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CEDIL Methods Brief 4

Explaining what works: using causal chain analysis in systematic reviews

Centre of Excellence for Development Impact and Learning

Box 1: Highlights

Many systematic reviews are solely concerned with effectiveness or impact. While a review which tells you what works can help you decide what to do, it is of less use in telling you how to do it. Causal chain analysis-based systematic reviews, which analyse the working of a logic model or a theory of change for an intervention, can give useful information on programme design and implementation.

Causal chain analysis is not yet common in systematic reviews. This brief lays out what causal chain analysis is, the benefits of using it, and how to do so.

The causal chain analysis approach is based on specifying the logic model for an intervention. A logic model provides the basis for the questions to be answered in the systematic review, the types of studies to be reviewed, coding forms, and analysis. The causal chain analysis identifies weak and missing links in the causal chain, and thus which assumptions in the logic model may not hold. Programme designers and implementers can learn from these lessons to achieve better development outcomes.

What is causal chain analysis?

Systematic reviews summarise and synthesise the global evidence about an intervention. By incorporating causal chain analysis, a systematic review moves beyond the question of 'does it work?' to 'why does it work, for whom, under what circumstances and at what cost?'. A causal chain analysis-based systematic review can offer richer evidence to inform decision-making for achieving better development outcomes.

Causal chain analysis lays out how an intervention is expected to work. That is, it specifies how the inputs provided and the activities undertaken are expected to result in the intended outputs and outcomes, i.e. the assumed causal process or processes. This approach involves specifying a logic model or a theory of change, commonly set out in the form of a flow diagram (possibly with annotations regarding assumptions). While some people make a distinction between a logic model and a theory of change, the similarities are greater than the differences and the two are used interchangeably here. Less commonly, a logic model may also be presented as a structural model, or as a directed acyclic graph (DAG).[1]

This brief provides guidance on conducting a causal chain analysis by illustrating with an example of a systematic review on farmer field schools. It also outlines the implications for undertaking or commissioning a causal chain analysis-based systematic review.

Why use causal chain analysis in systematic reviews?

By answering questions on why an intervention works, for whom, under what circumstances, and at what cost, a review provides evidence regarding the design and implementation of interventions. This kind of evidence is more useful to decision makers than simply knowing if an intervention is effective or not. Understanding contextual and other factors which influence the success or failure of an intervention helps us understand the transferability of a research finding from one setting to another.

Causal chain analysis-based systematic reviews can identify weak or missing links in the causal chain. For example, a review of farmer field schools found that extension workers were often poorly equipped for their role – they lacked facilitation skills and were not able to speak the local language. This is a weak link in the causal chain for many farmer field school programmes as it undermines the ability of extension workers to manage the participatory learning approach that is at the heart of farmer field schools. The review also found that attempts to target women often failed, for a number of reasons: women may need permission from husbands or fathers to attend the trainings or they may be unable to join because of a lack of access to childcare. The application of learning from the training was also found to depend on whether other complementary inputs were available or affordable.

These examples highlight three points regarding the use of causal chain analysis in reviews. First, by reviewing the body of evidence, rather than a single study, we can speak with more confidence about the success or failure, and the reasons for it, for a particular approach. Second, the analysis provides lessons for intervention design and implementation. What are the reasons behind why the causal process failed to operate? Third, in this example of farmer field schools, we are not saying that all farmer field school programmes have these issues: we are saying that these issues have arisen in some cases. And so, programme designers need to consider issues like the skills of extension workers, male sensitisation to the importance of the programme, and the provision of creche facilities. They also need to consider if farmers have access to the necessary complementary inputs. If they do not, will the project target only those who do, or will it find a means of providing them to those who do not have access to them?

Causal chain analysis in a systematic review may also help determine if the programme is poorly designed or has generally been poorly implemented. A school feeding programme could be poorly implemented if parents are not aware of it, or if the food is inadequate or unpalatable. So, a review should assess if these are common issues. But it may be that the programme is being well implemented as planned but still does not have any effect on the final outcomes. For example, the school feeding programme may have no effect on learning outcomes if there is persistent teacher absenteeism. The design problem here is that the programme is not tackling the binding constraint on learning. In this case, a review could conduct sub-group analysis for contexts in which teacher absenteeism is high and those where it is not a problem.

Causal chain analysis: some basics

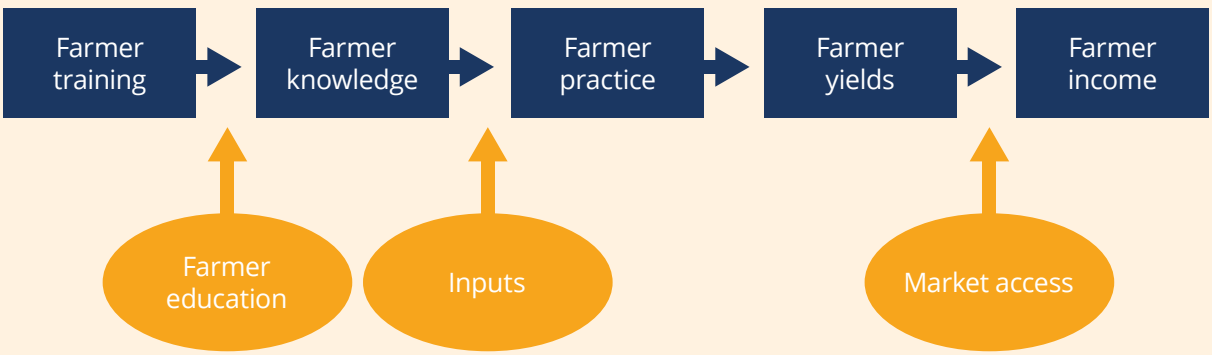
Mediators and moderators

Mediating variables are intermediate outcomes along the causal chain that describe the assumed causal process or processes which are expected to make the intervention work. If the intervention is effective then these outcomes should improve for at least some of the target beneficiaries. Moderator variables describe aspects of the context or the target beneficiaries' skills and assets which affect whether the intervention is effective.
A moderator may affect how effective the intervention is (the size of the effect), or whether the intervention has any effect at all. Some moderators may appear in the assumptions for the theory of change. In the school feeding example above, teacher absenteeism would be an important moderator.

Figure 1 provides the example of an agricultural extension programme. This is a simplified causal chain, which shows only those elements needed for the discussion here. The activity is training farmers. Training affects the intermediate outcomes of farmer knowledge and practice. Changed practice is expected to lead to the outcome of higher yields, which affects the final outcome of farm income. Farmer knowledge and practice, as well as yields, are all mediating variables in the causal chain from the activity to the final outcome of higher farm income.

Three possible moderators are shown in Figure 1. The extent to which exposure to the training leads to improved knowledge may be dependent on farmer education. The ability to turn new knowledge into practice may depend on the availability and affordability of inputs, such as improved seed varieties and sufficient water. And, finally, turning high yields into higher income requires access to a market for the crops.

Figure 1: Simplified causal chain for an agricultural extension programme



Source: Author

Different types of causal association

The arrows connecting the boxes in Figure 1 do not mean that one stage automatically leads to the next: not everyone who is exposed to training will acquire the knowledge, or they may acquire it imperfectly; and not all those who acquire the knowledge will put it into practice. Rather, the arrows may mean one of several things:

- **A probabilistic relationship:** The steps in the causal chain do not automatically follow on from one another. Not everyone who is offered training acquires the knowledge (they may not attend or they may simply not pay attention if they do), and some farmers will get the knowledge from elsewhere. But, on average, farmers who attend the training are more likely to have the knowledge than those who don't attend. That is, a farmer who attended has a greater probability of having the taught knowledge than those who did not attend.
- **Necessary and sufficient conditions:** A farmer having knowledge of new techniques is a necessary condition for the farmer adopting those techniques. But this alone is unlikely to be sufficient as other things are required, such as complementary inputs and adoption making sense economically. As a second example, attending the farmer field school sessions may be sufficient for farmers to acquire knowledge but it may not be necessary – the knowledge may be acquired by word of mouth or other sources.
- **Complementary conditions:** A single factor alone may not be sufficient to have an effect. Providing either microfinance or business services to youth separately may have no effect on their entrepreneurial activity. However, providing the two in combination may have an effect.
- **Threshold effects:** There may be diminishing returns, or even zero returns, after a certain point in a causal relationship. For example, in Figure 1, farmers may require functional literacy to benefit from a programme, but any education above that may have no further effect on the strength of the causal relationship between training and knowledge. To give another example, there can be diminishing returns to an input provided by the project, such as training. Too long spent in training may even have negative returns if the learning gains are low and farmers are being taken away from productive activities.
- **Feedback loops:** The arrows may embody a feedback loop, which may be a virtuous circle. In Figure 1 we may expect a 'learning by doing' feedback loop: as farmers adopt a new practice they will learn from that experience, which will further improve their knowledge, resulting in adaptations to practice.

Different approaches to assessing causality

The studies included in a review, and the review itself, may use different approaches to assessing causality. Approaches to using causal chain analysis in a review include the following:

- Effectiveness studies – that is, impact evaluations, such as randomised controlled trials (RCTs) and non-experimental designs with valid comparison groups – allow for causal statements which are usually probabilistic statements. In reviews, these statements are usually summarised using statistical meta-analysis. Sub-group analysis and meta-regression may be used to assess the role of moderators or for threshold effects. For example, a sub-group analysis of farmer field schools showed that it had been effective in pilots and local programmes, but not when taken to scale.
- Outcomes may be assessed along the causal chain. The review of farmer field schools reports effects for each of the outcomes related to knowledge, practice, yields, and outcomes. Meta-analytic structural equation modelling, in which related outcomes are specified and estimated as a system of equations, can give a more detailed insight into causal relationships, although this remains a comparatively rare approach.
- Combinations of necessary and sufficient conditions may be assessed using qualitative comparative analysis (QCA), which looks for combinations of factors present when an outcome is observed. Other non-parametric approaches for analysing DAGs are being developed which may allow for stronger causal statements than those from QCA.
- The logic model may be used to present and analyse evidence at the different stages of the causal chain, and so to test the causal chain. In the example of the review of farmer field schools, the review found support for the causal chain across outcomes: knowledge improved, practices changed, and both yields and net farm income went up. Proponents of farmer field schools say that these elements will also lead to positive spillover effects. Yet the review found no effect on knowledge, and so no effect on practice – and so, of course, no effect on yields or income.

Nancy Cartwright has distinguished between approaches which 'clinch' causality and those which vouch for it. Effectiveness studies, such as RCTs, clinch causality, whereas the other approaches vouch for it. However, while a 'bare bones' systematic review which simply reports a meta-analysis of final outcomes based on RCTs may be able to make strong causal claims (internal validity), it may be weak in terms of understanding the intervention logic and the claims made about transferability (external validity).

How to carry out a causal chain analysis-based systematic review

Systematic reviews using causal chain analysis are not currently widespread. CEDIL and other researchers are innovating in this area by incorporating the sort of analysis described earlier. This section describes the steps to follow in order to carry out a causal chain analysis-based systematic review.

The process begins with the specification of the logic model. But simply specifying the model does not make a review a causal chain analysis-based review. Reviews may specify the logic model but then make little use of it in the conduct and reporting of the review. However, when properly used, a causal chain analysis-based approach has implications for the evaluation questions, and the sorts of studies that will be included in the review. The review might rely on project documents or monitoring reports for the lower reaches of the causal chain in order to document activities and participation. It may use process evaluations for evidence related to implementation. And it will likely include impact evaluations for evidence of effects.

In a causal chain analysis-based review, the logic model informs the scope of the review, and helps identify the research questions, what type of literature is to be searched, what needs to be coded, and the analysis to be undertaken. For example, a key assumption in the logic model for farmer field schools is that the target farmers participate in the programme. The corresponding research questions would look at the extent of targeting errors in different programmes (which is a quantitative factual analysis), and the reasons for these errors (a qualitative synthesis of barriers and facilitators).

Using a logic model in a systematic review is a type of framework synthesis. Framework synthesis uses an analytical framework to guide the review questions, coding forms, and analysis. In a causal chain analysis-based systematic review, the logic model provides the framework. This may not be straightforward, because of common problems in the use of logic models – both in the primary studies and in some systematic reviews. Box 2 lists six common problems in how logic models and theories of change are currently generally presented.

Box 2: Six problems in the presentation of theories of change and logic models

Rick Davies reviewed more than 30 theories of change and identified the following problems:

Problem 1 – Unlabelled connections: Logic models typically don't label the arrows, to explain the nature of the posited causal relationship.

Problem 2 – Missing connections: A layered, or 'siloed', representation of the theory of change presents a list of inputs, activities, outputs, and outcomes, without linking specific activities to specific outputs and outcomes, so testable hypothesis are not identified or prioritised. This approach may also create the 'combinational problem', in which there are very many possible combinations of activities, so it is not clear which should be tested.

Problem 3 – Symmetric connections: There may be a concern for style over substance, with the theory of change being aesthetically pleasing but where its content doesn't provide much insight.

Problem 4 – Numerous pathways: Presentations may contain many arrows, or they may have a structure which implies thousands of potential causal pathways. Such presentations are not helpful in determining the priority evaluation questions.

Problem 5 – Feedback loops: Feedback loops are often included in theories of change but it is often not stated if they indicate positive or negative feedback. Multiple feedback loops may imply unstable impact trajectories for the outcomes, making observed outcomes difficult to interpret.

Problem 6 – Wider connections: Logic models which attempt to embody the wider context, and the role of external factors, may end up being too complex to help inform the evaluation.

Source: Rick Davies (2018), 'Representing theories of change: A technical challenge with evaluation consequences', *CEDIL Inception Paper 15*.

The following are some general principles for constructing and using logic models in reviews:

- Engage stakeholders in constructing the logic model as they will have an understanding of practical aspects of implementation, and insights into how causal processes may operate, and they may be more likely to use the findings of studies for which they have been consulted.
- A model should take into account relevant factors external to the intervention which also affect outcomes. Such factors may be important moderators, or they may have counteracting effects. For example, input and crop prices will affect a farmer's decision to adopt a new technology.
- The development of the logic model can help to identify unexpected and adverse effects from the intervention, and so inform the research questions and data requirements, and analysis to test for these.
- Use the logic model to clearly identify the review questions and types of evidence and study required to answer them. These will affect the scope of the review and study inclusion criteria. The logic model should help identify the key causal relationships, and the assumptions underlying them. 'Siloed theories of change', with a list of inputs, a list of activities, a list of intermediate outcomes, and then final outcomes, do not specify precise causal relationships, and so may be of limited help in informing analysis.
- The logic model will inform the analysis plan for the review. One way of doing this is by informing the nature of the causal relationship e.g. increase the likelihood of an activity, which is a necessary but not a sufficient condition or part of a set of sufficient but not necessary conditions.
- Model building normally involves iteration between theory and data. The model is a set of hypotheses to be tested, not a statement of a blueprint or a rigid framework. For complex interventions it may also be the case that there are emergent outcomes which were not understood when the logic model was first developed. A review may present the logic model that is used as the framework for the review, which should be included in the protocol, as well as presenting a final version of the model after the analysis is completed. The revised model may incorporate unexpected and adverse effects.
- As is clear from the above, the initial logic model should be developed and included in the review protocol.

Commissioning a causal chain analysis-based systematic review

If a systematic review is to use a logic model as a basis for the review, this requirement has to be clearly specified in the terms of reference for the review. Such a review may be expected to cost more, and to take longer, than a bare bones review. It is useful for the commissioner and other relevant stakeholders to be involved in the development of the logic model.

All CEDIL consortium members have experience in conducting causal chain analysis-based reviews. The CEDIL Secretariat can assist in shaping a review topic and commissioning a review from an appropriately qualified team. If you are interested in discussing how we may help, and what it will cost, please email cedil@lshtm.ac.uk

Endnote

[1] A DAG is a special type of flow chart in which the arrows (called 'edges') show the relationship between the nodes (or vertices).

About this brief

This brief has been prepared by Howard White. It is primarily based on *CEDIL Inception Paper 4* by Dylan Kneale, James Thomas, Mukdurat Bangpan, Hugh Waddington, and David Gough (2018), 'Causal Chain Analysis in Systematic Reviews of International Development Interventions'. However, the views expressed in the brief are not those of the authors of the paper on which it is based.

Additional resources

Supplementary reading includes Rick Davies (2018), 'Representing Theories of Change: A Technical Challenge with Evaluation Consequences', CEDIL Inception Paper 15, and Howard White (2018) 'Theory-based systematic reviews'.

Suggested citation

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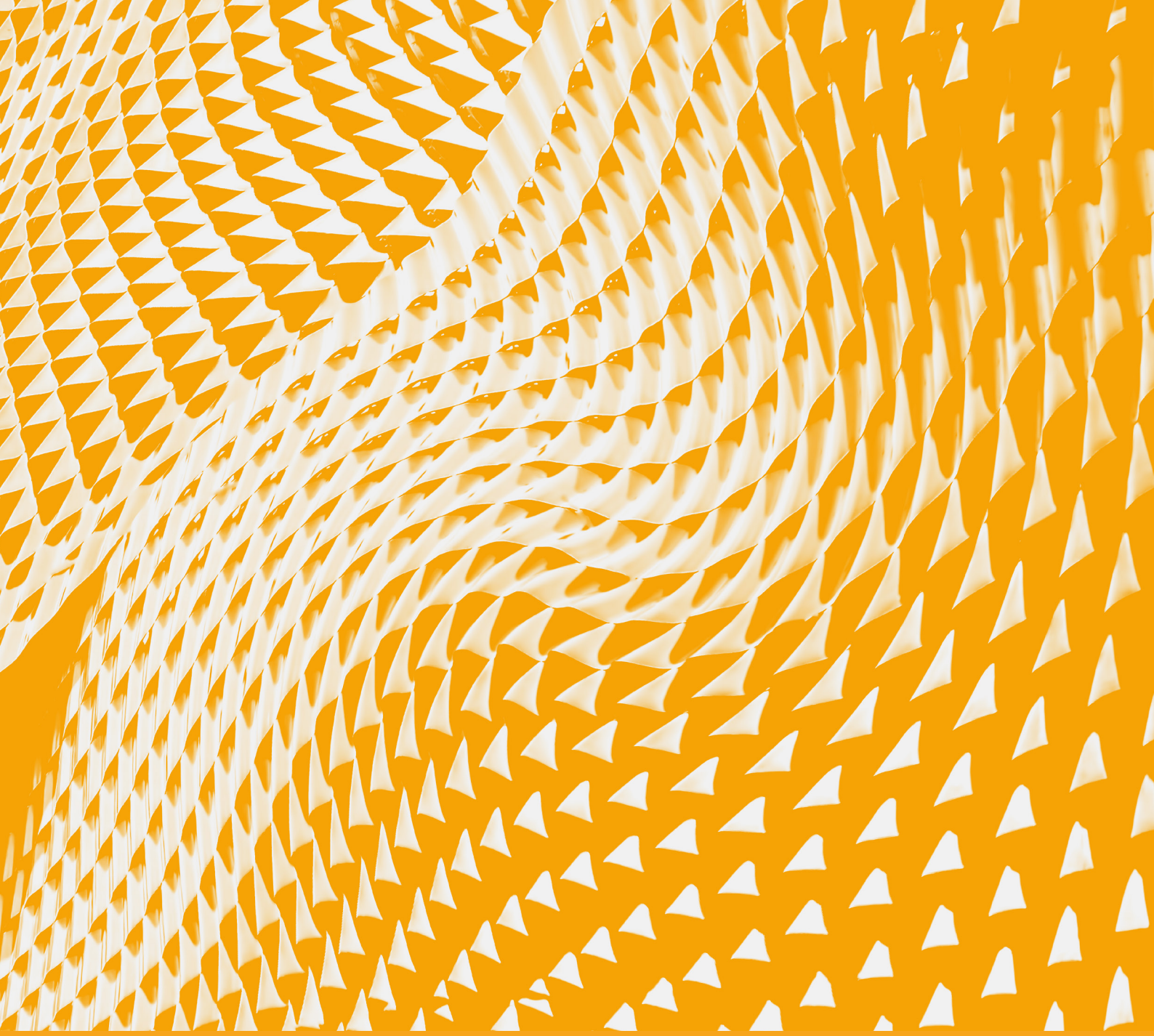

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