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Transforming brick manufacturing in Bangladesh to promote clean air and better health

Submission date	Recruitment status	[_] Prospectively registered
05/10/2022	No longer recruiting	[_] Protocol
Registration date	**Overall study status**	[X] Statistical analysis plan
21/10/2022	Completed	[X] Results
Last Edited	**Condition category**	[_] Individual participant data
16/05/2025	Other	

Plain English summary of protocol

Background and study aims

Across South Asia, the brick manufacturing industry is dominated by inefficient, coal-burning kilns. Brick kilns are one of the largest emitters in the region. In Bangladesh, kilns contribute 17% of the country's annual CO2 emissions and 11% of PM2.5. The pollution released by these kilns worsens local air quality, health and agricultural productivity, and global climate. Reducing these emissions could generate large social benefits. A properly constructed and operated zigzag kiln can reduce black carbon by 41%, CO2 by 21%, and PM2.5 by 80% – and strikingly, also increase kiln profitability. Yet the vast majority are incorrectly constructed and operated. Our preliminary work suggests two primary barriers to effective implementation: 1) lack of knowledge of the specific interventions and their true economic return and 2) inattention to the incentives of workers whose cooperation is crucial to running an efficient kiln. We propose to evaluate whether a randomized intervention among coal-fired zigzag kiln owners in Khulna Division, Bangladesh that relaxes these barriers improves kiln efficiency and operation.

Who can participate?

Our study will be conducted among coal-fired zigzag kiln owners in Khulna Division, Bangladesh. Owners that operate different types of kilns will not be able to participate in our study. Additionally, owners that have multiple kilns will only be able to include a single kiln on our study and any owners that participated in our pilot study in 2021-2022 will not be able to participate in this current study.

What does the study involve?

Our study includes two treatment arms: a technical only arm and a technical + incentive arm. Kiln owners and their workers assigned to both intervention arms will receive extensive technical training on best practices for stacking bricks and feeding coal into the kiln to achieve optimal combustion efficiency. This will be delivered in the form of an initial “classroom” training, a series of on-kiln trainings targeting specific operational components, and technical support available throughout the firing season. In addition to this technical training, kilns assigned to the incentive arm will also receive information and recommendations to encourage use of targeted worker incentives. The recommendations, which include a mix of financial and non-financial

mechanisms, such as bonuses, wage increases, extra meals/better quality meals. Participating in the study will also require owners and workers to answer questions about the operation of the kiln, brick production, experience of adopting the interventions, working conditions, and use of incentives, among other topics. These questions will be asked of owners and workers at the start of the study, before the intervention, and again at the end of the study, approximately 7 months later. We will also collect measurements of kiln operation, energy use, and brick production from all kilns in the study approximately 4-5 months after the start of the study.

What are the possible benefits and risks of participating?
There are minimal risks for kiln owners in this study. Our earlier pilot study in Jashore District was very successful, and the owners who adopted the technical interventions had increased economic returns relative to the control arm. Additionally, kiln owners in India who have used similar kiln operation practices also obtained higher profits. However, we cannot guarantee that owners will achieve higher profits and will not provide any compensation for profit loss that occurs during the brick firing season covered by our intervention. Kiln owners in the intervention arms will likely benefit from the improvements to the operation of the kiln, while all kiln owners and workers, will likely benefit from the reduction in emissions and improved air quality associated with the improvements. Kiln owners assigned to the control arm will be offered the technical training for the next brick firing season so they may also benefit from the improvements.

Where is the study run from?
A collaborative team of interdisciplinary researchers from Bangladesh (icddr,b and the Bangladesh University of Engineering and Technology), India (Greentech Knowledge Solutions Pvt. Ltd), and the United States (Stanford University and University of Connecticut) are implementing the study. The study is being conducted in Khulna Division of Bangladesh and fieldwork is managed by the local team of researchers in Bangladesh, supervised by icddr,b.

When is the study starting and how long is it expected to run for?
The study started in September 2022 and will run until the end of the brick firing season in August 2023.

Who is funding the study?
The study is funded by the Stanford Impact Labs (USA) and the JPAL/King Climate Action Initiative (USA)

Who is the main contact?
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Additional identifiers

EudraCT/CTIS number
Nil known

IRAS number

ClinicalTrials.gov number
Nil known

Secondary identifying numbers
67263

Study information

Scientific Title
The effectiveness of energy efficiency improvements and worker incentives for coal-fired brick zigzag kilns: a randomized controlled trial on energy use and brick quality

Acronym
BRICK

Study objectives
1. The technical and incentive interventions increase the percent of Class-1 bricks produced relative to the control arm.
2. The technical and incentive interventions reduce the specific energy consumption relative to the control arm.
3. The technical and incentive interventions reduce the CO/CO2 ratio relative to the control arm.

Ethics approval required
Old ethics approval format

Ethics approval(s)
Approved 25/07/2022, icddr,b Ethical Review Committee (68, Shaheed Tajuddin Ahmed Sarani Mohakhali, Dhaka 1212, Bangladesh, +880-2-9827084; salamk@icddrb.org), ref: PR-22052

Study design
Randomized controlled trial with two intervention arms (technical only, technical + incentives) and one control arm

Primary study design
Interventional

Secondary study design
Randomised controlled trial

Study setting(s)
Other

Study type(s)
Other

Participant information sheet
No participant information sheet available

Health condition(s) or problem(s) studied
Inefficient operation of coal-fired brick kilns that results in substantial emissions of PM2.5, black carbon, and CO2.

Interventions
We will have two experimental arms: 1) technical knowledge and training (technical arm) and 2) technical knowledge and training + worker incentives (incentive arm). Kilns assigned to both arms will receive information, training, and encouragement to adopt a suite of technical and operational improvements including improved firing practices, improved brick setting, increased insulation, and good bookkeeping. Trainings will highlight the financial benefits of these improvements and include live participation from owners who adopted them during our pilot, to directly address owners' uncertainty of economic returns. This will be delivered in the form of an initial "classroom" training, a series of on-kiln trainings targeting specific operational components, and technical support available throughout the firing season. Kilns in the incentive arm will receive the technical training plus additional information and recommendations to encourage use of targeted worker incentives. The recommendations, which include a mix of financial and non-financial mechanisms, are informed by the economics literature, the

experience of Indian kiln owners, results from our pilot, and testimonials from owners who participated in our pilot study.

The technical intervention (implemented in both study arms) will run from late-October - late November and the incentive intervention (only in the incentive arm), which includes nudge /reminders, will run from mid-November to late-February). A preliminary adoption follow-up will be conducted in November/December, the outcome measurements will be collected in March-April, and an endline survey will be collected in June. Randomization will be done using a computer program to generate random numbers for each kiln and kilns will be assigned to a study arm according to the randomly generated number.

Intervention Type
Behavioural

Primary outcome measure
1. Carbon monoxide/carbon dioxide ratio (a measure of combustion efficiency measured by placing a sensor into the flue gas)
2. Specific energy consumption (the energy used in MJ for firing 1 kg of brick) measured by multiplying tons of coal consumed by the gross calorific value of the coal and dividing by total production of bricks
3. Percent of Class 1 bricks produced measured by kiln owners' self-report of total brick production and the percent breakdown by quality, as well as fieldworker calculation of fired bricks coming out of the kiln.
All three primary outcomes will be collected during a 24-hour measurement visit to each kiln approximately 4 months post-intervention, which is when kiln firing reaches a steady-state.

Secondary outcome measures
1. Use of financial or in-kind incentives for workers to adopt technical intervention measured at 1 month, 4 months, and 7 months.
2. Worker self-reported respiratory symptoms collected by survey at 7 months compared to baseline.
3. Specific fuel consumption (SFC) measured at 4 months by dividing total quantity of coal consumed by total number of bricks produced.
4. Tons of CO2 equivalent measured by converted the primary outcome specific energy consumption into its CO2 equivalent by applying the Intergovernmental Panel on Climate Change (IPCC) carbon emissions factor for fuel, and a carbon to CO2 conversion factor.
5. Distributional change in brick quality of all types measured by kiln owners' self-report of total brick production and the percent breakdown by quality, as well as fieldworker calculation of fired bricks coming out of the kiln.
6. Value of production measured by multiplying brick production per brick class by the median price reported per class measured at 7 months.

Overall study start date
01/06/2022

Completion date
31/08/2023

Eligibility

Key inclusion criteria

The unit of randomization will be brick kilns. The study subjects will include the owner and workers of the brick kiln. Inclusion criteria for brick kilns are:
1. The kiln owner is a member of the Bangladesh Brick Makers Owners Association.
2. The kiln owner operates at least one coal-fired zigzag kiln that is located in Khulna Division.
3. The kiln owner consents to participate in the study

Participant type(s)
Other

Age group
Adult

Sex
Both

Target number of participants
300 brick kilns and 1800 workers (6 per kiln)

Total final enrolment
276

Key exclusion criteria
1. Participated in the pilot study
2. Took efforts on their own to adopt interventions similar to those implemented in the pilot study
3. Unwilling to be randomized to a control group
4. Already have one kiln from this owner enrolled in the trial

Date of first enrolment
01/10/2022

Date of final enrolment
28/10/2022

Locations

Countries of recruitment
Bangladesh

Study participating centre
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Funder(s)

Funder type
University/education

Funder Name
Stanford Impact Labs

Funder Name
King Climate Action Initiative (K-CAI)

Results and Publications

Publication and dissemination plan
Planned publication in a high-impact peer-reviewed journal.

Intention to publish date
15/04/2025

Individual participant data (IPD) sharing plan

Data and code will be made publicly available in a trusted digital repository in a manner that protects the confidentiality of all personally identifiable information.

IPD sharing plan summary

Stored in publicly available repository

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Statistical Analysis Plan	Pre-analysis plan	16/03/2023	20/03/2023	No	No
Results article		08/05/2025	16/05/2025	Yes	No