

The roles of women in cookstove intervention studies

Received: 11 December 2024

Accepted: 13 January 2026

Published online: 09 February 2026

 Check for updates

Annelise Gill-Wiehl¹✉ & Isha Ray²

Clean cooking fuel interventions can substantially advance Sustainable Development Goals related to health, poverty, gender equality and (possibly) climate change. Here we systematically review gender roles within cookstove randomized control trials (RCTs) with respect to (1) health and exposure; (2) time, labour, finance and behaviour; (3) climate; and (4) the research activities. We focus on RCTs because public health scholarship considers RCTs, despite limitations, to provide the highest-quality evidence to guide policy and widescale programming. Across our 123 included studies, women are frequently targeted but then not acknowledged in time, labour, finances and even health outcomes. Acknowledgement of gender norms is scarce. Using WHO gender-responsiveness categories, we find that 37% of studies were gender-unequal or gender-unaware. Women are often monitored only as proxies for their unborn children, our category of gender-unaware but sex-aware (26%). Twenty-nine percent are gender-sensitive, with only 6% gender-specific and two gender-transformative studies. We present recommendations for the field to shift to more gender-sensitive research designs, without which the field risks leaning into existing inequalities and basing future interventions on spuriously gender-neutral premises.

Gender-sensitive policies are integral to achieving all Sustainable Development Goals (SDGs). Interventions that expand access to clean cooking technologies have the potential to deliver gains across multiple SDGs, including health, poverty reduction, gender equality and (possibly) climate¹. Women, often serving as their households' main cooks, cope with the exposure, time and physical burdens of cooking with solid fuels^{2,3} and the resulting household air pollution⁴.

Cross-sectional and case studies have found that women spend more time than men do collecting fuels, cooking and cleaning utensils^{2,3,5}. They also face higher exposure to household air pollution⁶. Others have found that households with female heads, or with women decision-makers or income-earners, are more likely to use clean fuels^{5,7,8}. There have been calls to incorporate more women in the energy sector^{9,10} and intervention designs¹¹ and to design specific energy interventions aimed at empowering women¹². Researchers have also emphasized intrahousehold dynamics and

women's bargaining power when it comes to household cooking fuel choices^{5,13,14}.

Many cookstove studies claim gender equality and women's health as research motivations or as intervention cobenefits¹⁵⁻¹⁷; however, women's roles and impacts on women have not been comprehensively reviewed across the clean cooking literature. Review articles have covered the barriers to and drivers of improved¹⁸ and clean cooking access¹⁹⁻²³, time savings²⁴, the success or failure of behaviour-change interventions, emission exposures from different stoves²⁵⁻²⁷ and the health impacts of cleaner cooking²³. These reviews typically report findings by household, kitchen, general category of personal exposure or adult/child outcomes and do not disaggregate exposure, health or time spent by sex. When reviews do consider gender, it is as a driver of access, adoption or use of clean fuels^{18,28}, rather than evaluating the role of women in interventions or the intervention's effects on women. Therefore, it is often not clear whether or to what extent clean

¹Mailman School of Public Health, Columbia University, New York, NY, USA. ²Energy & Resources Group, University of California, Berkeley, Berkeley, CA, USA. ✉e-mail: ag5050@cumc.columbia.edu

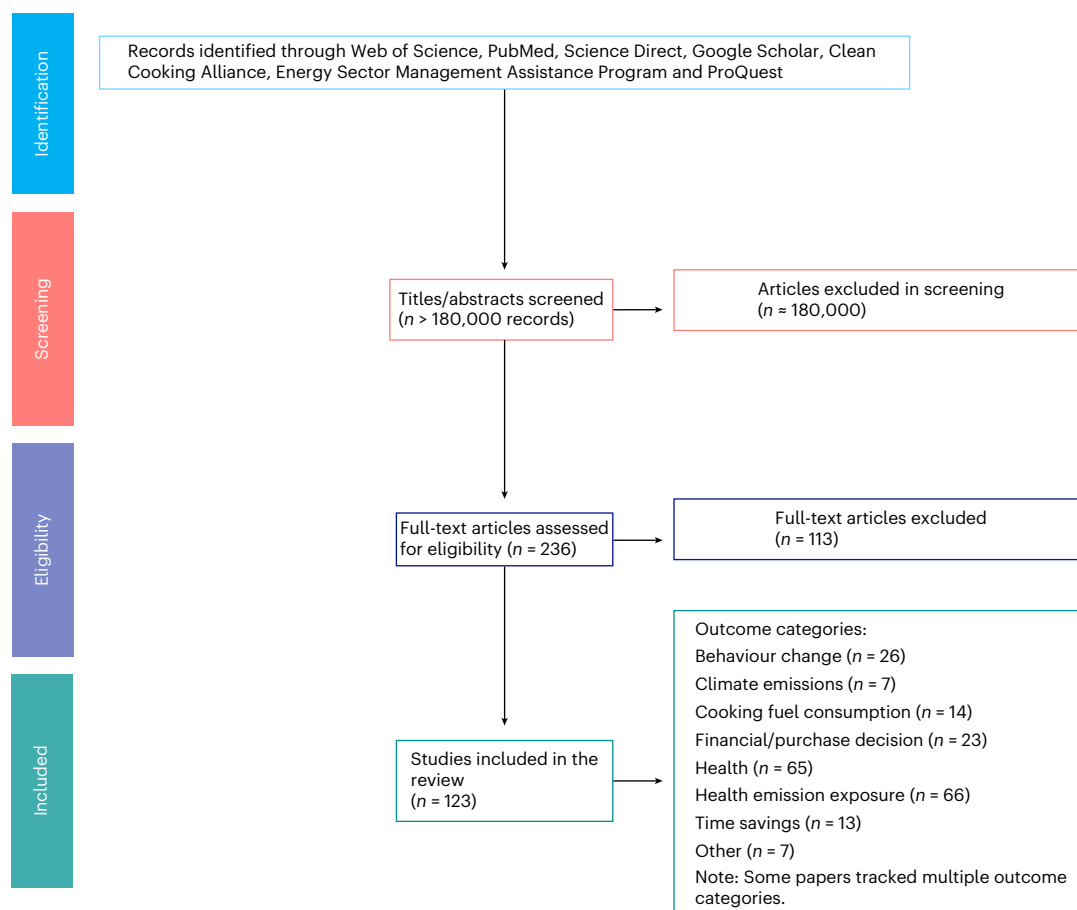


Fig. 1 Our literature selection process from identification and screening to the papers included, along with the specific outcome types. The primary criterion for inclusion in our systematic review was a cookstove RCT, published between 2000 and 2024 in LMICs. Only English language papers were reviewed. Figure adapted from ref. 67 under a Creative Commons Licence [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

cooking interventions are increasing gender equality or women's empowerment²⁸. There has been distinguished work on gender and modern domestic energy²⁹, but its focus on electrification limits its usefulness for clean cooking, given low rates of electric cooking in low-income settings. When cookstove studies report data by gender, these are sex-disaggregated along the male/female binary. Therefore, in this article, we adopt the same convention, although gender and sex are related but distinct.

Here we systematically review cookstove randomized control trials (RCTs) to ask, 'What are the roles played by women in cookstove intervention studies?' We apply this question to four specific dimensions within the literature: (1) How are women's health and exposure discussed? (2) How are women's time, labour, finance and behaviour discussed regarding the intervention? (3) How is gender addressed in climate emission studies? (4) How are women engaged in the research itself? We focus on RCTs because public health scholarship considers RCTs, despite critiques and limitations^{30,31}, to provide the highest-quality evidence to guide policy and widescale programming³². We build off a review paper in the water, sanitation and hygiene (WASH) literature showing that women are largely exploited within WASH RCTs³³.

Results

Systematically, we reviewed 236 full articles and included 123 (Fig. 1). We excluded roughly half of the identified articles as several papers were adjacent analyses, such as a nested cross-sectional study within an RCT, exposure response with the treatment but not control group or qualitative work only (Methods).

Outcomes spanned seven categories: health ($n = 65$), exposure to health-specific emissions ($n = 66$), climate emissions ($n = 7$), financial considerations (purchase decisions or willingness to pay (WTP)) ($n = 23$), time savings ($n = 13$), behaviour change ($n = 26$), cooking fuel consumption ($n = 14$) and other ($n = 7$). Some articles reported multiple outcome categories. Researchers, with first authors largely from the United States ($n = 80$), conducted trials across 17 low- and middle-income countries (LMICs; Supplementary Fig. 1). Thirty-six of the articles ($n = 36$ of 123) covered a 'clean' cookstove that meets the World Health Organization's (WHO) standards³⁴, and 64 covered an intervention with, for example, an improved biomass stove that does not meet the WHO health criteria. The rest ($n = 23$) covered interventions with both.

All cookstove RCTs, regardless of outcome focus, required the participation of at least one household member (that is, participation was essential to the trial). We distinguished this from participation in the research activities. Participation essential to the trial could mean using the improved/clean stove, buying fuels or engaging in an auction of different stoves to reveal WTP. The individual targeted as the participant was not necessarily the individual whose outcome was of interest. Interventions targeted unspecified members of households ($n = 32$ of 123), women ($n = 28$ of 123), pregnant women ($n = 27$ of 123), pregnant women as proxies for their unborn children ($n = 15$ of 123), a child/fetus and their mother ($n = 10$ of 123), a child and an unspecified-gender adult ($n = 2$ of 123), or both men and women ($n = 9$ of 123). Interventions reported outcomes for unspecified members of households ($n = 20$ of 123); women ($n = 26$ of 123); pregnant women ($n = 8$ of 123); a fetus, child or pregnant women as proxies for their unborn children ($n = 36$ of 123); a child/fetus

Table 1 | Assessment of gender in included studies

		n/N
Participation (N=123)	Intervention required the participation (compliance and involvement) of an individual	123/123
	Only targeted women	28/123
	Only targeted men	0/123
	Only targeted 'households' or an unspecified or ungendered member of the household	33/123
	Targeted pregnant women	27/123
	Targeted children and/or pregnant women / unspecified parent as a proxy	15/123
	Targeted children and their mothers	10/123
	Targeted children and an unspecified adult	2/123
	Targeted (or at least encouraged) both men and women in a household	8/123
Stove type (N=123)	Intervention assessed only a WHO 'clean' stove	35/123
Health outcome studies (N=65)	Study health outcomes disaggregated by gender	Yes (13/65) Explicitly included as a covariate ^a (15/65) Only women (18/65)
	Study exposure outcomes disaggregated by gender	Yes (6/66) Explicitly included as a covariate (6/66) Only women (36/66)
Health-specific emission exposure outcome studies (N=66)	Study considered income or expenditure in any financial or affordability discussion	No consideration of income/expenditure (4/23) Consideration of income/expenditure (13/23) Consideration of wealth (6/23)
	Study specified the gender of the individual(s) controlling the budget ^c	No (16/23) Assumed ^d man (3/23) Implied ^d woman (2/23) Yes (2/23)
	Study specified the gender of the individual(s) purchasing the stove or fuel	No (14/23) Implied woman (3/23) Implied man (5/23) Yes (1/23)
Financial outcome studies (N=23) ^b		
Time saving outcome studies (N=13)	Study reported time data on cooking activities, fuel collection and stove maintenance	Time for cooking activities (10/13) Time for fuel collection (8/13) Time for stove maintenance (1/13)
	Study specified whose time was saved	Woman (4/13) Household (5/13) Primary cook (4/13)
Studies that would require a behaviour change / training (N=118)	Study mentioned compliance with intervention as a factor leading to null or unexpected result	10/118
	Study explicitly specified the gender of whom they trained and thus who was expected to make the change or ensure that other household members changed their practices	28/118

^a Studies that include gender as a covariate do not present the results separately but have gender as a coefficient in presented regression results. ^b One study that did not track financial outcomes did track women's and men's earnings separately and implied that the woman was in charge of purchasing the stove; one study provided the stove and fuel for free and then reported whether participants generated any additional income during the additional time that the more efficient stove provided them. We include the former and exclude the latter in our financial outcome analysis. ^c One study's experiment was based on giving both spouses individual income and decision-making power and tracking outcomes; it did not specify outside of the experiment which spouse controlled the budget, so we included this as a no. One study assumed the man controlled the budget but did survey whether the wife was an earner. ^d 'Assumed' means the study states that the man controlled the budget without citing any research, pilot work or surveying done to conclude that, and 'implied' indicates that the study language implicitly indicates that a spouse of a specific gender had some control.

and their mother ($n = 8$ of 123); a child and an unspecified-gender adult ($n = 4$ of 123); both men and women ($n = 4$ of 123); or the household level ($n = 17$ of 123). Most studies ($n = 96$ of 123) reported the gender of the main participant in the main text, whereas 27 articles ignored it or only reported the statistic in a table. We evaluated our results on the role of women along the four dimensions identified above; some studies reported outcomes outside of our identified categories ($n = 7$ of 123), such as nutrient intake, school attendance, and so on.

Health and exposure

Women were often targeted as the main respondents because they are usually the main household cooks, but also because prenatal exposures

are important for children's lung development, birth weight, stunting and other health outcomes. Twenty-two studies ($n = 22$ of 65) reported women's outcomes (either alone or alongside their child's), whereas 34 studies ($n = 34$ of 65) monitored only women for exposures to explain their children's outcomes (Table 1). Thirteen studies ($n = 13$ of 65) disaggregated outcomes by gender (child or adult). Fifteen ($n = 15$ of 65) adjusted their models with sex as a covariate. Nineteen ($n = 19$ of 65) did not address gender (Table 1). Of the health studies reporting women's outcomes, 12 of 18 included only mothers and women of reproductive age.

For the exposure studies, we find that 28 of 66 studies reported women's outcomes, whereas 24 of 66 monitored only women for their

Table 2 | Assessment of research engagement in included studies

	<i>n/N</i>
Research activities necessitated involvement of a household member for data collection	123/123
The primary individual(s) facilitating research activities are:	
Women	60/123
Implicit that they are women	21/123
Men and women	9 /123
Unspecified member of the household	32/123
Children and an unspecified adult	1/123
Study reported time commitment required from participants to answer questions from field team	1/123
Study reported compensation provided for engaging in research activities	Yes (12/123) No (85/123) Mentioned free/subsidized stove/fuel for treatment and/or control at end of study and/or free transport/follow-up care (26/123)
Study reported thanked study participants or households in acknowledgements	Yes (56/123) No (67/123)

children's outcomes. The remaining studies had variations (total <10%). Regarding gender in exposure outcome studies, six studies ($n = 6$ of 66) disaggregated outcomes by gender (infant or adult), and six ($n = 6$ of 66) adjusted their models with sex as a covariate. Ten studies ($n = 10$ of 66) reported exposures at the kitchen/household level.

Women's behaviour, labour, time and finances

Few studies acknowledged the gender of those whom project staff trained and thus who were expected to make the necessary behaviour change or ensure that other household members did so ($n = 28$ of 123). It was usually implied, but not explicit, that the woman was responsible. For example, the intervention's communication or educational materials (if provided) clearly targeted women through pictures, instruction manuals and so on. Other studies simply enrolled pregnant women, provided them the stove and tracked their exposure, never acknowledging whether they were the ones cooking.

Additional labour needed could include chopping up biomass into smaller pieces to fit the improved stove, using specific tools for large pots (that is, metal supports on a gas burner), adjusting to the new stove and so on. The time or the gender of the individual facing those costs was rarely reported (Table 1).

Intervention stoves hypothetically saved time for cooks, as improved or clean stoves often light and cook foods more quickly than open fires and reduce fuel collection time. Only 13 of the 123 studies reported time saved, typically time saved cooking and/or collecting fuel; one study reported time to repair the stove. Cooking time was often determined through time diaries, defined as cooking episodes or monitored with stove use monitors. Only four of those ($n = 4$ of 13) acknowledged that it was the woman's time saved. Some studies even obtained the time saved from the female cook's diaries but then reported it as 'household' time.

Twenty-three articles reported financial outcomes (WTP, fuel purchases and so on), and studies typically controlled for household income/expenditure or a wealth index in their analyses (19 of 23). Only two reported who controlled the budget (1 of 23) and only one study reported the gender of the individual who purchased the stove (1 of 23). Some studies assumed or implied the identity of these individuals but did not explicitly survey who was responsible (Table 1).

Climate studies

Trials focused on climate emissions or fuel conservation to reduce climate emissions did not mention the gender of household members who had to change their behaviour or assist with the research activities. Fuel consumption was reported at the household level only.

Engagement in the research itself

All articles required the involvement of a household member for data collection (that is, participation was essential to reporting); this member was usually female but was sometimes left unspecified (Table 2). This participation, separate from that essential to the intervention, might require an individual to consent to answering questions, wearing a monitor or having a research team come in to measure emissions or the kitchen space and so on. Only one study reported the time commitment for participants. Most studies did not mention any compensation for research-related efforts (time spent answering questionnaires or having researchers inside the home to measure emissions) ($n = 85$ of 123). If reported, compensation was usually given as in-kind items (rice, children's toys, bed nets) ($n = 12$ of 123). Twenty-six articles reported providing the intervention stove for free, compensating control participants equivalently or reimbursing for transport for research-related activities (for example, health check-ups, focus groups and so on). A little under half the studies thanked participants or study households in their acknowledgements ($n = 56$ of 123).

Gender Responsiveness Assessment Scale

We assessed the reviewed studies against the WHO's Gender Responsive Assessment Scale (GRAS). The GRAS assesses health programmes and interventions through a gender lens, assigning each to one of five levels: gender-unequal, gender-unaware, gender-sensitive, gender-specific and gender-transformative^{35,36} (Fig. 2). According to WHO, gender-unequal interventions reinforce stereotypes and perpetuate inequalities, whereas gender-unaware/blind interventions ignore gender roles, norms and relations; WHO states that neither should be pursued as they are implicitly exploitative. Gender-sensitive interventions indicate awareness of gender but do not discuss or address inequalities. Gender-specific interventions acknowledge men's and women's specific needs and roles but do not challenge gender roles or norms. Gender-transformative interventions address the causes of gender inequality and suggest how to transform harmful gender roles, norms and relations and actively counter harmful stereotypes (Supplementary Table 1). We added a sixth category of 'Gender-unaware but sex-aware' based on the number of cookstove trials targeting exposures for pregnant women as proxies for their unborn or neonatal children.

Interventions and GRAS

We categorized ~63% of the reviewed interventions as gender-unaware ($n = 42$), gender-unaware but sex-aware ($n = 32$) and gender-unequal ($n = 4$); ~37% were gender-sensitive ($n = 36$), gender-specific ($n = 7$) or gender-transformative ($n = 2$) (Fig. 3a). Assigning articles by their major outcome, we find that health studies were mostly gender-sensitive or gender-unaware but sex-aware. Articles with outcomes related to time, labour and behaviour; finance; and climate were mostly gender-unaware (Fig. 3b). Studies covering a WHO 'clean' stove were split between gender-unaware, gender-unaware but sex-aware and gender-sensitive. Those categorized as gender-specific, gender-transformative and gender-unequal were largely studies of stoves that do not meet the WHO standard (Fig. 3c).

Discussion

The reviewed cookstove trials were generally split among the categories of (1) gender-unaware, (2) gender-sensitive and (3) gender-unaware but sex-aware. Within cookstove trials, women are frequently targeted as subjects/respondents but then not acknowledged in time, labour,

	Gender-unequal	Gender-unaware	Gender-unaware but sex-aware	Gender-sensitive	Gender-specific	Gender-transformative
Brief description	<p>Perpetuates gender inequality by reinforcing unbalanced norms, roles and relations</p> <p>Privileges men over women (or vice versa)</p> <p>Often leads to one sex enjoying more rights or opportunities than the other</p>	<p>Ignores gender norms, roles and relations</p> <p>Very often reinforces gender-based discrimination</p> <p>Ignores differences in opportunities and resource allocation for women and men</p> <p>Often constructed based on the principle of being 'fair' by treating everyone the same</p>	<p>Considers gender in relation to pregnancy and carrying children</p> <p>Ignores differences in experiences or outcomes for different-gendered parents</p> <p>Often fails to acknowledge the woman as a full participant, but rather as a proxy for their child</p>	<p>Considers gender norms, roles and relations</p> <p>Does not address inequality generated by unequal norms, roles or relations</p> <p>Indicates gender awareness, although often no remedial action is developed</p>	<p>Considers gender norms, roles and relations for women and men and how they affect access to and control over resources</p> <p>Considers women's and men's specific needs</p> <p>Intentionally targets and benefits a specific group of women or men to achieve certain policy or programme goals or meet certain needs</p> <p>Makes it easier for women and men to fulfil duties that are ascribed to them based on their gender roles</p>	<p>Considers gender norms, roles and relations for women and men and that these affect access to and control over resources</p> <p>Considers women's and men's specific needs addresses the causes of gender-based health inequities</p> <p>Includes ways to transform harmful gender norms, roles and relations</p> <p>Objective is often to promote gender equality</p> <p>Includes strategies to foster progressive changes in power relationships between women and men</p>
Example intervention from included studies	<p>Project assumes equal bargaining power in a joint decision to purchase, provides educational material that reinforces roles, tracks 'household' stove use and suggests policies to operate within current gender roles (that is, privileging men to encourage cookstove purchases).</p>	<p>Researchers assign 'households' to different pricing/credit arms to pay for the upfront cost of the stove and track 'household' fuel use. Never acknowledge the gender of who is interviewed or who is cooking. In Methods, the authors may acknowledge the gender of the main participant but then only ever refer to the 'household's stove use'.</p>	<p>The programme enrolls pregnant women and tracks their exposure to particulate matter to evaluate their child's prenatal exposure and relation to the child's outcome of interest. Does not specify who was trained on the stove or expected to make the behaviour change to adopt the improved or clean stove to reduce exposure. The woman is not an independent participant but rather a mother-infant dyad.</p>	<p>The study targets women to train and provide the improved or clean stove as the primary cooks and tracks outcomes for women. The article may acknowledge that women face a higher burden in terms of fuel collection and cooking but does not address that inequality.</p>	<p>The intervention provides women, as the primary cooks, with improved or clean stoves, acknowledges the burden faced by women and discusses how the intervention may help women fulfil their cooking duties.</p>	<p>The intervention engages women, acknowledges their disproportionate burden, tracks their outcomes and engages men to distribute the financial/physical burden and reduced exposure across household members. The researchers compensate the women for their time and report their time and labour.</p>

Fig. 2 | Example interventions from our included studies across our adjusted GRAS categorization. WHO developed GRAS to assess health programmes, policies and interventions, depicting approaches across five levels, with the goal of supporting only programmes that are gender-sensitive, gender-specific or gender-transformative^{35,36}. The green shading lightens as each category

progresses towards gender-transformative work. We added the category 'Gender-unaware but sex-aware' based on the number of clean cooking intervention trials targeting exposures for pregnant women as proxies for their neonatal children. These studies focus on women as purely reproductive beings.

finances and even health outcomes. This absence is not a deliberate neglect of women's wellbeing. Rather, it is an instance of what ref. 37 called the progress of 'normal science': an enterprise with widely accepted theories, research questions, methods and tools or 'the dominant paradigm' within which most work is conducted³⁷. Normal science builds systematically on what the field has already developed³⁸, addressing questions that have not been adequately answered, but not questions that are not asked at all. We discuss our results and present recommendations to steer the cookstove literature towards more gender-sensitive questions, designs and discussions.

Our review was dominated by health exposure and outcome studies, usually for children. These studies often targeted pregnant women but monitored their exposures only to predict the outcomes for the child (for example, birth weight). We augmented the GRAS schema to add the sex-aware category to acknowledge the critical importance of child health, but targeting pregnant women for their neonatal exposures, in their reproductive rather than gender roles, is neither gender-sensitive nor gender-unaware. As WASH scholars have noted, this gap is a missed opportunity to track the women's outcomes³⁹. Some of the interventions published separate articles on the child's and woman's health; however, the average ratio of articles on children to articles on women is 1.8. Further, two-thirds of the health studies reporting outcomes for women included only women of reproductive age, yet women cook well beyond their childbearing years. This oversight could be a product of research funders' understandable interest in child health, but some funders are open to expanding the research scope if researchers stress its importance. Overall, women's health outside of their reproductive years is understudied in cookstove research.

In behaviour change, labour, time and finance studies, gender roles are commonly ignored. In labour-time studies, the gender of the individual facing those time costs is rarely recognized. Financial studies rarely specify who is making the purchasing decisions. Several

studies assume that men control household finances, although in sub-Saharan Africa, for example, the gender-separated nature of household budgeting is well documented^{40,41}. WTP studies do not consider how differences in income earned or gendered spheres of expenditure determine stated WTP. This means that many cookstove interventions that require users to purchase the stove (or fuel) do not know their main consumers or how fuel purchases depend on the household's financial norms⁴²⁻⁴⁴. Therefore, the affordability or unaffordability of cleaner cooking remains unknown. Some trials have implied that women did not value the stoves and therefore failed to maintain them^{45,46}, without investigating the woman's available time or resources to do so.

Cookstove sector studies frequently imply that cooking time saved leads to women's empowerment. Yet only 11% of studies measured time, and even fewer acknowledged that it is 'her' time. Such an approach inadvertently condones the longstanding bias that women's labour, especially within the household, is 'free'⁴⁷. Further, reduced time or effort may not lead to empowerment^{48,49}, only one study acknowledged that women may not have agency over any time saved because of social norms and expectations. In fact, there is no direct link between time savings and empowerment^{50,51} when 'freed-up' time may not be under women's control^{52,53}. Clean energy access is necessary, but hardly sufficient, for empowerment⁵⁴.

Climate studies do not require gender-specific outcomes; however, we find a clear misalignment across climate and women's health trials. We found that 87 of 123 trials implemented a stove that did not meet WHO criteria, even when conducted after the guidelines were released. These 'improved' stoves improve wellbeing (less drudgery), decrease smoke exposure and have economic benefits (reduced fuel needs). These are valuable benefits, but they do not reduce the relative risk of disease⁵⁵. Yet many such studies motivated their trials hypothesizing both climate and health benefits. Although no clean fuel intervention can guarantee improved health outcomes, observational

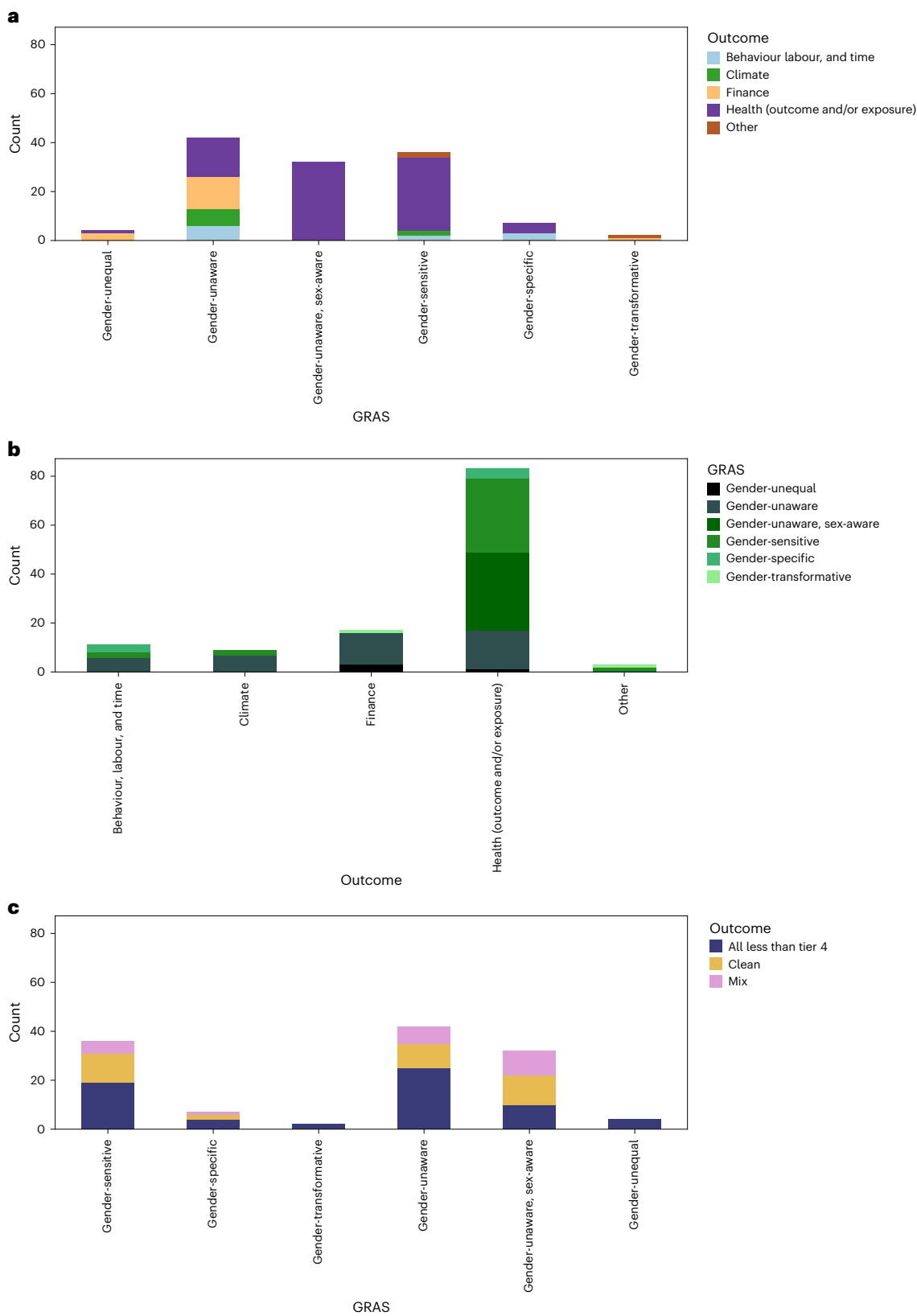


Fig. 3 | The GRAS applied across cookstove intervention outcomes. **a**, Outcomes organized into their GRAS category. **b**, GRAS breakdown in the outcome categories. **c**, Article stove categories organized across their GRAS categories ($N = 1,233$ for all). We augmented the WHO’s GRAS categorization,

adding an additional specification, ‘Gender-unaware but sex-aware.’ Although studies often collect data on outcomes spanning categories, for this analysis we identified the major outcome category to assign one category to each article.

studies and RCTs have established exposure–response curves showing that only specific fuels (liquefied petroleum gas, electricity, biogas and so on) lower exposure enough to decrease relative risk of disease^{23,26,56,57}. These fuels, absent stacking with polluting fuels (which is widespread due to unaffordability and unavailability), at least offer the possibility of health improvements.

Research indicates larger net benefits across health, climate and society for large-scale energy transitions to only clean fuels rather than partial transitions to improved stoves⁵⁸. Thus, the persistence of targeting women for improved-yet-unclean stove interventions, despite their inability to reduce exposures to levels needed for health benefits, could be a product of legacy effects (that is, normal science) or the carbon market projects that researchers may work with. Indeed, the field has a history of prioritizing stove designs for purposes other than women's needs⁵⁹. This position is especially troubling because women cooking over open fires are not major drivers of CO₂-equivalent (CO₂-e) emissions^{60,61}. Reducing cooking-related CO₂-e emissions through improved stoves could at best decrease annual CO₂-e by -1.8% of global CO₂-e in 2023^{62,63}.

Women had critical, time-consuming involvement in generating the research data: providing urine first thing in the morning, wearing personal exposure monitors, bringing in their children for biweekly visits to provide research data and answering fuel use and purchase questions at regular intervals. To comply thus with an intervention is to act as an unacknowledged research assistant. Women participants may have received some benefits but certainly donated their time; only one study acknowledged that commitment. We contend that even when compensation is not feasible, accounting for respondents' time is always possible.

We acknowledge that research fields have limited resources, funders have specific foci, and it takes time to change legacy effects within fields. Not every study needs to be gender-specific; however, our results indicate implicit biases within the overarching direction of the cookstove field and of where resources have been (or have not been) allocated. We do not imply any intention to dismiss women or perpetuate harmful gender norms. Our work is also limited to RCTs as the dominant form of empirical study in health and development economics, but there could be more gender-sensitive, gender-specific or gender-transformative studies in observational and quasi-experimental studies. However, cookstove RCTs as a whole could be more intentional in improving their number of gender-specific and gender-transformative studies (Fig. 3).

We present recommendations for researchers, funders and journals to acknowledge women, their roles and their costs in cookstove trials. Most journals require trials to report research design, sample size, randomization and so on. Few ask how the trial collected sex/gender data. The Sex and Gender Equity in Research guidelines, adopted by WHO, recommend sex-disaggregation throughout the research process⁶⁴. Health researchers have been encouraged to report on whether sex/gender was considered and how their study design enabled gender-specific investigations⁶⁵. Although insufficient⁴⁹, energy research has also acknowledged the need to disaggregate outcomes by gender⁶⁶. Cookstove researchers, funders and publishers must learn from gender-centred literature⁴⁹, beyond public health or economics, to understand how their interventions could cement, inform or change harmful gender dynamics. We urge all journals, trial registries and funders to require RCTs to publicly report the gender of participants, their time commitments and procedures undertaken and whether they were compensated, as a way to acknowledge their contributions. Time commitments and compensation are often estimated for ethical clearances and thus can be easily updated at publication. This could create a positive feedback loop in which other researchers do not have the expectation of free female labour and so properly budget future trials. Journal author guidelines and funder reporting should also encourage discussion of gender implications of their work. Finally, health-related

cookstove funders and researchers could realign to study the health of women of all ages as well as newborns. These steps would better support their stated goal of gender equality.

We also suggest some specific ways in which more cookstove researchers can emulate the gender-sensitive and gender-specific studies. WHO already does not recommend gender-unequal and gender-unaware studies³⁵. Studies can acknowledge the gender of their participants in the main text, document the shift in work due to the intervention (avoiding those with foreseen additional labour) and report women's outcomes for themselves rather than only as a proxy for their children. More studies could systematically investigate metrics that their participants (often women) value in addition to their health, such as their time and money. Studies could discuss differences in their participants' access to resources (for example, can she buy fuel), needs (given her current household responsibilities) or outcomes (for example, higher exposure given her responsibility to cook). Studies could discuss how the intervention does or does not help women or men in their expected roles or generate hypotheses for changing these dynamics in the long run. In contrast, unaware studies do not acknowledge gender, only mentioning their participants' genders in a table or supplemental material and automatically subsuming women's work into a falsely unitary 'household'. Gender-unequal studies potentially perpetuate harmful gender roles: they could suggest the design of stoves with features that men like (in settings where men have financial control), without considering what this means for the main user to be burdened with an 'odd' stove designed not for the cook but for someone else. In fact, the disproportionate number of gender-unequal studies with financial outcomes is partly a result of researchers, trying to increase WTP or actual purchases, inadvertently prioritizing men's preferences over women's. Only one financial (and transformative) study attempted to understand those dynamics and called for gender-specific cookstove financing policies, helping women to control the money to meet their needs rather than appeasing unequal norms to make progress on energy access numbers.

Cookstoves had more gender-sensitive projects than the recent re-review of WASH interventions that inspired this research³³ and even a few gender-specific and gender-transformative articles that discussed unequal norms and roles or how to improve women's positions or incorporate remedial action³⁵. Without more intentional change, however, women in cookstove interventions will remain invisible, enabling research to proceed without clear evidence of whether interventions are increasing their health, let alone their equality. As things stand, the clean cooking field runs the risk of, at best, leaning into existing inequalities and, at worst, basing current and future interventions and SDG progress on spuriously gender-neutral premises.

Methods

We reviewed all cookstove RCTs. The primary criterion for inclusion of the peer-reviewed and grey literatures was a cookstove-related RCT, published between 2000 and 2024 in LMICs. We searched through Science Direct, PubMed, Web of Knowledge, Google Scholar, ProQuest Dissertations & Thesis, the Clean Cooking Alliance and the Energy Sector Management Assistance Program databases. We used the search terms 'clean cooking' and 'cookstove' with 'intervention' and 'trial' and prioritized research articles and book chapters (as opposed to abstracts, conference posters and so on). In total, this produced more than 180,000 results. We screened titles and abstracts for eligibility and then removed duplicates. Both authors screened titles and abstracts; no inconsistencies were found. Throughout the studies identified, we conducted hand searches from their references. This process resulted in 236 articles that we read in full, of which we included 123 (Fig. 1). We excluded roughly half of the identified articles as several papers were not RCT themselves but were adjacent analyses such as a nested cross-sectional study within an RCT or qualitative work only. We included only articles that documented outcomes of treatment

participants compared to control as opposed to exposure responses or other impacts with only the treatment group.

We excluded studies focused on institutional or commercial settings or those conducted in a laboratory setting. We also excluded cross-sectional studies nested within RCTs and studies adjacent to RCTs such as deeper qualitative pieces. Only English language papers were reviewed.

If we found multiple versions of a paper, we included peer review publications: that is, in the case of duplicates across working papers or theses, we included the peer-reviewed article. Often, large RCTs produced a number of papers, each with a different scope or category of outcome but within the same overarching study design. Across our included sample, we identified 46 independent research endeavours that produced the 123 articles (Supplementary Table 2).

Analysis

Our review was narrative and mixed methods. We systematically tracked the type of intervention stove and whether it complies with WHO standards and whether the article came out before or after those standards were set. We tracked all outcome categories the article reported. For all articles, we tracked whether individual participation was necessary for the success of the intervention and whether the gender of the main participant was mentioned, and we categorized the individual who was targeted for participation (and their gender) and for whom outcomes were tracked (for example, women, men and women, men, unspecified member, child, child and unspecified adult, pregnant woman). For articles covering health outcomes and air pollution exposures, we tracked whether the article disaggregated results by sex and whether and how gender (or sex) was discussed or approached throughout the article text. For articles covering financial outcomes, we tracked whether income was considered and, if so, whose income (for example, woman's, man's, explicit joint). For studies on time savings, we tracked the types of time and whose time the article reported. For all studies, we tracked whether the article mentioned an individual they trained who was expected to make the behaviour change or be sure that others were following along in order to ensure the success of the intervention and whether this person's gender was acknowledged. We tracked how gender was conveyed throughout any intervention communication. For research involvement, we tracked whether participation of an individual was necessary for research activities and whether the study reported the time commitment required and any compensation for participating in the research. We reviewed all of the studies' 'Acknowledgements' sections and tracked whether participants were mentioned. Data were analysed in Microsoft Excel Version 16.89.1 and Python 3.9.13.

GRAS categorization

In order to categorize each article into a GRAS category, we evaluated the entire article against the GRAS definitions and our additional category and definition (Supplementary Table 1). To ensure consistency in our categorization of articles, we established a protocol to dictate how each article would be considered for its GRAS category (Supplementary Fig. 2), recognizing that some classifications have more porous boundaries. As categorization is more subjective than other variables we tracked, both authors discussed specific cases and determined appropriate categorization of large article categories as well as specific cases. We evaluated studies for the entirety of the text and tone of the article, focusing not only on results but also on how articles framed the introduction and discussion/conclusion sections. Please see Supplementary Fig. 2 for explanations of each GRAS categorization.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

All data and code are available at https://github.com/agillwiehl/roles_of_women_cookstove_RCTs.

Code availability

All data and code are available at https://github.com/agillwiehl/roles_of_women_cookstove_RCTs.

References

1. *Gender Equality in the Sustainable Energy Transition* (UNIDO and UN WOMEN, 2023); <https://www.unwomen.org/sites/default/files/2023-05/Gender-equality-in-the-sustainable-energy-transition-en.pdf>
2. Shupler, M. et al. Gendered time, financial & nutritional benefits from access to pay-as-you-go LPG for cooking in an informal settlement in Nairobi, Kenya. *World Dev. Sustain.* **5**, 100178 (2024).
3. Sharma, A., Singh, C. & Vaish, S. in *Axes of Sustainable Development and Growth in India: Essays in Honour of Professor Jyoti K. Parikh* (eds Tiwari, P. & Parikh, K.) Ch. 9 (Springer Nature, 2023); https://doi.org/10.1007/978-981-19-9756-3_9
4. Ji, W., Chen, Y., Huang, W., Zhou, H. & Xu, S. Trends and regional disparities in the global burden of disease attributable to household air pollution in 204 countries and territories, 1990–2021: an analysis of the global burden of disease study. *BMJ Open* **15**, e092162 (2025).
5. Akter, S. & Pratap, C. Impact of clean cooking fuel adoption on women's welfare in India: the mediating role of women's autonomy. *Sustain. Sci.* **17**, 243–257 (2022).
6. Okello, G., Devereux, G. & Semple, S. Women and girls in resource poor countries experience much greater exposure to household air pollutants than men: results from Uganda and Ethiopia. *Environ. Int.* **119**, 429–437 (2018).
7. Choudhuri, P. & Desai, S. Gender inequalities and household fuel choice in India. *J. Clean. Prod.* **265**, 121487 (2020).
8. Kelkar, G. & Nathan, D. Cultural and economic barriers in switching to clean cooking energy: does women's agency make a difference? *Energies* **14**, 7242 (2021).
9. Govindan, M. & Murali, R. in *Dilemmas of Energy Transitions in the Global South* (eds Kumar, A. et al.) Ch. 7 (Routledge 2021).
10. Kumar, P. & Mehta, S. Poverty, gender, and empowerment in sustained adoption of cleaner cooking systems: making the case for refined measurement. *Energy Res. Soc. Sci.* **19**, 48–52 (2016).
11. Wang, J. Why clean cooking programs fail among rural women? A female user-centered view from Uttar Pradesh, India. In *Proc. World Conference on Women's Studies* 57–75 (TIKM, 2021).
12. Shailaja, R. Women, energy and sustainable development. *Energy Sustain. Dev.* **4**, 45–64 (2000).
13. Cabiyo, B., Ray, I. & Levine, D. I. The refill gap: clean cooking fuel adoption in rural India. *Environ. Res. Lett.* **16**, 014035 (2021).
14. Pachauri, S. & Rao, N. D. Gender impacts and determinants of energy poverty: are we asking the right questions?. *Curr. Opin. Environ. Sustain.* **5**, 205–215 (2013).
15. Menghwani, V. et al. Determinants of cookstoves and fuel choice among rural households in India. *EcoHealth* **16**, 21–60 (2019).
16. Clasen, T. F. et al. Liquefied petroleum gas or biomass for cooking and effects on birth weight. *N. Engl. J. Med.* **387**, 1735–1746 (2022).
17. Jack, D. W. et al. A cluster randomised trial of cookstove interventions to improve infant health in Ghana. *BMJ Glob. Health* **6**, e005599 (2021).
18. Lewis, J. J. & Pattanayak, S. K. Who adopts improved fuels and cookstoves? A systematic review. *Environ. Health Perspect.* **120**, 637–645 (2012).

19. Rehfuess, E. A., Puzzolo, E., Stanistreet, D., Pope, D. & Bruce, N. G. Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review. *Environ. Health Perspect.* **122**, 120–130 (2014).
20. Puzzolo, E., Pope, D., Stanistreet, D., Rehfuess, E. A. & Bruce, N. G. Clean fuels for resource-poor settings: a systematic review of barriers and enablers to adoption and sustained use. *Environ. Res.* **146**, 218–234 (2016).
21. Gill-Wiehl, A., Ray, I. & Kammen, D. Is clean cooking affordable? A review. *Renew. Sustain. Energy Rev.* **151**, 111537 (2021).
22. Lindgren, S. A. Clean cooking for all? A critical review of behavior, stakeholder engagement, and adoption for the global diffusion of improved cookstoves. *Energy Res. Soc. Sci.* **68**, 101539 (2020).
23. Puzzolo, E. et al. Estimated health effects from domestic use of gaseous fuels for cooking and heating in high-income, middle-income, and low-income countries: a systematic review and meta-analysis. *Lancet Respir. Med.* **12**, 281–293 (2024).
24. Simkovich, S. M. et al. A systematic review to evaluate the association between clean cooking technologies and time use in low- and middle-income countries. *Int. J. Environ. Res. Public Health* **16**, 2277 (2019).
25. Pope, D., Bruce, N., Dherani, M., Jagoe, K. & Rehfuess, E. Real-life effectiveness of ‘improved’ stoves and clean fuels in reducing PM_{2.5} and CO: systematic review and meta-analysis. *Environ. Int.* **101**, 7–18 (2017).
26. Pope, D. et al. Are cleaner cooking solutions clean enough? A systematic review and meta-analysis of particulate and carbon monoxide concentrations and exposures. *Environ. Res. Lett.* **16**, 083002 (2021).
27. Quansah, R. et al. Effectiveness of interventions to reduce household air pollution and/or improve health in homes using solid fuel in low-and-middle income countries: a systematic review and meta-analysis. *Environ. Int.* **103**, 73–90 (2017).
28. Jeuland, M. et al. Is energy the golden thread? A systematic review of the impacts of modern and traditional energy use in low-and middle-income countries. *Renew. Sustain. Energy Rev.* **135**, 110406 (2021).
29. Das, I. et al. Frameworks, methods and evidence connecting modern domestic energy services and gender empowerment. *Nat. Energy* **8**, 435–449 (2023).
30. Deaton, A. & Cartwright, N. Understanding and misunderstanding randomized controlled trials. *Soc. Sci. Med.* **210**, 2–21 (2018).
31. Frieden, T. R. Evidence for health decision making — beyond randomized, controlled trials. *N. Engl. J. Med.* **377**, 465–475 (2017).
32. Irving, M., Eramudugolla, R., Cherbuin, N. & Anstey, K. J. A critical review of grading systems: implications for public health policy. *Eval. Health Prof.* **40**, 244–262 (2017).
33. Caruso, B. A., Ballard, A. M., Sobolik, J. et al. Systematic re-review of WASH trials to assess women’s engagement in intervention delivery and research activities. *Nat. Water* **2**, 827–836 (2024); <https://doi.org/10.1038/s44221-024-00299-2>
34. *Defining Clean Fuels and Technologies* (WHO, 2021); <https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean>
35. *Gender Mainstreaming for Health Managers: A Practical Approach* (WHO, 2011); <https://iris.who.int/server/api/core/bitstreams/002b3581-a6c3-48ef-9a21-c95c7baf37a7/content>
36. *Mainstreaming Gender within WHO Health Emergencies Programme: 2022–2026 Strategy* (WHO, 2022); <https://iris.who.int/bitstream/handle/10665/360406/9789240049291-eng.pdf?sequence=1&isAllowed=y>
37. Kuhn, T. S. *The Structure of Scientific Revolutions* (Univ. of Chicago Press, 1962).
38. Bird, A. Thomas Kuhn. *Stanford Encyclopedia of Philosophy* <https://plato.stanford.edu/entries/thomas-kuhn/> (2022).
39. Caruso, B. A. & Sinharoy, S. S. Gender data gaps represent missed opportunities in WASH. *Lancet Glob. Health* **7**, e1617 (2019).
40. Guyer, J. in *A Home Divided: Women and Income in the Third World* (eds Dwyer, D. & Bruce, J.) Ch. 8 (Stanford Univ. Press, 1988).
41. Peters, P. E. *Dividing the Commons: Politics, Policy, and Culture in Botswana* (Univ. Press of Virginia, 1994).
42. Gill-Wiehl, A. & Ojong, N. Yours, mine, and ours: gender, intra-household dynamics, and financing solar home systems in Tanzania. *Environ. Res. Lett.* **18**, 084018 (2023).
43. Mohapatra, S. & Simon, L. Intra-household bargaining over household technology adoption. *Rev. Econ. Househ.* **15**, 1263–1290 (2017).
44. Mekonnen, D. K., Arega, T. & Yimam, S. *Intra-Household Decisions on Cookstove Choices and Impacts on the Welfare of Women and Girls* (EEG, 2022); <https://cgspace.cgjar.org/items/53d8b838-3e3d-4522-b932-9c79da0eccb4>
45. Hanna, R., Duflo, E. & Greenstone, M. Up in smoke: the influence of household behavior on the long-run impact of improved cooking stoves. *Am. Econ. J. Econ. Policy* **8**, 80–114 (2016).
46. Mobarak, A. M., Dwivedi, P., Bailis, R., Hildemann, L. & Miller, G. Low demand for nontraditional cookstove technologies. *Proc. Natl Acad. Sci. USA* **109**, 10815–10820 (2012).
47. Beneria, L. Accounting for women’s work: the progress of two decades. *World Dev.* **20**, 1547–1560 (1992).
48. Chant, S. The ‘feminisation of poverty’ and the ‘feminisation’ of anti-poverty programmes: room for revision? *J. Dev. Stud.* **44**, 165–197 (2008).
49. Bradshaw, S. Sex disaggregation alone will not energize equality. *Nat. Energy* **3**, 813–815 (2018).
50. Ardrey, J. et al. ‘Cooking is for everyone?’: exploring the complexity of gendered dynamics in a cookstove intervention study in rural Malawi. *Glob. Health Action* **14**, 2006425 (2021).
51. Cornwall, A. women’s empowerment: what works? *J. Int. Dev.* **28**, 342–359 (2016).
52. Eissler, S. et al. Measuring women’s empowerment: gender and time-use agency in Benin, Malawi and Nigeria. *Dev. Change* **53**, 1010–1034 (2022).
53. Khed, V. D. & Krishna, V. V. Agency and time poverty: linking decision-making powers and leisure time of male and female farmers of Central India. *World Dev. Perspect.* **29**, 100484 (2023).
54. Zhang, A. T. et al. Evidence of multidimensional gender inequality in energy services from a large-scale household survey in India. *Nat. Energy* **7**, 698–707 (2022).
55. *WHO Global Air Quality Guidelines: Particulate Matter (PM_{2.5} and PM₁₀), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide* (WHO, 2021).
56. Balakrishnan, K. et al. Exposure–response relationships for personal exposure to fine particulate matter (PM_{2.5}), carbon monoxide, and black carbon and birthweight: an observational analysis of the multicountry Household Air Pollution Intervention Network (HAPIN) trial. *Lancet Planet. Health* **7**, e387–e396 (2023).
57. Burnett, R. T. et al. An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure. *Environ. Health Perspect.* **122**, 397–403 (2014).
58. Das, I. et al. The costs and benefits of clean cooking policies in low- and middle-income countries under real-world conditions. *Sustain. Dev.* **33**, 6108–6123 (2025).

59. Crewe, E. in *Discourses of Development* (eds Grillo, R. D. & Stirrat, R. L.) Ch. 3 (Oxford Univ. Press, 1997).
60. Bailis, R., Drigo, R., Ghilardi, A. & Masera, O. The carbon footprint of traditional woodfuels. *Nat. Clim. Change* **5**, 266–272 (2015).
61. Floess, E. et al. Scaling up gas and electric cooking in low- and middle-income countries: climate threat or mitigation strategy with co-benefits? *Environ. Res. Lett.* **18**, 034010 (2023).
62. *CO₂ Emissions in 2023* (IEA, 2024); <https://www.iea.org/reports/co2-emissions-in-2023>
63. *State of Global Air 2024: Special Report* (Health Effects Institute, 2024); <https://www.stateofglobalair.org/resources/report/state-global-air-report-2024>
64. Heidari, S. et al. WHO's adoption of SAGER guidelines and GATHER: setting standards for better science with sex and gender in mind. *Lancet* **403**, 226–228 (2024).
65. Thompson, K., Peters, S., Woodward, M., Carcel, C. & Norton, R. Reporting sex and gender in medical research. *Lancet* **393**, 2038 (2019).
66. *Tracking SDG 7: The Energy Progress Report 2024* (IEA, IRENA, UNSD, World Bank & WHO, 2024); <https://www.iea.org/reports/tracking-sdg7-the-energy-progress-report-2024>
67. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. & Group, T. P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *PLoS Med.* **6**, e1000097 (2009).

Acknowledgements

A.G.-W. would like to acknowledge funding from a National Institute of Health training grant (grant no. T32ES007322). We acknowledge B. Caruso for comments on an initial draft and for thinking of the 'sex-aware' nomenclature to articulate the distinctness of this category.

Author contributions

A.G.-W. and I.R. conceptualized the article, analysed results and wrote and edited the final manuscript. A.G.-W. conducted the review, created all figures and wrote the initial draft.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41893-026-01769-z>.

Correspondence and requests for materials should be addressed to Annelise Gill-Wiehl.

Peer review information *Nature Sustainability* thanks Kendra Williams and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.

© The Author(s), under exclusive licence to Springer Nature Limited 2026

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a | Confirmed

- The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement
- A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
- The statistical test(s) used AND whether they are one- or two-sided
Only common tests should be described solely by name; describe more complex techniques in the Methods section.
- A description of all covariates tested
- A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
- A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
- For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
Give P values as exact values whenever suitable.
- For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
- For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
- Estimates of effect sizes (e.g. Cohen's d , Pearson's r), indicating how they were calculated

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection

Data analysis

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

All data is available at https://github.com/agillwiehl/roles_of_women_cookstove_RCTs

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	We track for all papers included in the review whether or not outcomes were disaggregated by sex or gender. We note that when cookstove studies report data by gender, these are sex-disaggregated along a male/female binary.
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

Life sciences Behavioural & social sciences Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	We systematically review gender roles within cookstove randomized control trials with respect to (1) health and exposure, (2) time, labour, finance, and behaviour, (3) climate, and (4) the research activities.
Research sample	We reviewed all cookstove randomized control trials. The primary criterion for inclusion of the peer-reviewed and grey literatures was a cookstove-related randomized control trial, published between 2000-2024 in a low-and middle-income country (LMIC). We searched through Science Direct, PubMed, Web of Knowledge, Google Scholar, ProQuest Dissertations & Thesis, the Clean Cooking Alliance and the Energy Sector Management Assistance Program databases. We used the search terms “clean cooking” and “cookstove” with “intervention” and “trial,” and prioritized research articles and book chapters (as opposed to abstracts, conference posters, etc.). We included only articles that documented outcomes of treatment participants compared to control as opposed to exposure responses or other impacts with only the treatment group.
Sampling strategy	N/A all eligible studies were included
Data collection	After establishing criteria, we manually searched through databases with specific search terms outlined in methods. The first author screened titles and abstracts. Both authors confirmed identified article eligibility and established protocol for assessing all articles and data to report from each included paper. Blinding was not applicable to our study as this is a systematic review.
Timing	We conducted the review between February 23rd, 2024 and May 17th, 2025.
Data exclusions	No data from eligible studies according to our criteria was excluded
Non-participation	No participants were involved in the study.
Randomization	There is no experimental component to our systematic review.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

Methods

- | n/a | Involvement |
|-------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Antibodies |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Eukaryotic cell lines |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Palaeontology and archaeology |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Animals and other organisms |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Clinical data |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Dual use research of concern |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Plants |

- | n/a | Involvement |
|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> ChIP-seq |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Flow cytometry |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> MRI-based neuroimaging |

Plants

Seed stocks

Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.

Novel plant genotypes

Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.

Authentication

Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosaicism, off-target gene editing) were examined.