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PRACTICE PAPER
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# Natural Experiments: An Under-appreciated Evaluation Resource?

**Abstract** Natural experiments are observational studies of sharp, well-defined but unplanned changes. They hinge on identifying an uncontrolled but opportune 'intervention', typically of a kind or on a scale that could not – ethically or feasibly – be implemented deliberately, and communities, groups, or individuals that are affected and not affected, or that are differentially affected by that intervention. More than a method, natural experiments can also be understood as a resource – opportunities that must be recognised and wisely exploited. In this CDI Practice Paper Michael Loevinsohn explores some of the roles that natural experiments have played in evaluation and considers their potential and limitations and the prospects for their wider use. In the context of development, natural experiments' two most salient features are first, that they make it possible to assess scales and types of impact that are difficult or impossible to deal with through other approaches, and second that, being centred on large, notable events, they can lead to more open evaluations and wider public involvement in them. Of particular interest as experience of the effects of climate change widens is the potential they hold to support evaluation and learning around resilience and adaptability to extreme events.

## 1 Introduction

How do we know if the changes we are hoping to bring about are having the effects we expected? Are they having effects we didn't expect or intend? What effects, intended or not, have followed the changes that others have brought about? Those, broadly, are the questions that impact evaluation addresses and for this task practitioners can draw on a range of approaches and methods that are widely accepted and taught in graduate and undergraduate curricula.

This paper examines one approach in impact evaluation that is not well known, particularly in the area of international development, but that offers some intriguing possibilities for addressing questions that are difficult to get a grip on in any other way. Natural experiments can be described as 'observational studies of sharp, well-defined but unplanned changes' (Susser 1981). More than just a method, natural experiments can also be seen as a resource: opportunities that must be recognised and wisely exploited. They hinge on identifying an opportune but uncontrolled 'intervention' – typically of a kind or on a scale that could not ethically or feasibly be implemented deliberately – and communities, groups or individuals who are affected or not affected, or are differentially affected, by that intervention.

This Practice Paper draws on personal experience over a number of years and several literatures to examine the potential of natural experiments in development and evaluation contexts, their pitfalls and limitations, concluding with a consideration of their place within knowledge economies and the prospects for their wider use.

## 2 The scope of natural experiments

Natural experiments have long been employed as a research tool by, among others, natural scientists, economists and epidemiologists. The first and most compelling confirmation of Einstein's General Theory of Relativity came from a natural experiment: the 1919 solar eclipse made it possible to observe the predicted shift in the apparent position of stars when observed close to the sun. The epidemiologist Mervyn Susser, whom I quoted above, was involved for many years in assessing the consequences of an infamous natural experiment, the Dutch Hunger Winter of 1944–5. From October until

April, the Nazis blocked food shipments to the areas of western Holland they still occupied, causing the deaths of more than 20,000 people. The experiment turns on those who at the time were in gestation: the excellent Dutch civil records make it possible to determine how long and at what stage the foetuses were exposed to famine conditions and how many calories their mothers would have consumed (Lumey, Stein and Susser 2011). Comparisons are made, for example, with siblings who were in gestation before or after the Hunger Winter. Associations with several aspects of child and adult health have been found, including increased susceptibility to obesity and type-2 diabetes, which may result from epigenetic changes. These findings have been drawn on to explain the recent surge in diabetes in countries such as India (Shetty 2012). A number of other, sometimes grotesque, interventions that resulted in large numbers of people being denied access to adequate food have similarly been exploited to derive very useful knowledge that can extend and enrich lives (Apfelbaum 1946; Franco *et al.* 2007; Loevinsohn 2011; Loevinsohn [in review]).

Some economists and ecologists, for example Jared Diamond (1983), favour a looser definition of natural experiment which includes naturally occurring patterns of outcomes of interest but without a clearly identified intervention that supposedly gives rise to them. I prefer to consider here only natural experiments where something striking clearly happens, which I believe is the majority view across disciplines and the most useful stance in the context of evaluation.

There are two principle evaluation contexts in which natural experiments may be of use.

### Impacts *of* policy

The implementation of a policy or programme can itself constitute an intervention, defining 'before' and 'after' periods, and areas or groups to which it did and did not reach. Controlled experiments also make use of these divisions; natural experiments differ in that they have no part in decisions regarding implementation, instead making use of what has already been carried out or that is planned, and typically examining impacts, intended or unintended, over a wider area or a longer term.

Cummins *et al.* (2008) set out to assess whether the opening of a hypermarket in a deprived urban neighbourhood in Scotland would improve residents' access to nutritious food and revitalise the area's retail infrastructure, as government at the time expected. Their study examined indirect as well as direct effects, for example impacts on nutrition and health traceable to changes in employment and social inclusion. The researchers were also interested in the usefulness of the prevalent 'food desert' metaphor – urban areas where access to a 'healthy' diet is difficult, owing to poverty and the nature of the retail infrastructure.

Learning of the company's plans, researchers identified another neighbourhood, similarly deprived, as a control. They conducted individual interviews, focus group discussions and shop count surveys in both areas at baseline and a year later. They found that diet had improved in the two neighbourhoods but no more in the intervention than the control. There was some evidence of improved psychological health in the intervention neighbourhood, for unclear reasons, and a small improvement in the retail infrastructure. There was no evidence that food deserts were a reality for people in either neighbourhood, before or after the hypermarket's arrival.

The first substantial natural experiment I undertook was also concerned with the impact of policy, but working retrospectively, where Cummins *et al.* worked prospectively – and had to wait patiently through delays in the hypermarket's construction. My concern was with unintended consequences. I had come to the Central Luzon plains north of Manila to study the ecological effects of the Green Revolution in rice, but I was soon caught up in its

### Box 1 **Unanticipated policy impacts: pesticide poisoning in the Green Revolution**

In the Philippines, farmers' use of pesticides rose markedly after 1972 when subsidised credit was made widely available. Many of the insecticides promoted were highly toxic and farmers had no access to effective personal protection.

Compared with the decade before 1972, the death rate in the period 1972–84 rose by 27 per cent for men but fell for women and children, who generally weren't occupationally exposed. The peak of additional deaths occurred in the month of greatest insecticide use; when an irrigation system was completed that made a second crop possible, two annual peaks of excess mortality were seen. The death rate among unexposed urban men in the nearby provincial capital declined in parallel with that of women and children. Deaths due to diagnosed poisoning and causes associated with or readily confused with poisoning increased the most, and deaths from other causes declined or were stable. When an insecticide with distinctive intoxication symptoms – seizures, often interpreted as stroke – was banned, deaths attributed to stroke fell sharply.

Other possible drivers – biases in the reporting of vital statistics, increased smoking among men or falling real rural incomes – appeared inadequate as explanations for these patterns.

toxicological effects. I heard stories almost daily from farmers about pesticide poisoning – their own, relatives' or neighbours'. I tracked down several, after my day job, but soon realised I had to pursue it at a population level.

'Cummins *et al.* detect a growing acceptance of natural experiments and a corresponding recognition that many of the major social determinants of health and health inequalities are not amenable to randomisation.'

Drawing on studies of pesticide use, irrigation records and mortality estimates derived from death registries, I was able to conclude that pesticides – insecticides specifically – were probably responsible for a 27 per cent increase in the death rate of rural adult men in the period following the Green Revolution (Loevinsohn 1987). That attribution rests on the coherence between the pattern of mortality – who, when, where, due to what causes – and the detailed pattern of use, the hazard that insecticides posed and the absence of any other plausible explanation (Box 1). I come back to this below.

### Impacts *on* policy

The effects of shocks on the outcomes and impacts of different policies or implementation approaches have also been assessed by natural experiments, providing an indication of their adaptability or resilience. An example is the response to the outbreak of a new rice pest by Indonesian farmers who had been exposed either to integrated pest management through experiential learning in Farmer Field Schools, or to conventional extension programmes and fixed messages. The former proved the less likely to revert to hasty and ultimately counter-productive insecticide applications (Winarto 2004).

I am also trying to assess resilience, but prospectively, in work now getting under way with a four-country consortium in the Lower Mekong Basin. Farmers in rainfed tracts are being introduced to the System of Rice Intensification (SRI), which entails altering basic management practices: planting younger seedlings and fewer together, at wider spacing, keeping the soil moist but not saturated and using more organic and less synthetic fertiliser. The result is generally a more robust plant with deeper roots. Significantly higher yields and substantial water savings are often reported.

The monitoring and evaluation I am developing aims to provide a near real-time picture of how farmers adapt and modify these practices in their fields and what outcomes they achieve. We will use natural experiments to assess another purported trait of SRI for which there is still limited evidence: greater resilience to extreme weather events such as storms, floods and droughts. We can expect several such events each year at programme sites across the ten provinces. Farmers, local staff and national researchers will be prepared to assess the degree of exposure and performance of fields managed with different practices that they will already be monitoring. The findings will feed into community deliberations, programme revision and national policy forums.

These examples of natural experiments are situated in very different policy contexts:

- Cummins *et al.* are responding to calls from ministries and funding bodies in England and Scotland for evaluation of public health policy and of interventions in particular, for which the evidence base is acknowledged to be weak. They detect a growing acceptance of natural experiments in that audience and a corresponding recognition that 'many of the major social determinants of health and health inequalities are not amenable to randomization for practical or political reasons' (Petticrew *et al.* 2005).
- Early versions of the Philippines study became available in the dying days of the Marcos dictatorship and were unwelcome to national agencies as well as international organisations; they were, however, widely circulated among civil society organisations. Regulatory decisions, responding in part to the risks described by this and other research, were enacted by the subsequent, democratically elected government.
- In the Lower Mekong Basin countries, food security, to which rice is central, is threatened by increasing competition for water and a growing frequency of extreme weather, trends that are likely to accelerate. We will seek to ensure that our findings on the resilience of new farming practices can influence policies still being developed on climate change adaptation.

## 3 Advantages of natural experiments

Natural experiments are typically considered to be observational studies but they have one critical advantage over others of their kind: they entail an intervention – a sharp shock that defines before and after, with and without. It is easier to identify and test clear hypotheses in these conditions than in a flat social landscape in which nothing particular 'happens', or rather it happens in different degrees, at different times and in different places.

That sharp shock is likely to be memorable and to provoke discussion, drive people to write accounts or researchers to undertake ethnographic studies. These can provide important corroboration in the interpretation of natural experiments and, as discussed further below, add to their internal validity.

The interventions of natural experiments take place on the scale of human experience, in the open. Researchers can talk with the people involved, unconstrained by blinding or divisions between treatment and control, although they don't always take advantage of this opportunity. Skilful researchers conducting controlled experiments can and do get round those barriers, but it's harder for them to do so. In principle, one could test the resilience of rice crops to, for example, different depths and durations of flooding under simulated conditions on a research station. However, that would radically restrict the opportunities for interaction between farmers and researchers and among farmers compared with what is possible in the field, when flooding has actually happened. Co-constructing knowledge is a realistic prospect in this situation.

Natural experiments can be on spatial and temporal scales that are inaccessible to controlled experiments. One that is described below covered an entire country. The Philippine insecticide study spanned almost 25 years. Articles on the Dutch Hunger Winter are still appearing as its survivors approach their 70th birthdays.

'The interventions of natural experiments take place on the scale of human experience, in the open. Researchers can talk with the people involved, unconstrained by blinding or divisions between treatment and control.'

Natural experiments can be inexpensive. For better or worse, the intervention has already been paid for. Many natural experimenters gather their own outcome data, as in the Dutch Hunger Winter and hypermarket studies, and some also gather their exposure data, as we will in the Lower Mekong resilience work. But field costs can be substantially reduced if you make use of existing exposure and outcome data, as I was able to do in the Philippines insecticide study which involved, besides me, one research assistant. However, we spent a good deal of time checking the data and assessing their quality: it was crucial that we lived in the area and could follow up on the reliability of the death records with key informants at the municipal and provincial levels.

I have taken up three other natural experiments in which the key data were from existing sources that depended on the efforts – in some cases over years – of often barely supervised irrigation workers, meteorological station assistants and lab technicians (Loevinsohn 2011; Loeveinsohn [in review]; Loevinsohn, Bandong and Alviola 1993; Loevinsohn 1994). They had abundant opportunities to invent data and, poorly paid or sometimes unpaid as they were, seemingly few incentives to record them accurately. And yet almost every test to which I subjected those data suggested they were reliable. The professionalism of these people is as poorly recognised as the potential of the data they collect and record.

The multiplication of shocks impinging on human welfare whose effects are under-described suggests a broad scope and bright future for natural experiments. Perhaps the key factors required for their wider use are familiarity – which enables one to recognise an opportunity, frame and pursue it as a natural experiment – and the skill to analyse it appropriately. Wider recognition and acceptance of natural experiments in key audiences will help persuade researchers to take them up.

## 4 Challenges to natural experiments

Natural experiments are vulnerable to a number of biases. As the allocation of groups or areas to exposed, unexposed or differentially exposed classes is not randomised, there is a danger that factors relevant to the outcome are not evenly or randomly distributed among them. The risk is compounded if one has to rely on existing data which don't extend to those potential confounders, making it impossible to control for them statistically. Similarly, unsuspected drivers of change, in addition to the intervention, may be influencing the areas being studied. The greater the temporal and spatial scale of the natural experiment, the greater the potential for such unaccounted-for effects to bias the results. To some extent, their impact can be minimised by analytical methods such as difference-in-difference and fixed-effects models, which are also employed in controlled experiments in evaluation settings; however, they can be only a partial remedy where quantitative information is sparse and there is limited control over experimental design.

In these situations, corroboration plays a vital role. Contemporary accounts and testimony from eyewitnesses can confirm or disconfirm interpretations but, perhaps more usefully, they can suggest further hypotheses to be tested. In the Philippines, I met a toxicologist who, a few years earlier, had interviewed rural physicians and described to them a hypothetical man presenting with the symptoms of poisoning with the kinds of insecticide then in common use. What diagnosis would they suspect? Few answered 'pesticide poisoning'; most responded with a range of conditions associated with pesticide poisoning or easily confused with it. Drawing on this in the analysis, I found that the frequency of deaths attributed to these conditions rose sharply after the advent of the Green Revolution while that of deaths attributed to other causes declined. This result, together with positive results from six other hypotheses, buttressed the implication of insecticides in the increased death rate in rural men in Central Luzon.

These issues relate to the internal validity of a natural experiment: how true is the picture it offers of the place and time in which it is situated? In terms of external

### Box 2 **Poverty, hunger and HIV: An (un)natural experiment**

Loevinsohn analysed the 2001–03 Malawi famine as a country-scale (un)natural experiment on the effect of hunger on the dynamics of HIV, making use of the unequal experience of hunger among rural areas, between rural and non-rural areas and between men and women. The famine can be considered a 'natural' natural experiment because it was partly a consequence of two consecutive years of bad (but not unusually bad) weather. It was unnatural in that it was avoidable, in large part the consequence of actions and policies in the preceding months and years that had eroded dry-season livelihood options and, as in many famines, restricted people's access to food.

Bringing together three different sets of data, ethnographic research and a number of contemporary accounts, the study found that the greater the extent of hunger in a district, the greater the change in HIV prevalence during the famine, as measured at the district's antenatal surveillance site: prevalence rose at rural sites and fell at urban sites as hunger increased. Space does not permit an explanation of this seemingly incongruous latter finding but suffice it to say that transactional sex and migration were the most likely mechanisms linking hunger and the local changes in HIV prevalence, the evidence for the role of the latter being the stronger.

Hunger-linked migration was found to mostly involve young, rural women with a farming background. There was also evidence that hunger and the the rate of change in HIV infection were reduced, and food prices were less volatile, in rural districts where more households cultivated cassava, a robust root crop that many were turning to for food security.

validity – how well does it describe what happened elsewhere – a natural experiment has an easier time of it than, say, a case study, ethnography or controlled experiment, because its temporal and/or spatial scale is typically larger. On the other hand, natural experiments involve complex interventions whose impacts are likely to depend on how they are implemented and on local social, economic and ecological conditions and history. But because natural experiments are also out in the open, involving well-known events, it is possible for people reading or hearing about one to ask whether it does a good job of describing what they have observed or experienced. If the natural experiment is really low-cost, replicating it becomes more feasible and that assessment can be made with greater assurance. After my article was published, university researchers in several Philippine provinces consulted the civil registries in rice-growing municipalities and calculated the ratio of deaths attributed to the conditions associated or readily confused with pesticide poisoning to the all-causes total. They found steep rises in the ratio for men that coincided with the local timing of rapid increase in insecticide use. Very unfortunately, they never published this work.

## 5 Ethical issues in natural experiments

In a retrospective natural experiment, the intervention has already been paid for and implemented: the ethical issues it posed were either addressed or ignored. Researchers must still avoid doing harm in the collection and treatment of exposure and outcome data but if they make use of existing data then they really don't have much to answer for. In a prospective natural experiment where the intervention is a matter of policy or programme, researchers may see ethical issues in the way it is being implemented that are not being addressed. They have a responsibility to make these issues known but the ultimate responsibility rests with those charged with executing the policy or programme.

I believe the most important ethical issues in natural experiments are often issues of omission rather than commission. A researcher who sees an opportunity for a natural experiment, who is able to frame the situation in terms of intervention and exposed and unexposed or differentially exposed groups, and who has an idea where critical data might be found, may have identified an unparalleled means to shed light on poorly understood impacts. Where the impacts involve restrictions of people's capabilities and especially injury and death, the issue becomes: how can one *not* exploit the natural experiment?

In Central Luzon and in the months after, I felt this very clearly. Insecticides that could not possibly be used safely in those conditions had been subsidised, promoted, sold and applied. I really had no choice but to analyse that natural experiment as rigorously and draw the conclusions as forthrightly as I was able.

## 6 Natural experiments in the knowledge economy

The decisions confronting public policy in development contexts involve complex social phenomena evolving in response to numerous drivers. If, as mentioned above, the evidence available to UK decision-makers on public health policy and interventions is judged to be inadequate (Petticrew *et al.* 2005), it is unlikely to be any better in many development contexts. No single method can be relied on and it is important that the quality and characteristics of the evidence available from different sources is understood and that it is well integrated.

I have argued that natural experiments have some attractive features and a potential that deserve to be

### Box 3 **Poverty, hunger and HIV: A cluster randomised trial**

Baird *et al.* assessed the efficacy of a cash transfer scheme aimed at helping young women to stay in school and so reducing their risk of contracting sexually transmitted infections (HIV and herpes simplex virus [HSV]). Girls as well as their families received payments averaging $10 a month in randomly selected enumeration areas of Zomba district. Areas receiving the payments were further randomised to receive the transfers conditionally on the young women remaining in school, or unconditionally, and further randomised on the size of the transfer.

After 18 months, HIV prevalence among young women in the treatment areas was approximately 40 per cent of that in the control areas and HSV prevalence was 25 per cent. No differences were found in the effectiveness of conditional versus unconditional transfers or of the different sizes of transfer offered. Prevalence of the two infections among women who had dropped out of school and who had received the unconditional transfer was similar to that among dropouts who did not receive the transfer.

more widely appreciated. They can with profit be juxtaposed with other methods and the evidence they provide compared. Colleagues of mine are in a situation where they may do just that. With the aim of providing guidance to policy and programmes, they are synthesising evidence on factors that lead to high HIV infection rates in women and girls and on effective responses for prevention. Two recent studies from Malawi are likely to come to their attention.

Both address the relationship between aspects of poverty and women's risk of HIV infection. One assesses the impact of hunger during the famine of the early 2000s, the first in more than 50 years, which affected people and areas of the country differentially, thereby creating the conditions for a natural experiment (Loevinsohn 2011; Loevinsohn [in review]) (Box 2). The other study is of a controlled experiment which created differences in income by providing a cash transfer to some young women and their families and not others, randomised among areas within one of Malawi's districts (Baird *et al.*) (Box 3).

Both studies conclude that poverty increased risks of infection. The natural experiment also argues that the famine exacerbated inequalities which are widely believed to play a central role in the dynamics of HIV. Transactional sex is thought by both papers to have been a key situation of risk; distress-linked migration is strongly implicated by the natural experiment but is not considered by the controlled experiment. Both studies pay a good deal of attention to the processes through which the infection outcome was realised, though the controlled experiment was in a better position than the natural experiment to monitor and assess them directly.

The controlled experiment demonstrates the effectiveness of a specific instrument, a cash transfer, in one district, providing an estimate of what it might cost in an operational setting ($5,000 per infection averted). How that cost could be met over the long term is not addressed, although word limits imposed by medical journals leave little space for extended discussion. The natural experiment illustrates the consequences, unintended but avoidable, of policies that had left people vulnerable to the fate of the main maize harvest and the volatility of maize's market price. The study suggests that crop diversity, planting cassava in particular, provides a buffer but it does not discuss particular policy or programme options in any depth.

Though coming at the issue from different perspectives and, for the most part, citing different literatures, there is a good deal of consistency in the studies' findings and what they reveal about the situation. The strength of the controlled experiment derives from its adherence to good experimental design whereas the natural experiment relies to a much greater extent on consistency among different sources of information and the corroboration these provide for the conclusions. The natural experiment privileges realism and generality, the controlled experiment precision and specificity.

> 'The most important ethical issues in natural experiments are often issues of omission rather than commission. Where the impacts involve restrictions of people's capabilities and especially injury and death, the issue becomes: how can one *not* exploit the natural experiment?'

However, there is reason to be concerned that evidence from these two kinds of studies may not be assessed on an equal footing. In some quarters, the randomised controlled trial is still considered a gold standard although its characteristics and limitations are not always well appreciated. Devaluing natural experiments could narrow understanding of the social landscape that policy is working in and potentially skew consideration of policy options. The danger lies in conflating experimental intervention and policy instrument. Unlike a cash transfer, food security cannot be randomly allocated and delivered: it is affected by many decisions and actions – individual and collective – at different levels. But that says nothing about the speed with which it can change, positively or negatively, or how quickly its influence is transmitted to HIV risk. The natural experiment provided insight on this score.

The cash transfer, a social protection measure, can enable poor young women to remain in school and so avoid HIV infection. Enhancing food security reduces women's risk of HIV, in part by enabling them to avoid transactional sex, to which out-of-school young women are vulnerable. There is evidence of at least two kinds in support of these two statements. Along with the evidence, the limitations of these sources need to be communicated to decision-makers considering their options.

## 7 Conclusion

This paper has briefly explored the variety of forms natural experiments have taken and the roles they have played in evaluation. In the context of development, their two most salient features are that first, they make it possible to assess scales and types of impact that are difficult or impossible to deal with through other approaches, and second, being centred on large, notable events, they can lead to more open evaluations and wider public involvement in them.

Natural experiments can support learning around resilience and adaptability to extreme events: where networks are linked across a sufficiently wide area, the likelihood of an extreme event occurring somewhere in that area makes it possible to plan the organisation of follow-up. Retrospective natural experiments have a larger opportunistic element and are more difficult to plan. Potentially usable data sources often can only be identified close up and need to be explored and assessed. That itself may represent a considerable investment of time and effort but one that is difficult to estimate beforehand. This initial groundwork is akin to prospecting and entails a degree of uncertainty that is likely to be problematic for many funders in the development sphere. A better understanding of the potential pay-offs of natural experiments may ease the investment decision.

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## Centre for Development Impact (CDI)

The Centre is a collaboration between IDS (www.ids.ac.uk) and ITAD (www.itad.com).

The Centre aims to contribute to innovation and excellence in the areas of impact assessment, evaluation and learning in development. The Centre's work is presently focused on:

(1) Exploring a broader range of evaluation designs and methods, and approaches to causal inference.
(2) Designing appropriate ways to assess the impact of complex interventions in challenging contexts.
(3) Better understanding the political dynamics and other factors in the evaluation process, including the use of evaluation evidence.

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