Conditional Acceptance of Off-Grid Solar Energy: Trust, Repair, and Continued Use Among Rural Households in Tharaka South, Kenya

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ABSTRACT

Purpose: Off-grid solar energy has become an important pathway to electricity access for rural households in Sub-Saharan Africa, yet research has focused largely on adoption and immediate welfare benefits, with less attention to the conditions that sustain use after acquisition. This study examines post-adoption experiences of off-grid solar energy in Tharaka South, Kenya, a semi-arid rural setting with limited access to electricity. It explores how households and local stakeholders understand the benefits of solar energy, the conditions shaping trust in solar products and providers, and the processes through which continued use is supported or constrained.

Methodology: The study used the qualitative strand of a convergent parallel mixed-methods design within a pragmatist orientation. Participants were purposively sampled: three focus group discussions with solar-using household heads (youth, women and mixed-gender groups; n = 28) and 22 key informant interviews with administrators, vendors and technicians, community stakeholders and development practitioners. Data were collected in person between December 2025 and March 2026 using semi-structured guides and analysed using reflexive thematic analysis.

Findings: Five themes were generated: health, safety and educational benefits; uneven economic gains; trust and seller accountability; cost and repair constraints; and community demonstration and peer learning. Households generally valued solar energy, but positive attitudes did not necessarily translate into sustained use. Product failures, inadequate after-sales support, repair difficulties, battery replacement costs and irregular incomes undermined continued use, whereas accountable providers, accessible repair, manageable payment arrangements and visible evidence of successful use strengthened confidence.

Unique Contribution to Theory, Practice and Policy: Theory: Diffusion of Innovations, trust in abstract systems and energy justice informed the study as sensitising concepts and were used to interpret themes developed inductively from the data. The study develops *conditional acceptance*, in which a favourable evaluation of solar is sustained as continued use only when four conditions are met: assured quality, accessible repair, payment fit and visible proof. Unlike post-adoption confirmation, discontinuance or fuel stacking, it locates continued use in the surrounding service ecosystem rather than in the adopter's evaluation alone. *Constrained discontinuance* names the outcome when these conditions fail. Practice: providers should ensure genuine products, honoured warranties, local technicians and affordable battery replacement. Policy: policymakers should enforce product standards and vendor registration, support decentralised repair networks, design financing around irregular rural incomes, and monitor sustained functionality rather than installations alone.

Keywords: Off-Grid Solar Energy, Conditional Acceptance, Trust, Continued Use, Energy Justice

INTRODUCTION

General Introduction

Access to modern energy remains an important dimension of rural inequality in Sub-Saharan Africa, which is home to the majority of the world's population without access to electricity (IEA et al., 2024). Where extension of the electricity grid is technically difficult or economically costly, off-grid solar products, ranging from small solar lanterns to solar home systems, have become an important pathway to basic electricity services. Kenya has been central to this development, with a long history of market-led solar diffusion (Acker & Kammen, 1996; Jacobson, 2007) and the subsequent expansion of pay-as-you-go (PAYG) models that enable households to spread payments over time (Rolffs et al., 2015). The expansion of off-grid solar, however, raises a question that extends beyond whether households acquire the technology: under what conditions does initial acceptance translate into continued and meaningful use?

Research on solar adoption has predominantly examined the characteristics and circumstances associated with adoption, including household income, education, access to credit, and access to information (Guta, 2018; Karakaya & Sriwannawit, 2015). Other studies have documented welfare benefits, particularly improved lighting, communication, and opportunities for evening activities (Grimm et al., 2017; Lemaire, 2018). This literature provides important evidence concerning why households adopt solar technologies and what they may gain from them, but gives comparatively less attention to the period after acquisition. Once households begin living with a solar system, they must evaluate its reliability, respond to breakdowns, obtain repairs, manage replacement costs, meet payment obligations, and decide whether the technology remains worth using. These post-adoption experiences can therefore shape whether an initially positive assessment becomes sustained use.

Existing qualitative evidence indicates that these processes are consequential. Breakdown, repair, maintenance, and disposal form part of the everyday experience of solar technologies (Cross & Murray, 2018), while social relationships influence adoption alongside technical and financial considerations (Rolffs et al., 2015; Winther et al., 2018). Evidence from large-scale payment data also suggests that access through solar home systems can become intermittent and that late-term payment default is substantial (Mergulhão, 2025). Such evidence points to an important distinction between having acquired a solar system and having reliable access to its services over time. The distinction may be particularly significant in marginal and semi-arid rural settings, where irregular household incomes and limited availability of vendors, technicians, repair services, and replacement components can make continued use more difficult.

Statement of the Problem

This post-adoption perspective is also important for understanding the social-transformative potential of off-grid solar energy. From the perspective of Sen's (1999) capability approach, social transformation involves more than the introduction or possession of a technology; it concerns whether people acquire and sustain greater practical opportunities to pursue activities and outcomes they value. Energy technologies contribute to such capabilities when they provide reliable services that can be incorporated into everyday social and economic life over time (Day et al., 2016). A solar system that provides useful lighting for a period but becomes unusable because of product failure, unaffordable repair, or unsuitable payment arrangements may generate a temporary benefit without producing sustained expansion of capabilities. Thus, the social significance of off-grid solar depends not only on adoption but also on the conditions under which its benefits can be maintained.

This concern also exposes a limitation in conventional diffusion perspectives. Diffusion of Innovations (DOI) has provided a useful framework for understanding relative advantage, compatibility, complexity, trialability, and observability in technology adoption (Rogers, 2003). Yet the decision to adopt is not necessarily the endpoint of a technology's social trajectory. Post-adoption experiences may confirm an earlier decision, strengthen confidence, lead to modification or replacement, or contribute to discontinuance. What remains less clearly understood in rural off-grid energy research is how these post-adoption experiences interact with the social and service environment surrounding the technology. In particular, trust may depend not simply on whether

households perceive solar as beneficial but on whether vendors, technicians, warranties, and repair arrangements provide credible and accessible forms of accountability.

The present study addresses this gap through an examination of off-grid solar use in Tharaka South Sub-County, Tharaka-Nithi County, a semi-arid rural setting in Kenya. Available local records indicate limited uptake of solar home systems, with 328 of 15,245 households identified as users (Kenya National Bureau of Statistics, 2019; Sub-County Energy Office, 2024). The setting provides an important context for examining post-adoption experience because the value of solar technology is closely connected to the availability of local support, the capacity of households to meet financial obligations, and the visibility of successful systems within the community. The study draws on the qualitative strand of a convergent parallel mixed-methods doctoral study and brings together accounts from solar-using household heads and local stakeholders involved in administration, technology provision, community life, and development.

The article makes three related contributions. First, it shifts analytical attention from adoption to post-adoption use, showing that the acquisition of solar technology does not necessarily constitute sustained energy access. Second, it conceptualises trust as relational and infrastructural rather than solely attitudinal: confidence in solar technology is produced partly through the accountability of vendors and technicians, the availability of repair and replacement services, and the credibility of warranty and payment arrangements. Third, it develops the concept of conditional acceptance to explain a pattern in which households regard solar energy positively while their continued use depends on identifiable material, financial and social conditions. Conditional acceptance differs from post-adoption confirmation, discontinuance and fuel stacking in that it explains whether use can continue, not only whether or why it stops, and it places that explanation in the service ecosystem rather than in the adopter's evaluation alone. Constrained discontinuance, introduced in the discussion, is the outcome that results when these conditions are not met, and is treated as a component of conditional acceptance rather than a separate construct. In this account, acceptance is neither a simple decision made at acquisition nor a stable individual attitude; it is sustained through an ecosystem that enables the technology to remain functional, affordable, and socially credible.

Accordingly, the article addresses two questions: (1) How do rural households experience off-grid solar energy after adoption, particularly in relation to its benefits, reliability, and repair? (2) What conditions shape trust and continued use of off-grid solar energy among rural households? Diffusion of Innovations (Rogers, 2003) provides the principal conceptual point of departure, particularly its attention to post-adoption confirmation and discontinuance, while Giddens's (1990) account of trust in abstract systems and the principles of energy justice (Sovacool & Dworkin, 2015) serve as sensitising perspectives for interpreting accountability, service relationships, affordability, and unequal access to the conditions necessary for continued use. Through these perspectives, the article develops conditional acceptance as a way of understanding why positive evaluations of solar energy do not necessarily translate into sustained use.

LITERATURE REVIEW

Theoretical Framework

Diffusion of Innovations

From a Diffusion of Innovations (DOI) perspective, adoption is understood as a process through which households become aware of an innovation, assess its perceived benefits and limitations, make a decision to use it, and subsequently reconsider that decision in light of their experience. Rogers (2003) identifies relative advantage, compatibility, complexity, trialability and observability as characteristics that influence how an innovation is perceived and adopted. These perceptions may also be shaped through communication with family members, neighbours and other trusted community members. DOI has been applied to the adoption of renewable-energy technologies, including household solar systems (Karakaya et al., 2014; Karakaya & Sriwannawit, 2015). Importantly for the present study, Rogers (2003) extends the innovation-decision process to a confirmation stage, during which users reassess their decision and may continue, modify or discontinue their use of an innovation. Discontinuance may occur because a better alternative becomes available (replacement

discontinuance) or because users become dissatisfied with the innovation (disenchantment discontinuance). This perspective therefore helps the study examine continued use of solar systems as a process rather than treating acquisition as evidence of successful adoption. At the same time, DOI gives less attention to the wider structural and service conditions that may enable or constrain sustained use (Greenhalgh et al., 2004).

Trust in Abstract Systems

Giddens's (1990) theory of trust in abstract systems complements DOI by drawing attention to the relationships and institutional arrangements through which households experience and evaluate technology. In modern societies, individuals routinely depend on systems that they cannot fully understand or control. Their confidence in such systems is partly developed through access points—everyday encounters through which abstract systems become tangible to users (Giddens, 1990). In the context of household solar, vendors, technicians, repair providers, warranties and mechanisms for obtaining replacement components can serve as such access points. The continued use of a solar system may therefore depend not only on the household's perception of its benefits but also on whether the surrounding service system is perceived as reliable and responsive. Experiences of product failure, repair difficulties and limited technical support may weaken trust and contribute to interrupted use or discontinuance. This perspective is particularly relevant to the Kenyan context, where the availability and reliability of repair and maintenance services can shape everyday experiences of technology (Cross & Murray, 2018).

Energy Justice

The third perspective is energy justice, which provides a broader framework for examining the social and structural conditions surrounding access to and use of household energy technologies. Energy justice commonly incorporates distributive justice, concerning who receives energy resources and benefits; procedural justice, concerning participation and voice in decisions; and recognition justice, concerning whether the different needs and circumstances of affected groups are acknowledged (Jenkins et al., 2016; Sovacool & Dworkin, 2015; Sovacool et al., 2017). This perspective is important because continued solar use cannot be understood solely as an individual household decision. Affordability, availability of appropriate products, quality of services, geographical accessibility, information, and the ability to obtain repairs or replacements may create unequal opportunities for households to sustain solar use. The energy-ladder perspective has also been challenged by evidence that households combine different energy sources according to their circumstances and changing needs (Masera et al., 2000). Thus, returning temporarily to kerosene or another energy source following solar-system failure should not automatically be interpreted as rejection of solar technology; it may represent fuel stacking as a practical response to an unreliable or incomplete energy service.

Integrating the Three Perspectives

Taken together, these three perspectives provide complementary lenses for understanding sustained household solar use. DOI explains household perceptions and decisions concerning the technology; Giddens explains the role of trust and service relationships in maintaining confidence in the technology; and energy justice draws attention to the structural conditions that shape households' ability to access, use and sustain the technology. The perspectives were used as sensitising concepts rather than predetermined coding categories. Data were analysed inductively to allow themes concerning household experiences, continued use, interruption, repair, discontinuance and the surrounding social and structural conditions to emerge from participants' accounts, after which the three theoretical perspectives were used to interpret and explain the findings.

Positioning Conditional Acceptance in Relation to Existing Concepts

Several concepts address what happens after a technology is acquired, but each captures only part of the pattern examined here. Rogers's (2003) confirmation stage describes how adopters reassess their decision, and his distinction between replacement and disenchantment discontinuance classifies why use stops. Both locate the explanation mainly in the adopter's evaluation of the innovation or of available alternatives. The fuel-stacking literature (Masera et al., 2000) shows that households combine energy sources, but it describes the resulting

pattern of use rather than the conditions that determine whether a technology remains in the household's energy mix. Research on breakdown and repair (Cross & Murray, 2018) and on the social relations of off-grid energy markets (Rolffs et al., 2015) identifies the material and social constraints that shape everyday experience, yet does not offer a construct linking favourable evaluation, constraint and continued use. Integrative diffusion frameworks acknowledge environmental context (Wejnert, 2002), but principally to explain the spread of innovations rather than the maintenance of use after acquisition.

Conditional acceptance differs from these concepts in four ways (Table 1). First, it shifts the unit of explanation from the adopter's evaluation to the service ecosystem of vendors, technicians, warranties, repair and financing through which a technology stays functional. Second, it separates *evaluative acceptance* (a favourable judgement of the technology) from *practical continuity* (ongoing functional use) and treats the gap between them as the object of analysis. Third, it specifies the conditions on which continuity depends, derived inductively from the data. Fourth, it yields indicators of sustained functionality that can be monitored in programmes and policy.

Table 1: Conditional Acceptance Compared with Related Concepts

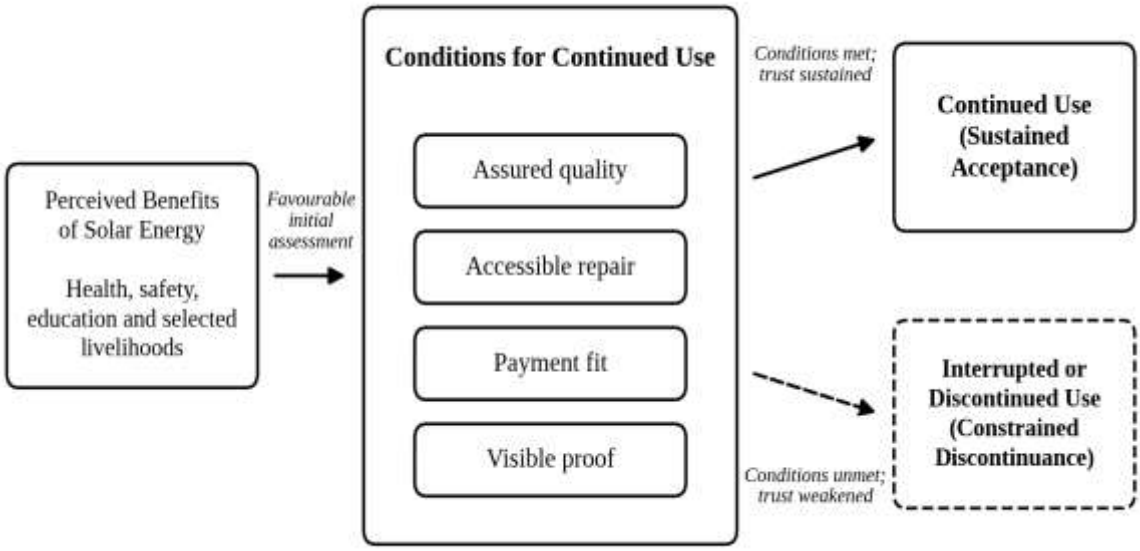
Concept	What it explains	Main locus of explanation	What it leaves open	What conditional acceptance adds
Post-adoption confirmation (Rogers, 2003)	Reassessment of the adoption decision	Adopter's evaluation	Why positive evaluation can coexist with interrupted use	Treats continued use as dependent on external conditions, not evaluation alone
Replacement / disenchantment discontinuance (Rogers, 2003)	Why use stops (better alternative or dissatisfaction)	Adopter's decision	Cessation without rejection or dissatisfaction	Constrained discontinuance: use stops while acceptance remains
Fuel stacking (Masera et al., 2000)	Households combine multiple energy sources	Household practice	Which conditions keep solar in the mix	Explains when a return to kerosene reflects constraint rather than rejection
Breakdown and repair (Cross & Murray, 2018)	Everyday material constraints on solar	Technology and its afterlife	A framework linking constraint to acceptance	Integrates repair, trust, payment and visibility into one construct

Note. The comparison is analytical and draws on the sources cited in the text.

CONCEPTUAL FRAMEWORK

The conceptual framework for the study (Figure 1) draws on the findings and the three theoretical perspectives. Households' perceived benefits of solar energy, namely health, safety, education and selected livelihood gains, support a favourable initial assessment of the technology. Continued use, however, is expected to depend on four interconnected conditions: assured quality, accessible repair, payment fit and visible proof. These conditions operate through trust, understood as relational and infrastructural rather than solely attitudinal. Where they are met, trust is sustained and acceptance is maintained as continued use; where they are not, use may be interrupted or discontinued because of constraints rather than rejection of the technology. The framework therefore distinguishes three linked states: *evaluative acceptance*, a favourable judgement arising from perceived benefits; *sustained acceptance*, in which the four conditions are met and the judgement is maintained as continued use; and *constrained discontinuance*, in which one or more conditions fail and use is interrupted or ceases although the favourable judgement persists.

Figure 1: Conceptual Framework



Empirical Review

Research on household solar energy in rural Africa and the wider Global South has concentrated on adoption and welfare outcomes. Studies of adoption identify household income, education, access to credit and access to information as important correlates (Guta, 2018; Karakaya & Sriwannawit, 2015), while studies of welfare outcomes document improved lighting, communication and opportunities for evening activities (Grimm et al., 2017; Lemaire, 2018). In Kenya, solar diffusion has a long market-led history (Acker & Kammen, 1996; Jacobson, 2007), and pay-as-you-go models have since enabled households to spread payments over time (Rolffs et al., 2015).

Qualitative and data-driven studies indicate that the period after acquisition is consequential. Cross and Murray (2018) show that breakdown, repair, maintenance and disposal form part of the everyday experience of solar technologies in Kenya, while Rolffs et al. (2015) and Winther et al. (2018) show that social relationships, including gender relations, influence adoption and its consequences alongside technical and financial considerations. Analysis of large-scale payment data further suggests that access through solar home systems can become intermittent and that late-term payment default is substantial (Mergulhão, 2025).

Research Gaps

Taken together, this literature explains why households adopt solar technologies and what they may gain from them, but gives comparatively less attention to the period after acquisition, when households must evaluate reliability, respond to breakdowns, obtain repairs, manage replacement costs and decide whether the technology remains worth using. DOI has been applied to solar adoption, yet it gives less attention to the wider structural and service conditions that enable or constrain sustained use (Greenhalgh et al., 2004), and it remains less clearly understood how trust in vendors, technicians, warranties and repair arrangements shapes continued use in marginal, semi-arid rural settings such as Tharaka South. This study addresses these gaps by examining post-adoption experience and developing the concept of conditional acceptance.

METHODOLOGY

This study employed a qualitative approach within a convergent parallel mixed-methods design conducted as part of the first author's doctoral research (Creswell & Plano Clark, 2018). Guided by a pragmatist orientation (Morgan, 2014), the qualitative strand was designed to examine household and stakeholder experiences of

acquiring, using and sustaining household solar systems, with particular attention to continued use, trust, social influences, repair and service conditions, and circumstances associated with interrupted or discontinued use. The methodology comprised the study design and setting, participant selection and sampling, data collection, data analysis and reflexivity, and ethical procedures.

Research Design and Study Area

This article reports the qualitative strand of a convergent parallel mixed-methods study conducted as part of the first author's doctoral research (Creswell & Plano Clark, 2018) within a pragmatist orientation (Morgan, 2014). The quantitative strand comprised a household survey and addressed complementary questions; its findings are not reported in this article. The qualitative strand was used to examine household and stakeholder experiences of acquiring, using and sustaining solar energy systems, including perceptions of their benefits and limitations, trust in suppliers and technical services, social influences, experiences of system failure and repair, and circumstances associated with interrupted or discontinued use. These dimensions require attention to participants' meanings and experiences and therefore cannot be adequately captured through fixed-response measures alone. Data were analysed using reflexive thematic analysis, following Braun and Clarke (2019, 2021), in which themes represent patterns of shared meaning organised around a central concept rather than categories assumed to exist independently in the data. The study was conducted in Tharaka South Sub-County, Tharaka-Nithi County, in eastern Kenya. The area is semi-arid and predominantly agrarian, with livelihoods based mainly on mixed farming, livestock keeping and small-scale enterprises. Limited access to reliable grid electricity provides an important context for understanding household reliance on off-grid solar systems and the conditions affecting their continued use.

Sampling Technique and Sample Size

Participants were selected purposively to obtain accounts from both solar-using households and actors involved in the wider social, administrative, technical and development environment surrounding household solar systems (Table 2). Three focus group discussions (FGDs) were conducted with household heads who were using solar systems: a youth group (n = 9), a women's group (n = 9), and a mixed-gender group (n = 10), giving a total of 28 household participants. Solar-using households were identified through a household screening exercise undertaken within the broader mixed-methods study. Recruitment across several locations enabled the qualitative sample to include participants with varied demographic characteristics and experiences of solar ownership and use. Participants were invited according to the inclusion criteria and their willingness to participate, and FGDs were conducted in neutral community settings, including school classrooms and community halls. In addition, 22 key informants were interviewed, comprising county and sub-county administrators, ward and community leaders, solar vendors and repair technicians, community and social stakeholders, and development practitioners. These participants provided perspectives on the wider conditions influencing access to, use of, maintenance of and confidence in household solar systems. Sampling was not intended to achieve statistical representativeness; rather, adequacy was considered in relation to the study purpose, diversity of relevant perspectives and information power (Malterud et al., 2016).

Table 2: Qualitative Participants (N = 50)

Method	Participant group	n
FGD	Youth household heads	9
FGD	Women household heads	9
FGD	Mixed-gender household heads	10
KII	Administrative decision-makers (county and sub-county officials, ward administrators, area chief)	6
KII	Technical and market actors (solar vendors, repair technicians)	4

Method	Participant group	n
KII	Community and social stakeholders (community health workers, school administrators, women's group leaders)	9
KII	Development practitioners (rural electrification and non-governmental organisation field officers)	3
Total	28 FGD participants and 22 key informants	50

Note. FGD = focus group discussion; KII = key informant interview.

Data Collection Procedure

Semi-structured guides were developed from the study objectives while allowing participants to introduce issues that were not anticipated in advance. FGD questions explored households' experiences of using solar systems, perceived benefits and limitations, factors supporting or constraining continued use, experiences of breakdown and repair, trust in vendors and technicians, social influences on energy choices, and circumstances in which households supplemented, interrupted or discontinued solar use. KII questions examined the wider social, institutional, technical and market conditions affecting household solar use, including availability of products and spare parts, after-sales services, repair arrangements, user support, trust and the factors that may enable or constrain sustained use. Data were collected between December 2025 and March 2026. Sessions were conducted in person and generally lasted 45–60 minutes. The first author moderated the discussions and interviews, assisted by trained research assistants who supported audio recording and field-note taking. At the conclusion of each session, the moderator summarised key issues and invited participants to clarify, correct or expand the summary. Interviews and FGDs were conducted in English, Kiswahili or Kitharaka according to participants' preference.

Data Analysis, Reflexivity and Quality

Audio recordings were transcribed verbatim, and transcripts conducted in Kiswahili or Kitharaka were translated into English while retaining the meaning of participants' accounts. Identifying information was removed during transcription and data preparation. Analysis followed the six phases of thematic analysis described by Braun and Clarke (2006): familiarisation with the data, generation of initial codes, construction of candidate themes, review and refinement of themes, definition and naming of themes, and production of the final analysis. Coding was undertaken by the first author using qualitative data analysis software. The analysis remained primarily inductive, allowing patterns concerning continued solar use, interruption, repair, trust, social influence and structural conditions to be developed from participants' accounts. Household and key-informant accounts were analysed within the same overall analytic process, while attention was maintained to similarities and differences between these sources. The resulting themes were subsequently interpreted in relation to the study's three theoretical perspectives, Diffusion of Innovations, trust in abstract systems, and energy justice, rather than forcing the data into predetermined theoretical categories.

The first author's familiarity with the study area facilitated communication and contextual understanding but also created the possibility that familiar practices or meanings could be taken for granted (Berger, 2015). Reflexive attention was therefore given to the researcher's position throughout data collection and interpretation. Open-ended and non-leading questions were used, divergent and contradictory accounts were actively considered, and household narratives were examined alongside accounts from key informants. Interpretive discussions with the doctoral supervisor provided an opportunity to question emerging interpretations and consider alternative explanations. The interview and FGD guides were reviewed by experts before data collection. A detailed description of the study setting, participants and research procedures is provided to enable readers to assess the applicability and transferability of the findings to other contexts (Lincoln & Guba, 1985).

Ethical Considerations

Ethical approval was granted by the Tangaza University Research Ethics Committee (TUREC; reference TU/ISERC2025/01/00130), and a research permit was issued by the National Commission for Science, Technology and Innovation (NACOSTI; permit number 470208). Administrative clearance was also obtained from the relevant county and sub-county authorities. Before participation, each participant received an explanation of the study, its purpose, procedures, potential risks and benefits, and their rights as participants. Informed consent was obtained by signature or thumbprint, with explanations provided in the local language where necessary. Participation was voluntary, and participants were informed of their right to decline to answer particular questions or withdraw from the study. Confidentiality was maintained throughout data management and reporting. Quotations are identified only by data source and respondent number, while personal names, village names and other potentially identifying details were removed from the dataset and manuscript.

RESULTS AND DISCUSSION

Overview of the Themes

Five themes were developed from the qualitative data (Table 3). Across the five themes, participants generally expressed positive views of household solar energy, particularly in relation to health, safety, education and selected livelihood activities. However, positive perceptions did not necessarily translate into sustained use. Continued use depended on whether households could afford the technology, maintain functioning systems, obtain repairs or replacements, and rely on accessible and accountable service providers. Participants also described social and community experiences that shaped confidence in solar technology. Taken together, these findings point to conditional acceptance, whereby households valued solar energy but their ability to sustain its use depended on the technical, economic, service and social conditions surrounding the technology. Quotations are identified by data source (FGD or KII) and respondent number (Res.), with respondent numbering assigned within each theme.

Table 3: Themes and Illustrative Evidence

Theme	Focus	Illustrative evidence
1. Health, safety and education benefits	Cleaner indoor air, longer study time, lower kerosene spending, fewer fire risks	"…they study peacefully without coughing or watery eyes" (FGD, Res. 2)
2. Economic gains, real but uneven	Longer trading hours, phone charging, evening home enterprises	"Solar light keeps my shop open until ten o'clock" (FGD, Res. 3)
3. Trust as the presence of an accountable seller	Early failure, counterfeit goods, vanished sellers	"…no one replaced it, I now hesitate to buy another" (FGD, Res. 4)
4. Cost and repair constraints	Upfront cost, competing needs, costly batteries, distant technicians	"We want solar, but who will lend us the money?" (FGD, Res. 3)
5. Community demonstration and peer learning	Use seen in clinics, schools and markets; exchange among neighbours	"We saw the clinic using solar lights at night. That made us believe it works." (FGD, Res. 4)

Note. Quotations are verbatim, translated where necessary. Res. = respondent number, numbered within each theme.

Theme 1: Health, Safety and Education Benefits

Participants consistently described the benefits of solar energy in practical terms, often comparing their current experience with the period when they relied on kerosene lamps. Cleaner indoor air and improved lighting for children's schoolwork were particularly prominent. One household participant explained, "Before solar, our children used to read with a smoky tin lamp, but now they study peacefully without coughing or watery eyes" (FGD, Res. 2). Another described the change more broadly: "The smoke from paraffin used to disturb us at night, especially the young ones, whereas now the house is clean and comfortable" (FGD, Res. 7). Improved lighting also enabled children to study for longer periods. One participant stated, "My children can read for longer hours now, whereas before they would stop early because the lamp was too dim" (FGD, Res. 11). Another noted, "Even when exams are near, I can revise at night without any problem" (FGD, Res. 14).

Reduced expenditure on paraffin was another important benefit. One participant explained, "I save the money I used to buy paraffin and use it for school fees instead" (FGD, Res. 5), while another stated, "Every week I used to buy fuel, but now that cost is gone completely" (FGD, Res. 9). Participants also associated solar lighting with improved household safety. One participant recalled, "I feared the lamp could fall and burn the house, making solar a much safer option" (FGD, Res. 6). Key informants, including community health workers and teachers, described similar perceived benefits, including fewer respiratory and eye complaints among children and improved opportunities for completing homework. These accounts represent participants' perceptions rather than clinical measurements. Overall, participants valued solar primarily because it provided a cleaner, safer and more reliable source of lighting than the kerosene alternatives they had previously used.

Theme 2: Economic Gains, Real but Uneven

Participants also described solar energy as supporting selected livelihood activities, although these economic benefits were not experienced uniformly across households. Small traders, young people and women engaged in home-based enterprises reported that access to lighting after dark extended the time available for trading or other productive activities. A market trader explained, "Solar light keeps my shop open until ten o'clock, allowing me to sell to boda boda riders returning from town" (FGD, Res. 3). Similarly, a kiosk owner stated, "Before solar, I used to close early because it was too dark, but now I stay open longer and attract more customers" (FGD, Res. 8). Phone charging provided another modest income-generating opportunity. One young participant explained, "Solar helps me charge mobile phones for people in the village, providing a small income that supports my family" (FGD, Res. 5). A woman described using solar lighting to support food preparation: "I use the light to prepare snacks at night to sell them early in the morning" (FGD, Res. 10).

Key informants similarly reported that some women's groups used evening lighting for meetings and handicraft production, while local administrators described increased evening trading in some parts of the area. However, participants did not experience these benefits equally. Many household systems were primarily designed for lighting and had insufficient capacity to operate machinery or other energy-intensive equipment. Consequently, the economic value of solar depended partly on the capacity of the installed system and the nature of the household's livelihood activities. The findings therefore indicate that solar could create or support modest productive opportunities for some households, but they do not support a general claim that solar use resulted in substantial increases in household income.

Theme 3: Trust as the Presence of an Accountable Seller

Although participants generally valued solar energy, confidence in the technology was closely connected to their experiences with sellers and service providers. For many participants, trust depended less on the technology itself than on whether someone remained available when a system failed. One participant recalled, "I once bought a solar lamp that stopped working after two months, and because no one replaced it, I now hesitate to buy another" (FGD, Res. 4). Another explained, "When a system breaks, I do not know where to take it because the seller is no longer there" (FGD, Res. 6). The absence of after-sales support could also result in financial losses: "I lose money because there is no one available to repair or replace the system locally" (FGD, Res. 11).

Concerns about counterfeit products further weakened confidence. One participant observed, "There are many fake products in the market, making it hard to know which one is genuine" (FGD, Res. 2). However, experiences with established and responsive dealers were more positive. One participant stated, "When you buy from a trusted dealer, the system works well and they can even help you if there is a problem" (FGD, Res. 15). Key informants, including vendors and technicians, confirmed that inexpensive and unbranded components were available in local markets. One key informant also linked counterfeit products and poorly regulated intermediaries to declining confidence in solar technology (KII, Res. 1).

These accounts show that participants evaluated solar technology together with the service arrangements surrounding it. Trust was expressed through practical expectations of accountability: whether the seller could be located, whether faulty products would be replaced, and whether technical assistance would remain available after purchase.

Theme 4: Cost and Repair Constraints

Financial considerations affected both access to solar systems and their continued use. Participants generally did not describe solar energy as undesirable; rather, they weighed its cost against competing household priorities. One participant explained, "We want solar, but who will lend us the money? My husband says we must first pay school fees" (FGD, Res. 3). Another stated, "Even if solar is good, we have many pressing needs at home. Sometimes food and fees come first" (FGD, Res. 9). A third participant explained, "The cost is too high for us to pay at once. That is why many people delay" (FGD, Res. 12).

Participants repeatedly expressed interest in payment arrangements that would spread the cost over time. One participant suggested, "If there were small payments like mobile phone companies offer, many more people would adopt solar" (FGD, Res. 5), while another stated, "We can manage if we pay little by little, not one big amount" (FGD, Res. 14). Key informants involved in rural electrification and energy programmes reported that subsidy and pay-as-you-go arrangements were available in some areas but did not consistently reach remote parts of the sub-county. They associated this limitation partly with distribution costs and inadequate mobile-money coverage.

The financial challenge continued beyond the initial purchase. Participants identified repair and replacement costs as important barriers to sustained use, with battery replacement perceived as particularly expensive. Some households reported returning to kerosene when they could not afford repairs (FGD, Res. 7). Physical access to technicians created an additional constraint. One participant stated, "There is no technician nearby, so when a system breaks, it can take a long time before it is fixed" (FGD, Res. 10). Another explained, "You have to travel very far to find someone who actually understands how to troubleshoot the system" (FGD, Res. 15). Consequently, a technical failure could become a prolonged interruption in solar use when households lacked the financial resources or local services needed to restore the system.

Theme 5: Community Demonstration and Peer Learning

Participants described direct observation and interaction with other users as important sources of information about solar technology. Public institutions such as health facilities and schools provided visible examples of solar use. One participant explained, "We saw the clinic using solar lights at night. That made us believe it works" (FGD, Res. 4). Another stated, "When you see it working in the school, you feel reassured that it can help at home too" (FGD, Res. 9). A further participant observed, "People trust what they see with their own eyes, and if it is used publicly in the community, many start to accept it" (FGD, Res. 12). Another reported deciding to purchase a system after "seeing solar operating reliably in the local market and the dispensary" (FGD, Res. 7).

Neighbours were also important sources of practical knowledge. One participant explained, "We learn from each other. When one person installs, others come to ask and see" (FGD, Res. 6). Key informants similarly reported that installations in public institutions increased familiarity with solar technology among surrounding communities (KII, Res. 2). However, participants also described uncertainty in places where visible examples

were limited. One participant noted, “There are places where people have not seen these systems at all, so they remain unsure of how they work or what they cost” (FGD, Res. 15). Another stated, “Some people still think solar is very expensive because they don’t have the right information” (FGD, Res. 11).

DISCUSSION OF FINDINGS

The findings are discussed in relation to the study’s central concern with the conditions that shape the continued use of household solar energy after acquisition. Particular attention is given to the relationship between perceived benefits, post-adoption experiences, trust, material constraints and the social and institutional conditions that influence sustained use.

Conditional Acceptance and the Post-Adoption Problem

The findings suggest that a favourable assessment of solar energy does not necessarily translate into sustained use. Participants valued solar for cleaner indoor lighting, improved opportunities for children’s study, reduced reliance on kerosene and selected livelihood activities. These benefits are consistent with previous research on the advantages of small-scale solar products in rural settings (Grimm et al., 2017; Lemaire, 2018). From a Diffusion of Innovations (DOI) perspective, such experiences represent a strong relative advantage over kerosene and other traditional lighting sources (Rogers, 2003). However, the findings indicate that the innovation-decision process does not end with acquisition. Once households experienced system failure, repair difficulties, replacement costs or the disappearance of sellers, the question shifted from whether solar was desirable to whether its use could realistically be sustained.

This finding gives particular importance to Rogers’s (2003) confirmation stage, during which adopters reassess an innovation in light of their experience and may continue or discontinue its use. Some participants who returned to kerosene or left failed solar systems unused could be understood as experiencing disenchantment discontinuance. However, this interpretation is incomplete. Several participants did not reject solar or conclude that it lacked value; they could not continue using it because the financial, technical or service conditions required for operation were beyond their reach. A participant who returned to kerosene because repairs were unaffordable (FGD, Res. 7), and another who hesitated to buy again after a lamp failed with no seller to replace it (FGD, Res. 4), still valued solar but were prevented from using it. We call this pattern constrained discontinuance, and explain below how it relates to conditional acceptance.

Trust as Infrastructural

The findings further indicate that trust in solar technology is inseparable from trust in the local systems that support it. Giddens’s (1990) concept of access points helps explain this relationship. Vendors, technicians, warranty providers and repair services constitute points at which households encounter the wider technical and commercial system surrounding solar. When these actors remain accessible and responsive, they provide tangible grounds for confidence. When sellers disappear, warranties are not honoured or technicians are difficult to reach, households have fewer reasons to trust that a solar system can be maintained after purchase.

This finding extends previous research showing that breakdown and repair are central to the everyday experience of solar energy in Kenya (Cross & Murray, 2018). It also supports the understanding of off-grid energy markets as social and institutional arrangements involving households, suppliers and service providers rather than simply transactions involving technical products (Rolffs et al., 2015). In this context, repairability becomes part of the practical value of the technology. A solar system may perform well when functioning, but its value to a household declines substantially when a failed component cannot be replaced or repaired. From a DOI perspective, repeated experiences of breakdown may also increase the perceived complexity and risk associated with ownership, while stories of unreliable products can influence the decisions of potential users through interpersonal communication. Thus, trust is not simply an individual attitude towards solar; it is produced and reproduced through the reliability of the local infrastructure of supply, maintenance and accountability.

Justice, Inequality and the Conditions of Continued Use

The findings also demonstrate that the capacity to sustain solar use is unevenly distributed. Energy justice provides a useful framework for understanding these differences through its distributive, procedural and recognition dimensions (Jenkins et al., 2016; Sovacool & Dworkin, 2015). Distributive inequality was evident in the unequal availability of vendors, technicians, replacement parts and financing. Households located farther from service providers faced greater difficulty when systems failed, while households with limited financial resources were less able to absorb repair or battery-replacement costs.

Procedural concerns were reflected in participants' limited avenues for redress when products failed or sellers became unavailable. The value of a warranty depends not simply on its existence but on whether the household can effectively invoke it. Similarly, financing mechanisms such as pay-as-you-go arrangements may formally expand access while remaining less accessible to households in remote areas with weak mobile-money coverage or irregular incomes. Evidence that standardised PAYG arrangements do not work equally well across rural users reinforces the importance of designing financing around actual household circumstances rather than assuming uniform patterns of income and payment (Mergulhão, 2025).

The findings also raise questions of recognition. Participants described household circumstances in which expenditure on solar competed directly with food, school fees and other immediate needs. A financing arrangement that appears affordable in aggregate may therefore remain unsuitable when payment schedules do not correspond with the timing and variability of household income. One participant's account of prioritising school fees also suggests that intra-household decision-making may influence energy choices. Research in Kenya has similarly shown that gender relations shape the experience and consequences of solar adoption (Winther et al., 2018). However, because the present study was not designed to examine intra-household gender relations systematically, this interpretation should remain tentative.

Community demonstration provides a complementary dimension to these structural conditions. Public institutions such as clinics and schools created visible examples through which participants could observe solar functioning in practice, while neighbours provided opportunities for informal learning. This finding corresponds with DOI's emphasis on observability and communication (Rogers, 2003). Yet the findings also reveal a limit to demonstration: seeing solar functioning in a clinic or school can establish that the technology works, but it does not establish that a particular household product will be genuine, affordable, durable or repairable. Visibility can build initial confidence, but sustained confidence requires dependable performance and support.

Conditional Acceptance and Constrained Discontinuance: Relationship and Analytical Use

Conditional acceptance is the overarching construct; constrained discontinuance is its diagnostic outcome. It is not a separate theoretical contribution. Conditional acceptance holds that a favourable evaluation of solar becomes sustained use only when assured quality, accessible repair, payment fit and visible proof are present. Constrained discontinuance names what happens when one or more of these fail: use is interrupted or ceases while the favourable evaluation persists.

The concept emerged inductively from the analysis. In coding, accounts of interrupted use repeatedly paired a positive valuation of solar with a specific material or service obstacle, such as an unreplaced failed product, a distant technician, an unaffordable battery or a vanished seller (Themes 3 and 4). These accounts could not be coded as disenchantment, because dissatisfaction with solar itself was absent, nor as replacement, because the alternative was kerosene, which participants regarded as inferior (Theme 1). A category was needed for cessation without rejection, and it was refined by relating it to the four conditions in Table 5.

The two concepts work together analytically (Table 4). Conditional acceptance identifies which conditions a household or programme must secure; constrained discontinuance identifies the observable failure that signals an unmet condition. A temporary return to kerosene (fuel stacking) can then be read as a behavioural expression of constrained discontinuance rather than as rejection, and this reading can be checked by asking which condition has failed.

Table 4: Analytical Use of Conditional Acceptance and Constrained Discontinuance

State	Evaluation of solar	Condition status	Observable pattern	Illustrative evidence
Sustained acceptance	Favourable	All four conditions met	Continued functional use	Trusted dealer who helps when problems arise (Theme 3, FGD, Res. 15)
Constrained discontinuance	Favourable	One or more conditions unmet	Interrupted use, return to kerosene or non-replacement	FGD, Res. 7 (Theme 4); FGD, Res. 4 (Theme 3)
Disenchantment discontinuance	Unfavourable	Not the primary explanation	Abandonment after dissatisfaction	Not evident in the present data

Note. States are derived from the five themes and the four conditions in Table 5.

A Conditional Acceptance Framework

Taken together, the findings suggest that continued household solar use depends on four interconnected conditions: assured quality, accessible repair, payment fit and visible proof (Table 5). These conditions extend the conventional understanding of adoption by shifting attention from the initial acquisition of an innovation to the conditions that allow its use to continue.

Table 5: Conditions for Continued Use and Their Practical Implications

Condition	Evidence from the findings	Justice dimension	Implication for practice
Assured quality	Counterfeit and short-lived products; difficulty telling genuine goods from fakes	Procedural	Enforce product standards; register vendors; honour warranties
Accessible repair	Vanishing sellers; distant technicians; unaffordable batteries	Distributive	Local service points; trained local technicians; affordable battery replacement
Payment fit	Competing household needs; irregular income; PAYG not reaching remote areas	Recognition; distributive	Small, staged payments built around income cycles and weak mobile money coverage
Visible proof	Use seen in clinics, schools and markets; learning from neighbours	Procedural; recognition	Demonstration in trusted institutions; community information engaging women and youth

Note. The conditions are derived from the five themes and are interdependent.

The framework indicates that the four conditions should not be treated as separate interventions. Product quality without repair access leaves households vulnerable when components fail; repair services without affordable financing may remain inaccessible to poorer households; financing without reliable products can increase rather than reduce household vulnerability; and demonstration without quality assurance may generate expectations

that individual systems cannot meet. Continued use therefore depends on the alignment of technological, financial, service and social conditions.

The findings have several implications for rural energy programmes. First, acquisition should not be treated as the endpoint of energy access. A system that becomes unusable cannot continue to provide the lighting, educational and productive capabilities associated with energy access. This is consistent with Sen's (1999) distinction between possessing resources and having the substantive capability to use them. Programmes that measure success primarily by the number of systems distributed may therefore overestimate the extent to which energy access has been sustained.

Second, monitoring should extend beyond installation to include functionality over time, duration of use, access to repair, warranty performance, availability and cost of replacement components, and patterns of interrupted or discontinued use. Such indicators would provide a more meaningful assessment of whether solar technologies remain usable within households.

Third, the findings suggest that quality assurance, local repair networks and appropriate financing should be treated as components of the energy-access system itself rather than as supplementary services added after installation. Community demonstrations and peer learning remain valuable because they increase visibility and familiarity, but information campaigns alone cannot resolve the concerns that participants identified. Awareness can encourage households to consider solar; it cannot ensure that the product is genuine, affordable, repairable or supported after purchase.

The principal contribution of the study is therefore not simply that rural households value solar energy. Rather, it demonstrates that acceptance is conditional on the social and material conditions surrounding continued use. The post-adoption experience is consequently as important as the initial adoption decision. Understanding rural energy transitions requires attention not only to who acquires solar technology, but also to who can keep it functioning, who can obtain assistance when it fails, and whose household circumstances are accommodated by the systems designed to support its use.

CONCLUSION AND RECOMMENDATIONS

Summary

This study shows that rural households may value solar energy while remaining uncertain about their ability to sustain its use. Participants associated solar with cleaner and safer lighting, improved conditions for children's education and, for some households, modest livelihood opportunities. However, positive perceptions alone did not guarantee continued use. Product quality, seller accountability, access to repair and replacement components, affordability of maintenance, payment arrangements and the reliability of local service networks shaped whether households could continue benefiting from solar systems. Community demonstrations and peer learning strengthened confidence, but visibility of the technology could not compensate for poor-quality products or inadequate after-sales support.

Conclusions

The study therefore proposes conditional acceptance as a way of understanding the post-adoption experience of household solar users. It differs from post-adoption confirmation, discontinuance and fuel stacking by explaining whether use can continue, not only whether or why it stops, and by locating that explanation in the service ecosystem. Where its conditions fail, the result is constrained discontinuance: use ceases while acceptance remains. Acceptance should not be understood simply as a favourable attitude or the acquisition of a system. Rather, sustained acceptance depends on whether households have the practical and financial conditions necessary to keep the technology functioning. This extends conventional adoption-focused approaches by drawing attention to what happens after installation and to the social, technical and structural conditions that sustain energy access.

The findings have broader implications for rural social transformation. Energy access should be assessed not only by whether households acquire energy technologies but also by whether those technologies remain functional and usable over time. Quality assurance, accountable suppliers, accessible repair, appropriate financing and trusted community-based demonstration should therefore be understood as integral components of sustainable energy access.

Limitations

This study has several limitations. First, all household participants were current or recent solar users identified through the wider household screening exercise; households that had never adopted solar and those that had permanently abandoned solar systems were therefore not directly represented. The findings may consequently place greater emphasis on the perceived benefits of solar than would be the case if non-adopters and former users had been included. Constrained discontinuance was therefore inferred from participants' accounts of interruption and from key informants' observations, not from households that had permanently abandoned solar. Its prevalence, and the existence of disenchantment discontinuance in this setting, remain to be tested. Second, participation in FGDs was voluntary, and recruitment may have favoured individuals who were comfortable expressing their experiences in a group setting. Group composition may also have influenced the accounts that participants were willing to share.

Third, the study was conducted in one sub-county and used purposive rather than probability sampling. The findings are therefore not statistically generalisable to rural Kenya, although the detailed contextual accounts may support analytical comparison with other rural settings. Fourth, the study relied primarily on participants' reported experiences. Claims concerning health, educational and economic benefits should therefore be understood as perceived benefits rather than independently measured outcomes. Similarly, the economic benefits described by some participants do not indicate their prevalence across the wider household population.

Fifth, interviews and FGDs were conducted in English, Kiswahili and Kitharaka, and translation into English may have resulted in the loss or modification of some culturally specific meanings despite efforts to preserve participants' intended meanings. Sixth, the first author's familiarity with the study area facilitated access and contextual understanding but may also have influenced interpretation; reflexive strategies were used to address this possibility, although researcher influence cannot be completely eliminated. Finally, the study was not designed to examine intra-household gender relations systematically. Although some accounts suggest that household decision-making may shape solar use, this aspect requires dedicated investigation in future research.

Recommendations

Based on the findings, recommendations are made for theory, practice and policy.

Recommendations for Theory

Conditional acceptance should be tested and refined in other rural settings, and research on solar adoption should extend its attention from acquisition to continued use. Future research should include non-adopters and households that have discontinued solar use, examine intra-household decision-making more systematically, and use longitudinal designs to examine how breakdown, repair, payment obligations and fuel stacking influence energy choices over time.

Recommendations for Practice

First, develop decentralised repair and maintenance networks. Solar programmes should incorporate after-sales service from the point of installation rather than treating repair as a subsequent responsibility of individual households. Training and supporting local technicians, establishing accessible service points and improving the availability of replacement components, particularly batteries, could reduce the period for which households remain without functioning systems after breakdown.

Second, design financing around rural household realities. Financing arrangements should recognise irregular and seasonal household incomes and competing priorities such as food, education and other essential expenditure. Staged payment arrangements should therefore be designed around local income patterns rather than assuming uniform capacity to make regular payments. Where pay-as-you-go models are used, their suitability to areas with limited mobile-money coverage should be assessed before implementation.

Third, use trusted community institutions to support demonstration and learning. Schools, health facilities, community organisations and other trusted institutions can provide visible demonstrations of solar technology and create opportunities for peer learning. Such initiatives should, however, combine demonstration with practical information about product quality, costs, maintenance, warranties and available repair services. Demonstration should build informed confidence rather than simply promote adoption.

Recommendations for Policy

First, strengthen product quality assurance and vendor accountability. Relevant authorities and industry actors should strengthen enforcement of product standards, vendor registration and consumer-protection mechanisms, particularly in rural markets where participants reported difficulty distinguishing genuine products from counterfeit or poor-quality alternatives. Warranties should be meaningful and practically accessible, with clear mechanisms through which rural consumers can obtain replacement or repair when products fail.

Second, redefine programme monitoring from installation to sustained functionality. Government and development programmes should complement installation and adoption indicators with measures of continued functionality, duration of use, frequency and cost of repairs, warranty performance, battery replacement, access to technicians and periods of interrupted use. Such measures would provide a more meaningful assessment of whether rural households have achieved sustained energy access.

Declarations

Ethics approval and consent to participate: Ethical approval for the study was obtained from the Tangaza University Research Ethics Committee (TUREC; reference TU/ISERC2025/01/00130). The study was also authorised by the National Commission for Science, Technology and Innovation (NACOSTI; permit number 470208). All participants provided informed consent prior to participation.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors used Claude (Anthropic) as an AI-assisted writing tool to improve structural organisation, language clarity and readability, align formatting with APA 7 and the relevant

journal requirements, and identify potentially relevant literature. Literature suggestions generated by the tool were independently checked against the original sources before inclusion. The AI tool was not used to collect, code, analyse or interpret the primary qualitative data. The authors reviewed and critically evaluated all AI-assisted outputs and made the final decisions regarding the content, interpretation and presentation of the manuscript. The authors remain fully responsible for the originality, accuracy, integrity and final content of the manuscript.

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