptoms, to monitor disease control or discuss inhalation medication.

Health-care professionals were generally familiar with the terms asthma, COPD, and chronic bronchitis (appendix 4 pp 36–38), but associated these diseases mainly with their acute manifestations (such as a status asthmaticus). Many considered asthma too severe to treat in their primary care practice; asthma required treatment in referral hospitals. In multiple Kyrgyz interviews, asthma was regarded as the end stage of respiratory problems. Of the 163 Ugandan, Kyrgyz, and Vietnamese surveyed health-care professionals, 68 (41.7%) answered to (be able to) prescribe asthma inhalers. Qualitative data indicated that inhaler availability and affordability was low. Again, Greek health-care professionals were an exception. In the interviews they described asthma and its implications closely aligned with biomedical conceptions. The observations and survey confirmed that the health-care professionals generally followed well established Greek guidelines. Appendix 4 (pp 39–42) details health-care professionals perceptions and clinical behaviour.

Theme 2 was the perceived causes for chronic respiratory symptoms. Community members and health-care professionals in each setting strongly related respiratory symptoms to the quality of the air they inhaled, influenced by dust, factory smoke, and other forms of polluted air. The harm of tobacco smoke was especially well understood (figures 3, 4).

“I was smoking so much that I felt it was harmful for me. I had sputum, dyspnoea, fatigue...”

Greece: focus group with men (aged 30–60 years; FG 9)

Qualitative field activities demonstrated that smokers were generally male. During several interviews and focus groups the men mentioned to be mindful of smoke exposure towards pregnant women and babies; however, the observations revealed that second-hand-smoke exposure was common. Notably, three out of six men in a Vietnamese focus group indicated to smoke every time, everywhere, regardless of other household members.

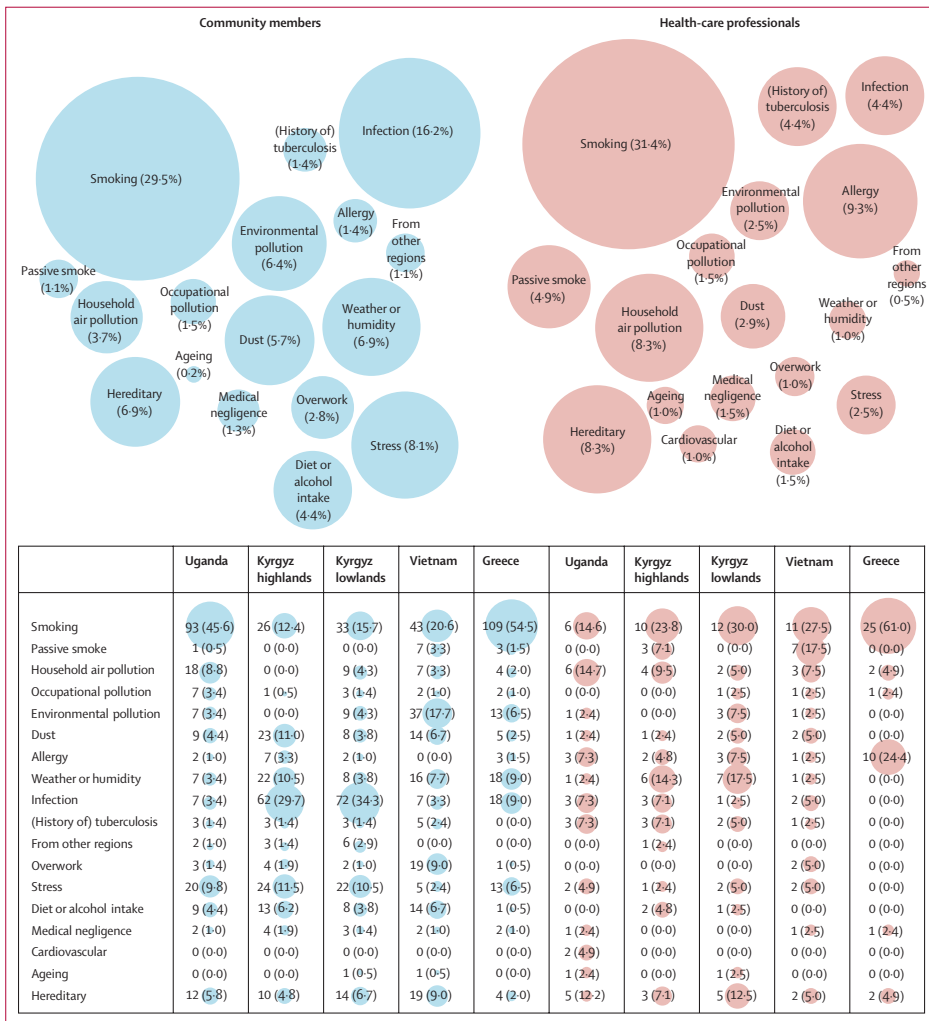


FIGURE 4: Perceived most important cause for chronic respiratory symptoms

Answers to the open question in the survey what was perceived as the most important cause for the chronic respiratory symptoms in the vignette. Infection included a virus, germ, cold, or the flu. Data in table are n (%). Community members n=1035. Health-care professionals n=204.

Interviewer: "Could you show me where you smoke? [points at a drafted house map]."

Man: "Everywhere, except for the rooftop, as it's hard to climb up [laughs]."

Vietnam: focus group with men (aged 30–60 years; FG 4)

The Roma also stated openly that second-hand-smoke exposure in their house was very common, also to children.

“Inside, also our babies smoke.”

Roma: focus group with women (FG 6)

The survey confirmed that the majority of smokers were male (three [100.0%] in Uganda, 38 [100.0%] in the Kyrgyz highlands, 44 [95.7%] in the Kyrgyz lowlands, 48 [90.6%] in Vietnam, and 19 [63.5%] in Greece) and exposed others to their smoke (two [66.7%] in Uganda, 25 [65.8%] in the Kyrgyz highlands, 27 [58.7%] in the Kyrgyz lowlands, 43 [81.1%] in Vietnam, and 36 [69.2%] in Greece; table 3). The majority of smokers wanted to quit (table 3), but among others, cultural norms refrained them from doing so (theme 3).

Besides tobacco smoking, participants in each setting perceived air pollution to cause chronic respiratory symptoms. The perceived sources of pollution reflected what people encountered in their daily lives, such as traffic (Vietnam, Greece), nearby factories (Kyrgyzstan, Vietnam, and Greece), livestock (Kyrgyzstan and Vietnam), burning plastic (Vietnam and Roma), and dust, particularly dusty roads (Uganda and Vietnam).

Many community members were at risk of HAP exposure due to daily solid fuel use (Uganda 198 [95.7%], Kyrgyz highlands 201 [95.7%], Kyrgyz lowlands 127 [60.5%], Vietnam 89 [42.4%], and Greece 29 [14.5%] for cooking; table 3). HAP was less frequently mentioned by community members compared to health-care professionals, and with less consistency and conviction compared to other sources of air pollution.

“Even if smoke from firewood causes problems, it cannot be compared to cigarettes because the cigarettes have a lot of things that cause tuberculosis, but the firewood doesn’t contain a lot of chemicals.”

Uganda: Focus group men (aged ≥30 years; FG 6)

HAP was perceived to cause chronic respiratory symptoms also in Greece, because during the recent economic crisis, many people were pushed back into burning wood or olive pits as a cheaper source of domestic heating. Roma commonly burned poor-quality wooden pallets for heating and sometimes for cooking; electricity was available from expensive generators only for several hours daily. Although most people were aware of the harm of burning these materials, they reported that cleaner alternatives were unaffordable. The pallets observed in the Roma camp were often covered with paint and other chemicals. The effect of HAP exposure on children was rarely considered in the six settings. However, children’s health was perceived as very important and regarded as a trigger to change risk behaviour.

Besides shared perceived causes for chronic respiratory symptoms, culturally specific causes were identified (table 3; figure 5). These ranged from witchcraft in Uganda, to the Evil eye in

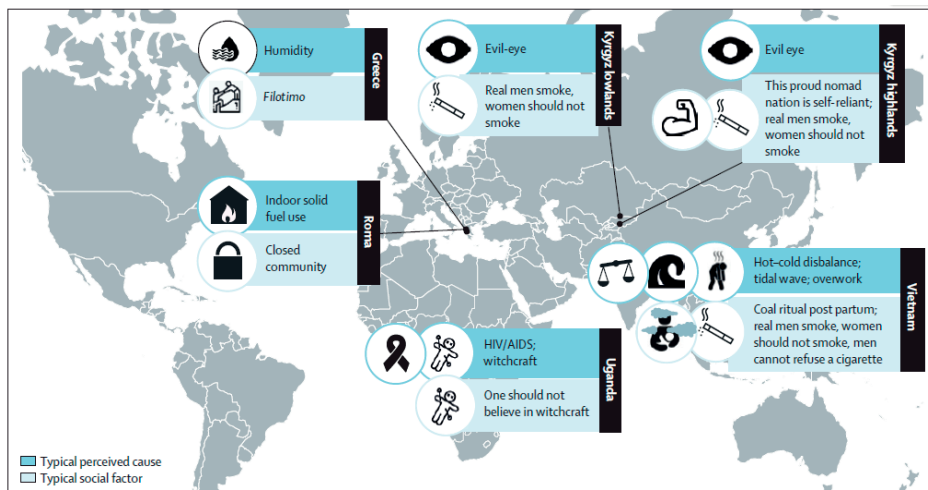


FIGURE 5: Typical perceived cause for CRD and social factors determining CRD-related behaviour Overview of the context-specific traits per setting. Causes and behaviour are not necessarily related. CRD=chronic respiratory disease.

Kyrgyzstan, a hot–cold disbalance in Vietnam, humidity in Greece, and burning poor quality wooden pallets in the Roma camp. We illustrate two such perceived context-specific causes; the examples are not exhaustive.

In Uganda, although none of the informants openly stated they believed in supernatural powers, all confirmed that others in their community did. For example, the lady in the vignette might believe she is bewitched. The local (Lusoga) term used for witch doctors was *omuyiwa*, *wamawembe* and according to the informants this means the one who heals or the one who thinks on your behalf (Uganda, focus group men). By our team members, fluent in Lusoga and English, this term was translated as witch doctor. Different wordings were used for traditional healers and herbalist.

Woman: “She thinks she was bewitched, her friends might be bewitching her.”

Interviewer: “Can Nangobi [the lady in the vignette] also seek help from the traditional healers?”

Chorus: “No [all laugh].”

Woman: “That’s impossible, that is wasting time.”

Uganda: focus group with women (aged ≥30 years; FG 2)

Notably, most survey participants indicated to (strongly) disagree with witchcraft causing symptoms, while 235 (22.6%) of the 1037 community members and 16 (7.9%) of 204 health-care professionals indicated to (strongly) agree (figure 3).

In Vietnam, a prevailing perceived cause for illness was a hot-and-cold disbalance in the body. Therefore, eating cold or hot food, showering in the morning (cold) versus later during the day (warmer), breathing cold air versus smoking a hot cigarette were all believed to relate to the presence of symptoms.

“I get a sore throat when I am smoking too much, it is the heat inside the body.”

Vietnam: focus group with men (aged 30–60 years; FG 4)

Vietnamese community members and health-care professionals also mentioned overwork relatively frequently as a perceived cause (figure 4). Qualitative data explained that the Vietnamese word for tuberculosis, *Lao*, resembles the word for overwork, *Lao Lực*, which inflicted a perceived relationship between overwork and respiratory symptoms.

Theme 3 was local social factors related to health keeping and health seeking. Local social structures, norms, and traditions strongly influenced (CRD related) health-keeping and health-seeking behaviour across the settings. Three such local norms are highlighted here, for prevailing social factors, see table 3 and figure 5.

Local beliefs in Vietnam about the cold-hot disbalance were also reflected in norms regarding post-partum care. Midwives and family members prescribed women and their newborns to stay in bed for a month while burning coal underneath their bed and limiting all ventilation. Doing so is perceived to protect mother and child from (respiratory) disease later in life. This custom leads to high levels of HAP exposure to mother and baby during a decisive period in the baby's lung development.

Interviewer: “Is it risky when lots of smoke is generated?”

Women: “I’m not sure... This is a habit from generation to generation, we don’t even question it.”

Vietnam: focus group with women (aged ≥60 years; FG 3)

One of our highly educated local team members highlighted the social pressure to comply to the custom. Although she perceived it as harmful to health, she had also complied to avoid social condemnation. A local university professor explained his perceived origin of the tradition during an interview: mothers lose blood during the delivery which decreases their body temperature. Burning coal restores the balance.

In the Kyrgyz highlands, a prominent social value related to health seeking behaviour was self-reliance.

“We are a nomad nation. We used to herd cattle and didn’t see any doctors. And in fact, we didn’t have doctors. It is in our blood. It is just possible to drink hot tea, or sheep fat—it [the nomad lifestyle] stays in our blood. They [our ancestors] did not consult doctors. This habit is in our blood. We have gotten used to this and think that the illness will pass by itself.”

Kyrgyz highlands: focus group with men (aged 30–60 years; FG 2)

A feldsher (physician assistant) explained that self-reliance was essential in the region; access to health care and medication were geographically limited.

Key informants and health-care professionals characterised the Roma as a population with an inward-facing social structure. Roma were perceived to distrust outsiders of their community; the key informants and health-care professionals had needed years to gain their trust.

“...when we started [working] here 10 years ago, it was very difficult, all this, because they didn’t know us, we had not developed this kind of confidence. Now, after 10 years, approaching them is easier and it is easier for them now, addressing us.”

Roma: Social worker in Roma community (key informant 4)

Providing health support was perceived as challenging because Roma would arrive late for appointments or not show up at all. Also (health) illiteracy formed a barrier to access health care, because in the social structure, girls would often not attend school or drop out prematurely. On the other hand, multiple Roma shared that they felt ignored and discriminated in their attempts to access health care.

Almost all community members across the settings (1026 [98·9%] of 1037) indicated that they would seek help if they had symptoms like the person in the vignette. Most Ugandan community members would seek help from a community health worker (126 [60·9%] of 207), Kyrgyz and Vietnamese community members from a general practitioner (402 [95·7%] of 420 Kyrgyz and 177 [84·3%] of 210 Vietnamese community members), and Greek community members from a specialist (141 [70·5%] of 200; appendix 4 p 38).

DISCUSSION

This mixed-methods study explored community members’ and health-care professionals’ beliefs and behaviours regarding CRDs across diverse low-resource settings. Use of a consistent method based on the same theoretical framework enabled us to identify three themes that consistently played an important role in each setting, and which should be addressed when implementing CRD-related interventions, (1) the locally perceived identity of CRD, (2) local be-

liefs about the causes, and (3) local social values and structures that determine health behaviour. These themes showed both similar and context-specific traits across the settings.

In all settings but Greek, long-lasting respiratory symptoms were commonly identified as infections, particularly as tuberculosis. Asthma and COPD and their chronic, non-communicable nature were relatively unknown, especially among community members. Tobacco smoking was mostly perceived as an important cause for chronic respiratory symptoms. HAP was less frequently cited. Context-specific perceived causes were diverse, and ranged from witchcraft in Uganda to a hot– cold disbalance in Vietnam. Each setting had social factors that shaped behaviour related to CRD; such as the norm that real men smoke (Kyrgyzstan and Vietnam) or a common distrust in medical help from outside the community (Roma). Awareness of these shared and context-specific traits is crucial for designing the right interventions that people adhere to over time.^{5,7,8,34}

To our knowledge, this is the first study that systematically mapped communities' beliefs and behaviours regarding both asthma and COPD this extensively. Regardless of their actual burden, CRD were not perceived to play an important role in the communities. This implies that, despite earlier calls for action over the past decades,^{35,36} health policies have yet failed to adequately raise awareness on CRD. In addition to our study among communities, previous studies reported that knowledge and awareness were poor even among CRD patients.^{37–39} Awareness of tuberculosis was much higher compared to CRDs in our study. We hold several explanations. First, communicable diseases have traditionally burdened LMICs more than non-communicable diseases (and in some settings, they still do—although CRD are on the rise while tuberculosis and respiratory infections are in decline).¹⁵ This could still be deeply rooted in communities' perceptions. Second, it is a self-fulfilling prophecy; the lack of awareness of CRD among health-care professionals (and the lack of spirometers and skills needed for their interpretation) results in the underdiagnosis of CRD.²⁰ Hence, CRD are perceived to play a less significant role. Third, WHO's active campaigns to eliminate tuberculosis over the past decades seem to have successfully increased awareness among communities and their health-care professionals.⁴⁰ Fourth, communicable diseases cause more public fear and prioritisation (also in high-income settings), as the relationship between infections and symptoms is acute and conspicuous.³⁶ The current COVID-19 pandemic probably raised fear for infections even further. Although a silent one, CRDs are also a pandemic, especially in LMICs. Therefore, health policies and funding should equally treat CRDs and their preventable risk factors as a health priority, and increase efforts to promote awareness.^{41,42}

One such preventable risk factor that requires more awareness is HAP.⁴³ Although most participants indicated to (strongly) agree with HAP as a cause for chronic respiratory symptoms, a substantial part also indicated to (strongly) disagree or perceive the risk as neutral. Awareness

of the harm to children and of intrauterine smoke exposure was particularly low. Similar limited awareness among community members and health-care professionals was reported in other settings.^{44,45} WHO's Breathe Life campaign for clean air launched in 2016, and WHO's clean household energy toolkit (CHEST), will potentially increase HAP awareness and provide solutions to address this risk factor.

A successful global public health programme that targeted risk awareness and implemented preventive measures is WHO's Framework Convention on Tobacco Control.⁴⁶ Also in our settings awareness of tobacco's harmful effects was high. Nevertheless, awareness alone is generally insufficient to change health behaviour.^{9–11,46} Most the smokers in our study said they desired to quit, but encountered various barriers to do so, of which local cultural norms played an important role. For example, an offered cigarette—a way to open a conversation—cannot be refused (Vietnam), or real men smoke (Kyrgyzstan and Vietnam). Therefore, beyond addressing awareness, such norms and other contextual factors should be addressed in implementation strategies to enhance their success.³⁴

This study responds to the urgent calls from numerous international parties for more and better implementation evidence in LMICs, especially for non-communicable diseases.^{1–4} We consistently applied the same method¹⁹ across six settings in four countries on three continents, enabling comparison from a global perspective. Using a robust mixed-methods approach we triangulated qualitative findings (from 340 informants in over 200 interviews, focus groups, and observations), with findings from a quantitative survey. To further optimise internal data validity, two researchers independently applied the rigorous Framework Method. Local community researchers in the team ensured excellent knowledge of local themes and networks. They additionally facilitated trust and openness from the communities, resulting in deeper insights. To promote practical relevance of the study and uptake of our findings, the study was grounded in the local context and co-designed with our stakeholders.⁴⁷

To limit sources of bias, we took a broad range of measures—eg, we addressed participants' self-serving and social desirability bias by triangulating interviews with observations, confirmation, and culture bias by a diverse research team, and selection bias by a solid random sampling approach. Nevertheless, possible sources of bias remained, such as observation bias during health-care professional consultations, or survey-selection bias because more women than men were at home during the daytime. Another study limitation was the use of different languages. Despite careful translation procedures for the research materials and having researchers fluent in both the local language and English, nuance might have been lost in translation. Additionally, qualitative findings from the Roma setting could not be triangulated; the qualitative research activities taught us that conducting a survey was not feasible in the Roma camp within our budget and timeframe. Lastly, during our RAP we reached saturation on many themes, yet we

cannot provide an exhaustive description of each setting. For further in-depth exploration, a more time-consuming approach is recommended.

Our study findings were translated directly into practical leverage points in the implementation strategies of FRESH AIR health interventions¹⁹—eg, communities' limited awareness of the harm of HAP exposure required us to deliver an extensive awareness programme⁴⁸ before the cleaner cooking programme⁴⁹ was implemented. This awareness programme emphasised the risks of HAP to children, which we had learned was a trigger to change behaviour. Our cooking programme achieved above-average adoption rates of cleaner cookstoves.⁴⁹ Similarly, we highlighted the benefits of exercise to patients in our Vietnamese pulmonary rehabilitation programme, to overcome the locally perceived risks of overwork. Meanwhile, in the Greek pulmonary rehabilitation programme we embraced the *filotimo* norm; we capitalised on the positive social pressure to exercise together as a group and not let down the others by missing a training.⁵⁰ The post-partum coal-burning ritual in Vietnam could possibly be addressed by preserving the element of heat while avoiding smoke exposure.

Beyond the FRESH AIR implementation research project, these findings could serve implementation efforts globally. The mapped settings ranged from deprived slums in Uganda, to highly risk-burdened Kyrgyzstan, rapidly developing Vietnam, austerity-impacted rural Greece, and a hard-to-reach Roma camp. The same three themes turned out to play a role across the settings suggesting high generalisability; therefore, we recommend these themes be considered and addressed in the implementation of CRD-related interventions in other low-resource settings.

Furthermore, some specific beliefs and behaviours within a theme were reported to occur in settings with similar characteristics, such as the coal-burning ritual (Indonesia)⁵¹ or that real men smoke (China and Indonesia).^{52,53} Therefore, by looking at the main characteristics (table 3) and the associated health beliefs and behaviours, one could carefully infer what beliefs and behaviours might prevail in new settings with similar characteristics. Also, our findings of where people seek medical help in each setting can help determine who to involve in future health programmes.

This overview of CRD-related beliefs and behaviours could be complemented by insights from new settings. It could expand beyond CRD, to serve as a starting point for mapping contexts for other (non-communicable) diseases—eg, limited perceived chronicity might be applicable to cardiovascular or mental illnesses. It is plausible that this context-mapping approach and some of the findings could also be generalised to high-income settings, yet this remains to be assessed.

Our data emphasise the importance of raising public awareness on asthma and COPD, their chronic nature, and their preventable risk factors. Whole-system approaches are needed, includ-

ing public education on how we breathe and how risk factors affect breathing; health-care professional training on preventing, detecting, and treating CRD; and training policy makers on interpreting the underdiagnosis in their country data and on effective measures to combat risk factors. Second, our data demonstrate the importance of understanding the local context. We recommend relevant beliefs and behaviours be elicited before every intervention, because it will help tailor the implementation strategy at population and individual level. The SETTING-tool, as used in this study, can be a helpful instrument for doing so. It was easily adaptable to and effective in a diverse range of settings, as long as the core elements (the six steps) remained intact.¹⁹

In conclusion, to facilitate a successful implementation process of CRD-related interventions in low-resource settings, implementers should address the locally perceived identity of CRD, local beliefs about causes, and local social values and structures that influence health behaviour. Therefore, we recommend these beliefs and behaviours be mapped before every intervention to design tailored implementation strategies. Such strategies can reduce the risk of implementation failure, which in turn can optimise the use of resources in settings where they are scarce already. Ultimately, this can improve health outcomes.

Contributors EAB led the conceptualisation and design of the study, supported by RMJJvdK, CCP, NHC, MRC, and RR. PLA, MA, BK, CL, TS, and SWa ensured alignment of the design with the corresponding setting. EAB coordinated data collection and further conduct of the study across the sites, together with MA, PLA, LHTCH, TS, and SWa for the corresponding sites; all coauthors supported. SWi contributed to the formation of the stakeholder engagement groups through the network of the International Primary Care Respiratory Group (IPCRG). RR trained the team and supervised application of the qualitative methodology on the ground in the first site. EAB led qualitative data collection at each site, supported by CCP. RMJJvdK contributed to data collection in Uganda, MM in Kyrgyzstan, LTTO and LHTCH in Vietnam, and MA in the Roma camp. All authors had access to all study data. EAB, RMJJvdK, and RR analysed the qualitative data, verified by CCP, MRC and NHC (all sites), and PLA, MA, BK, MM, TS, and SWa for the corresponding sites. PLA, LHTCH, MA, TS, and SWa supervised the quantitative data collection, EAB and RMJJvdK quantitatively analysed data, verified by RR and NHC. NHC was the principal investigator of the overall FRESH AIR project. EAB wrote the Article, RMJJvdK, SWi, CCP, and RR provided feedback. All authors critically reviewed the Article and approved its final version.

Declaration of interests We declare no competing interests.

Data sharing All deidentified data and meta-data, which are not already available in appendix 4 of this Article and the preceding open access methodology paper,¹⁹ will be available on reasonable request to the corresponding author (EAB) within a reasonable timeframe.

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