The Strategy Unit.

# 2.01 The interrupted time series design: introduction

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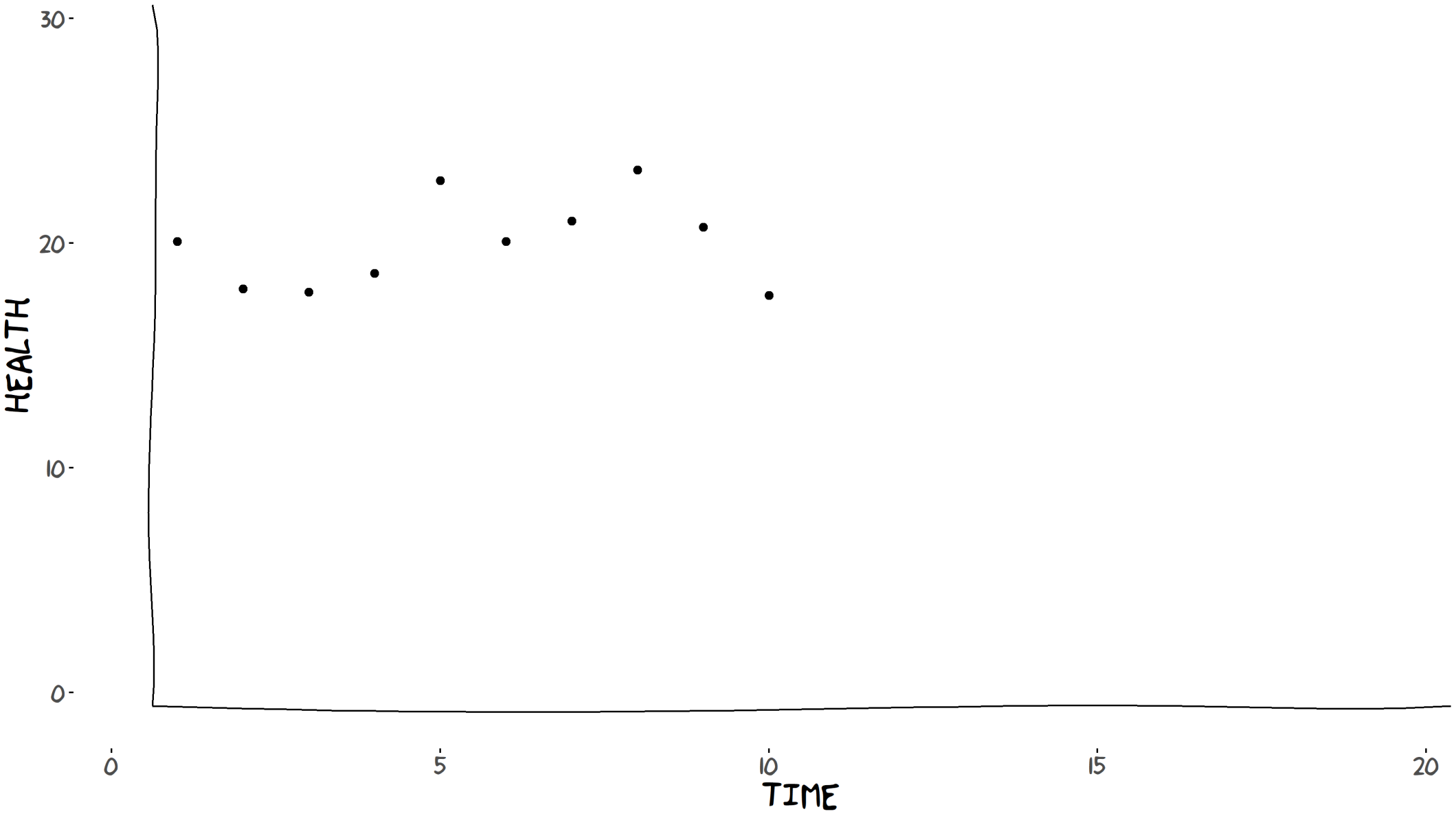
NHS
Midlands and Lancashire
Commissioning Support Unit

> A study that uses observations at multiple time points before and after an intervention (the “interruption”). The design attempts to detect whether the intervention has had an effect significantly greater than any underlying trend over time.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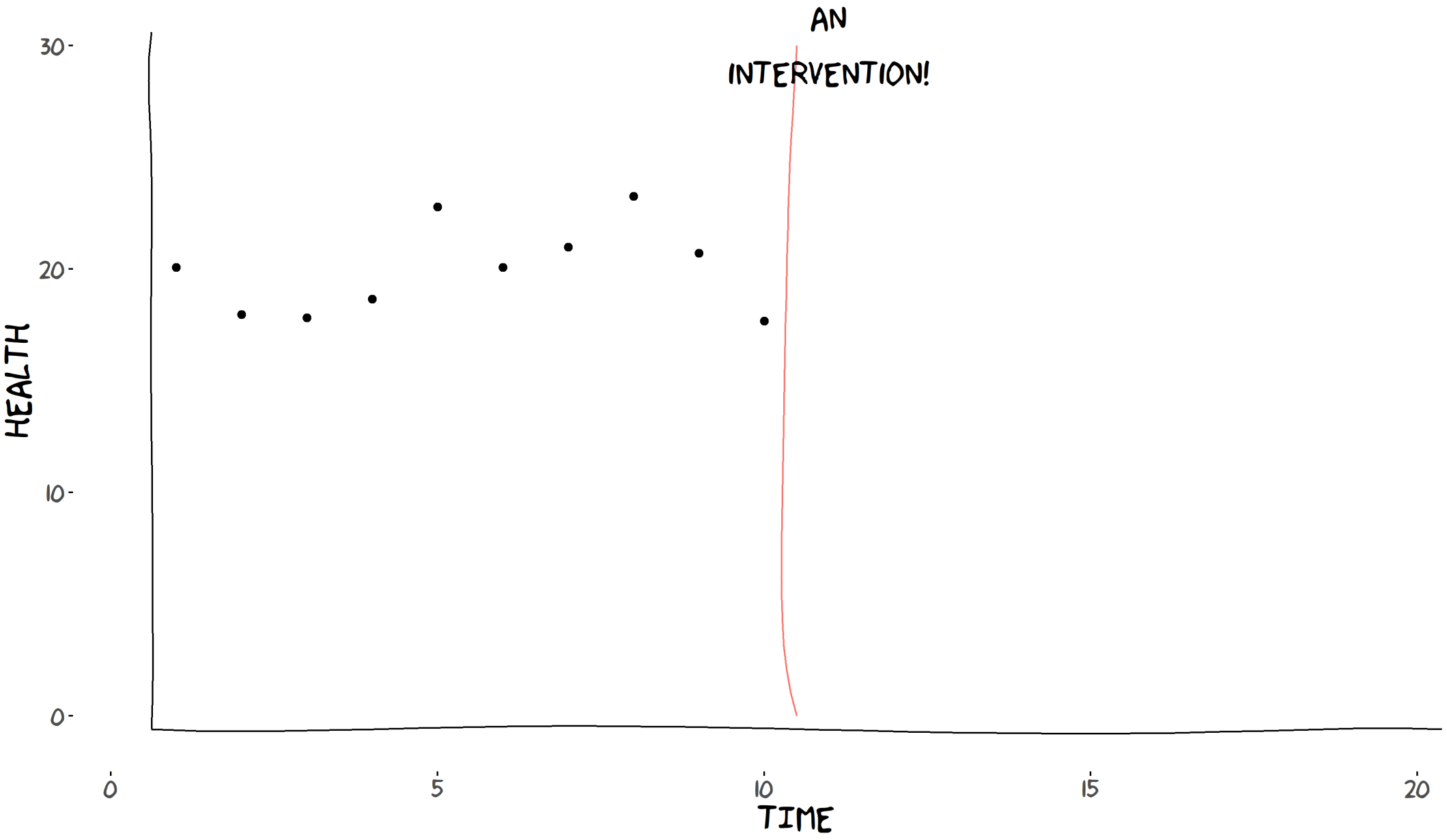
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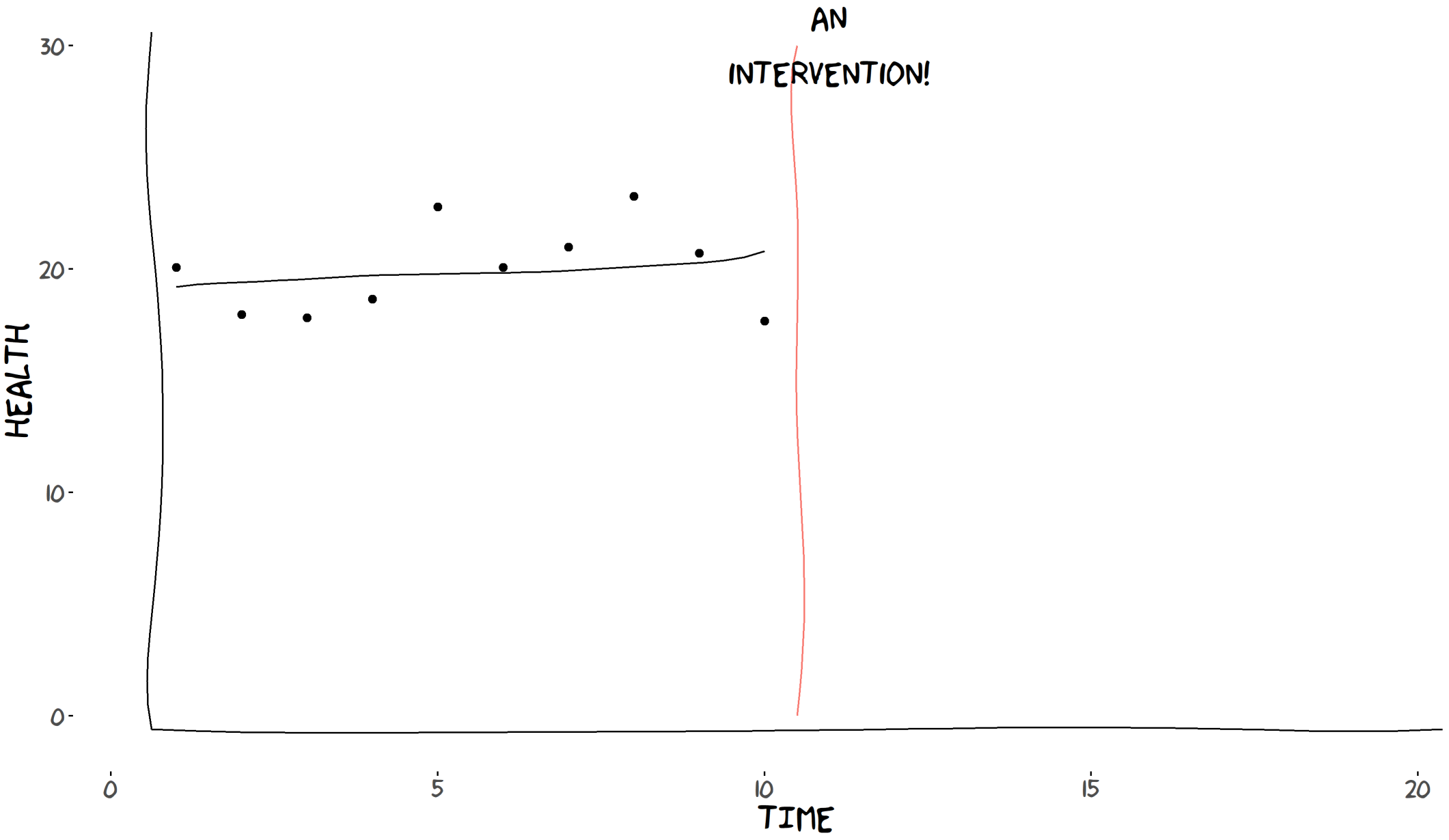
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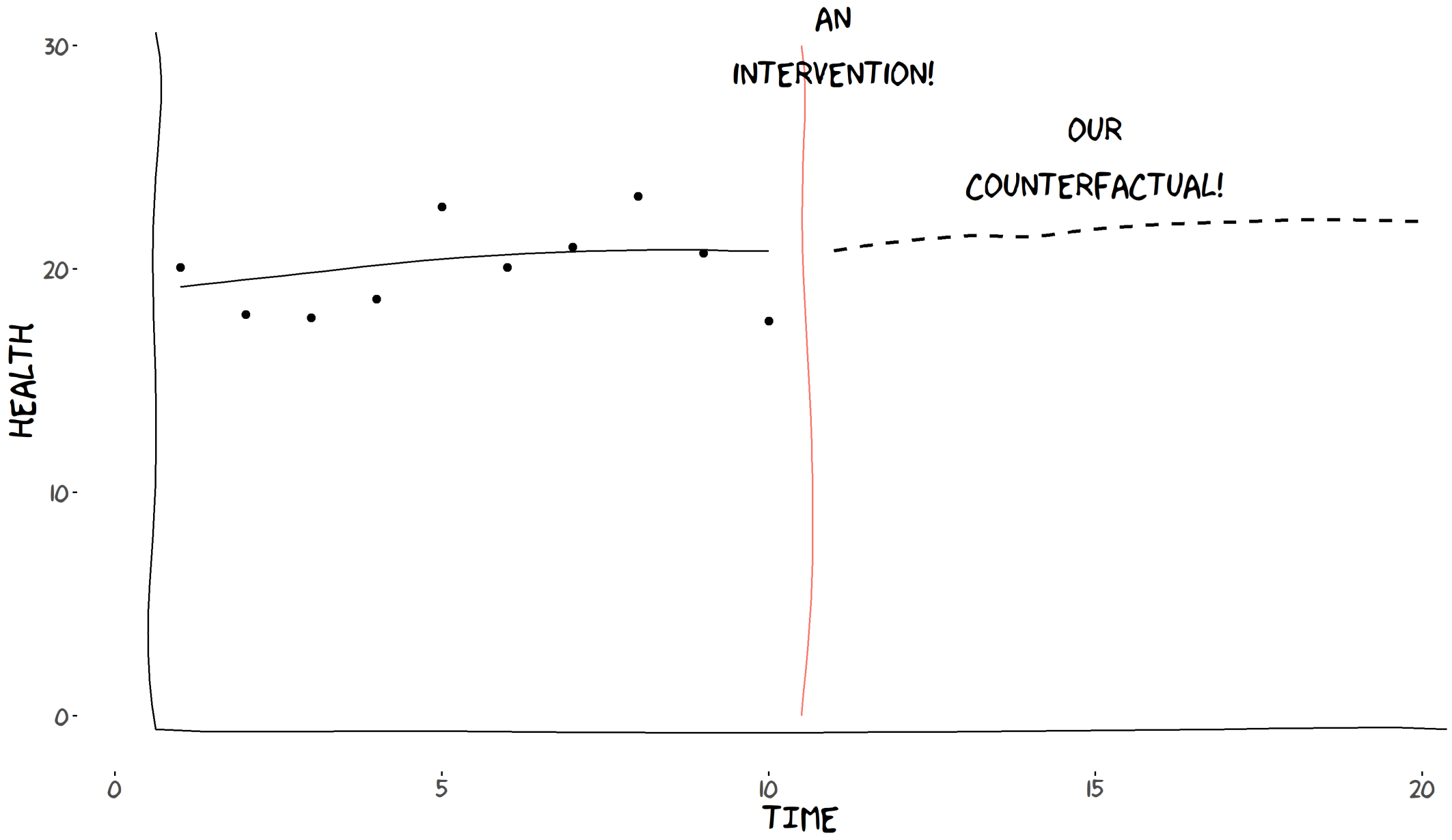
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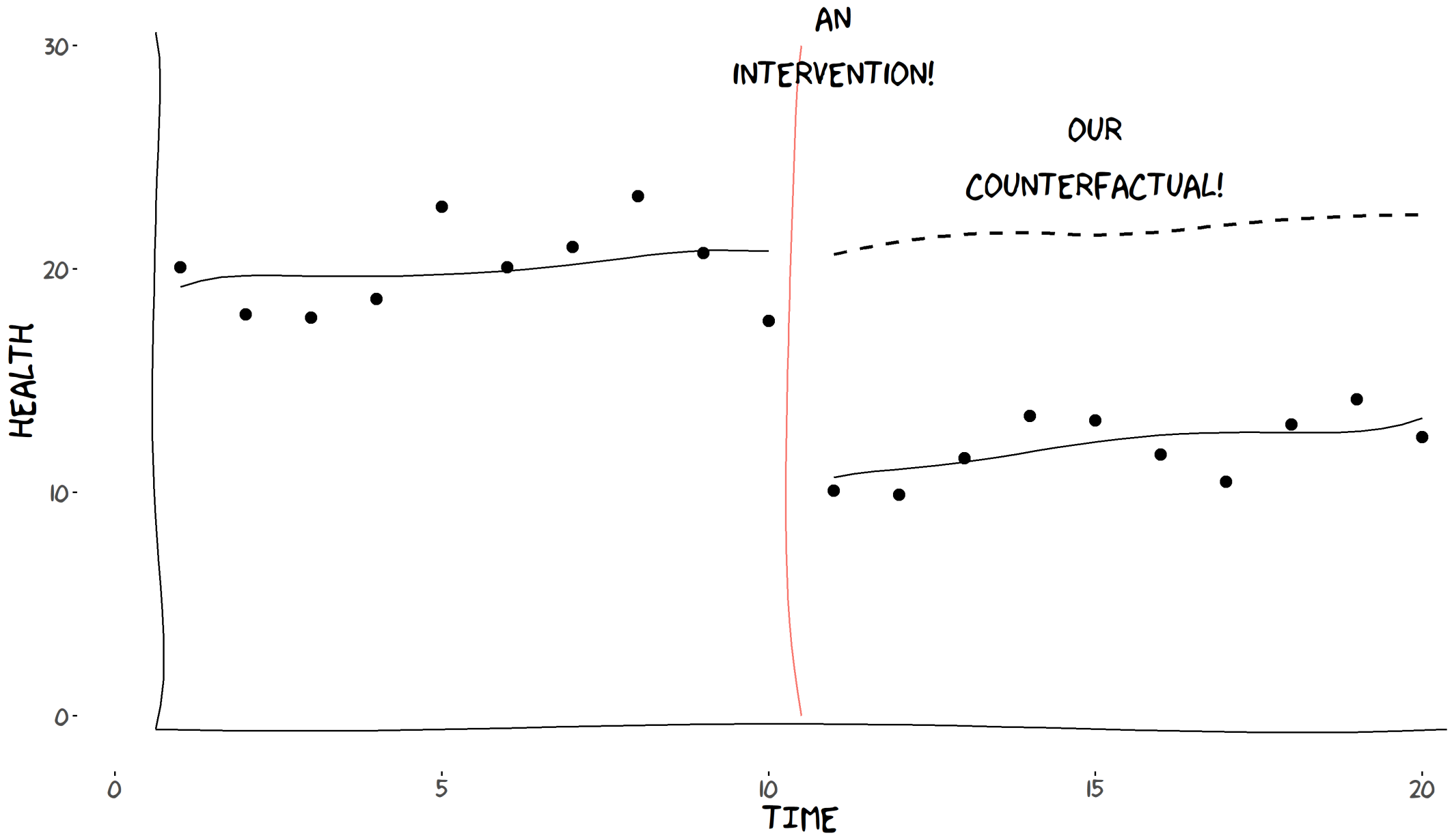
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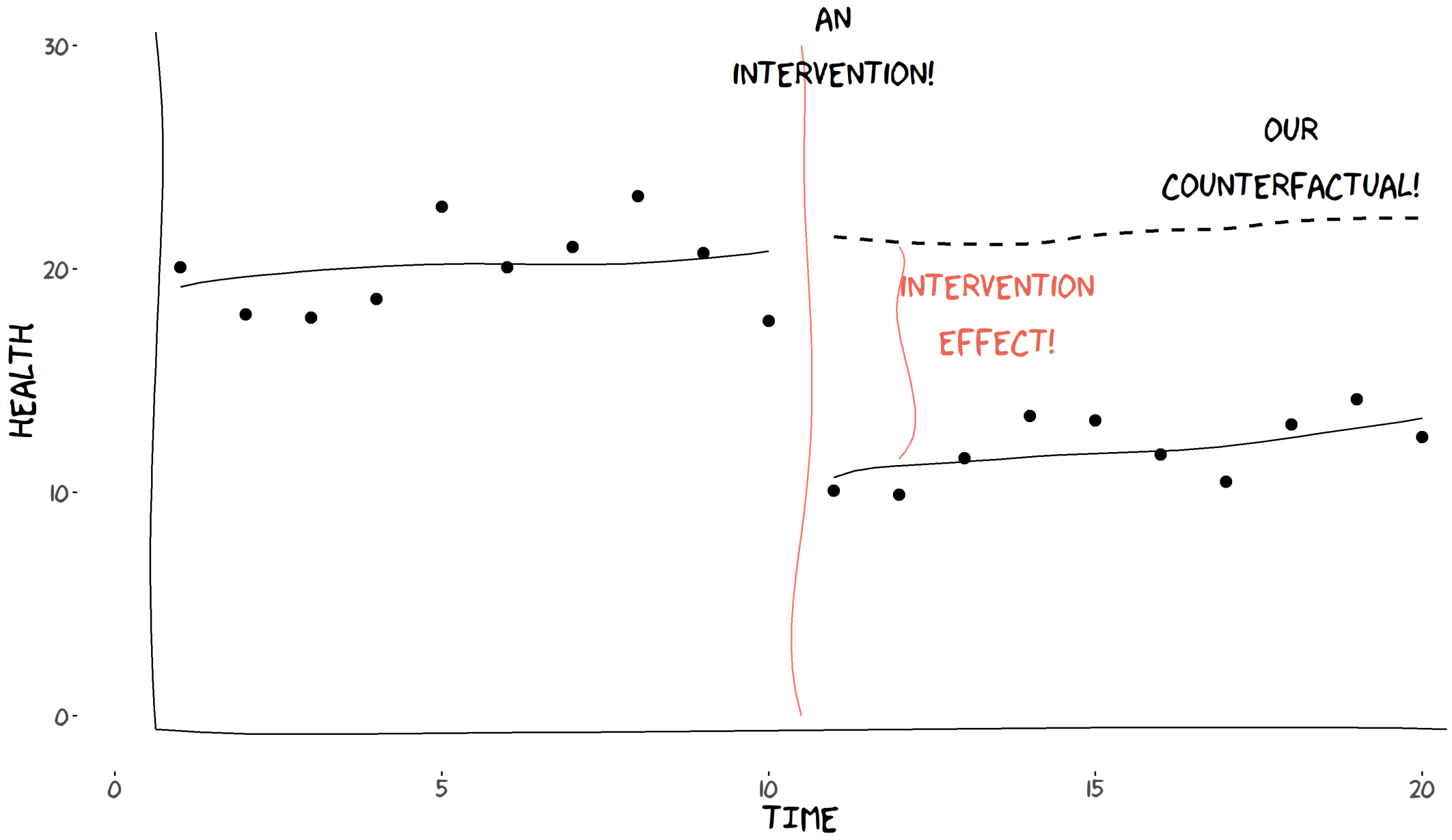
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# Why would you use this study design?

Excellent method of conducting naturalistic studies of the effects of a change at a systems level. ITS is particularly suited to interventions introduced at a population level over a clearly defined time period and that target population-level health outcomes.

Can get an unbiased estimate of the difference between pre and post intervention. Because time is the rule on which it was decided who got the intervention.

Can capitalize on existing data

Intuitive graphical representation

# Data requirements

Minimal!

Data collected at equally spaced intervals on some variable over time—a time series

—could be counts, rates, proportions, percentages etc.

Some sort of time delimited intervention that effects the variable of interest (specified independently of inspection of the data)

—could be a policy change, reform, real world event, marketing campaign etc.

Continue to collect the variable at the same equally spaced intervals after the intervention is introduced

… A time series of quantitative data relating to your variable of interest pre and post implementation of the intervention

# Improving on the standard pretest-posttest design: a classic example

**A crackdown on speeding in Connecticut**

On December 23, 1955, Governor Ribicoff announced that in the future all persons convicted of speeding would have their licenses suspended for 30-days on their first offense.

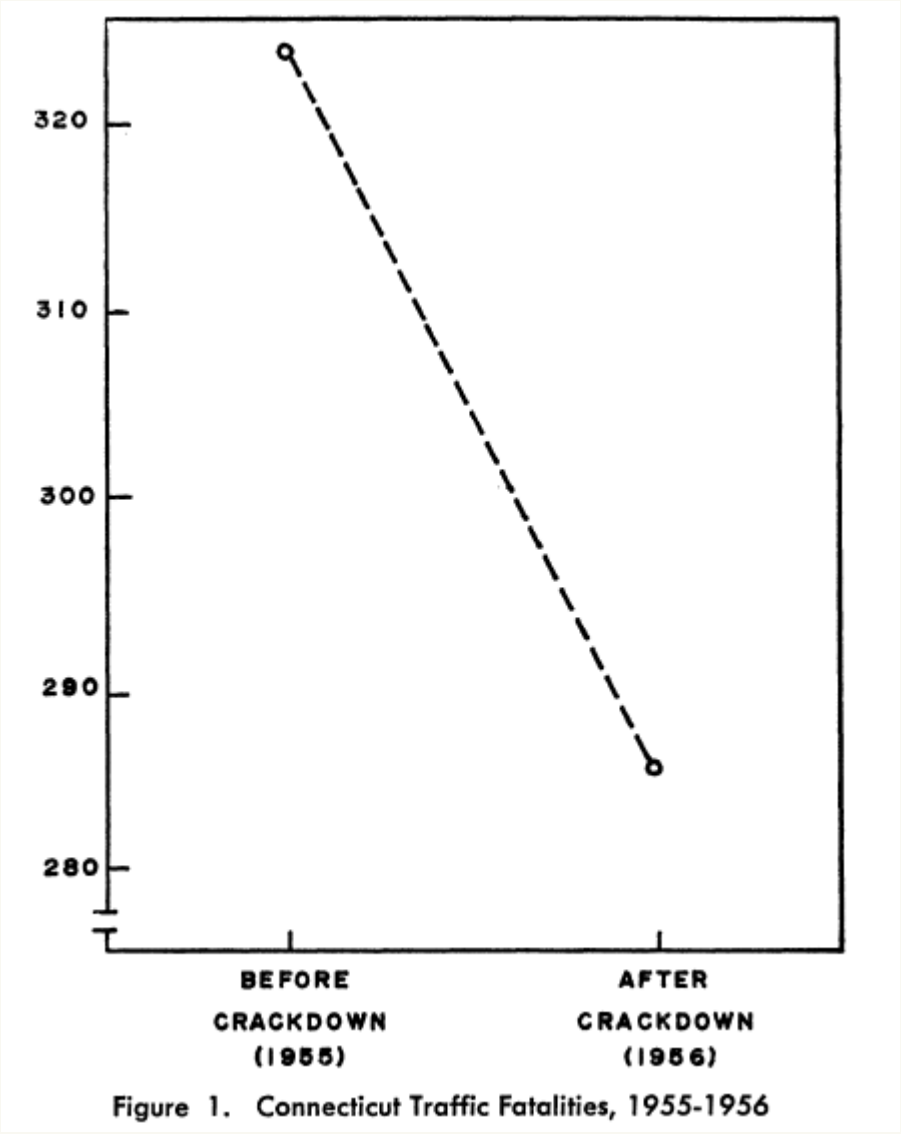

Figure 1. Connecticut Traffic Fatalities, 1955-1956

> With the saving of forty lives in 1956, a reduction of 12.3% from the 1955 motor vehicle death toll, we can say the programme is definitely worthwhile

? But to what extent are the results claimed for the program by Governor Ribicoff valid?

# Threats to the validity of experiments

The standard pretest-posttest design fails to control for 6 common threats.

- History (events)
- Maturation (processes)
- Testing
- Instrumentation
- Instability (random variation)
- Regression to the mean

# … back to speeding in Connecticut

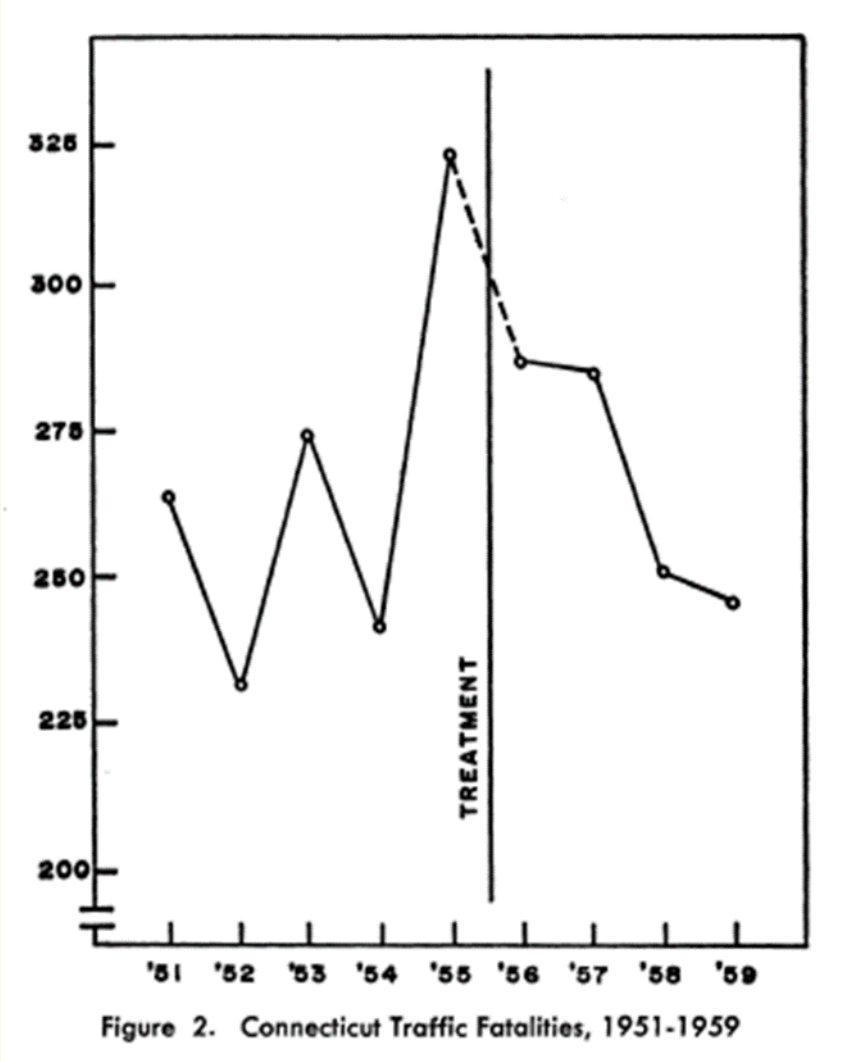

Figure 2. Connecticut Traffic Fatalities, 1951-1959

In the light of formerly and more recently available statistics are the claims made by Governor Ribicoff for the effect of the program valid?

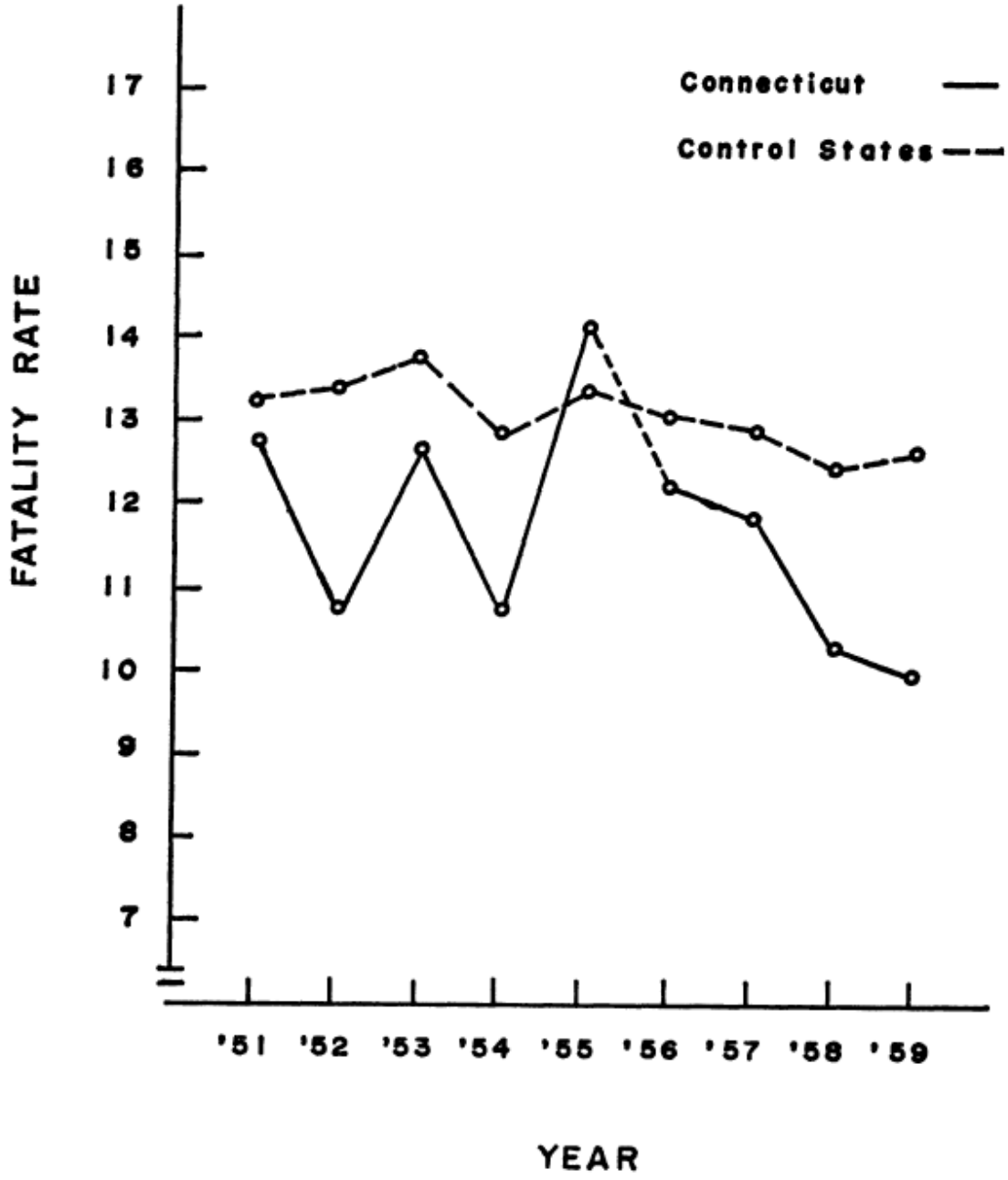


Figure 3. Connecticut and Control States Traffic Fatalities, 1951-1959
(per 100,000 population)

# Effect of restricting the legal supply of prescription opioids on buying through online illicit marketplaces: interrupted time series analysis

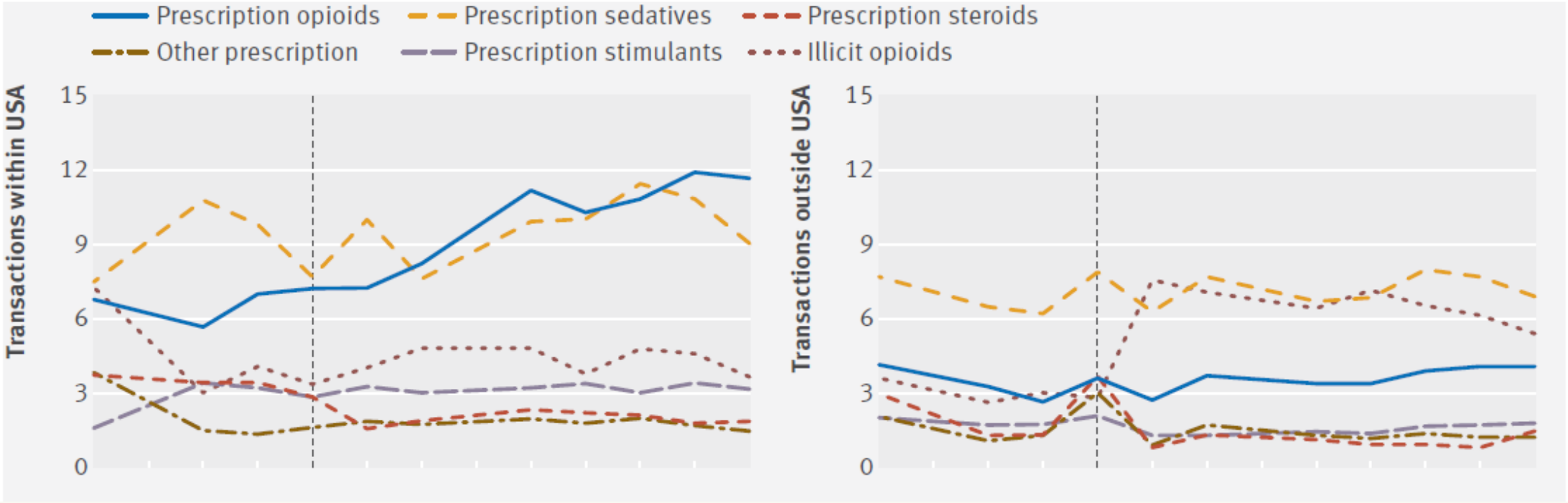


**Fig 1 | Percentage of online drug transactions, for products sold within the US compared with elsewhere, quarter 3 2013 to quarter 3 2016**

# Limitations and mitigations 1

If correctly specified, potential confounding in ITS studies is limited to factors that are related to the outcome of interest and that changed at the time of the intervention.

Threats to internal validity:

- It is difficult to infer causality between an observed pattern and the intervention. Concomitant reforms or events are likely to have a direct or indirect influence on the outcome of interest
- Typically, ITS models assume that the characteristics of the population under study remain unchanged throughout the study period (i.e. model estimates do not control for covariates)
- Changes in measurement or “instrumentation”

# Adding controls

Analysis of the outcome of interest in the study group only is less desirable because it does not allow control for other changes/events that may have influenced the outcome and that may have occurred at the same time as the intervention.

However, even in the absence of a control group the level and trend of the pre-intervention period still serve as controls for the post-intervention segment

# Selecting controls

1. Can be a different group of subjects. Ideally, a control group that is identical to the study group, but does not experience the intervention is followed over the same time period as the intervention group.

2. When a separate control group is not available the control can be represented by a related but different outcome within the intervention group not expected to change following the intervention.

# Impact models

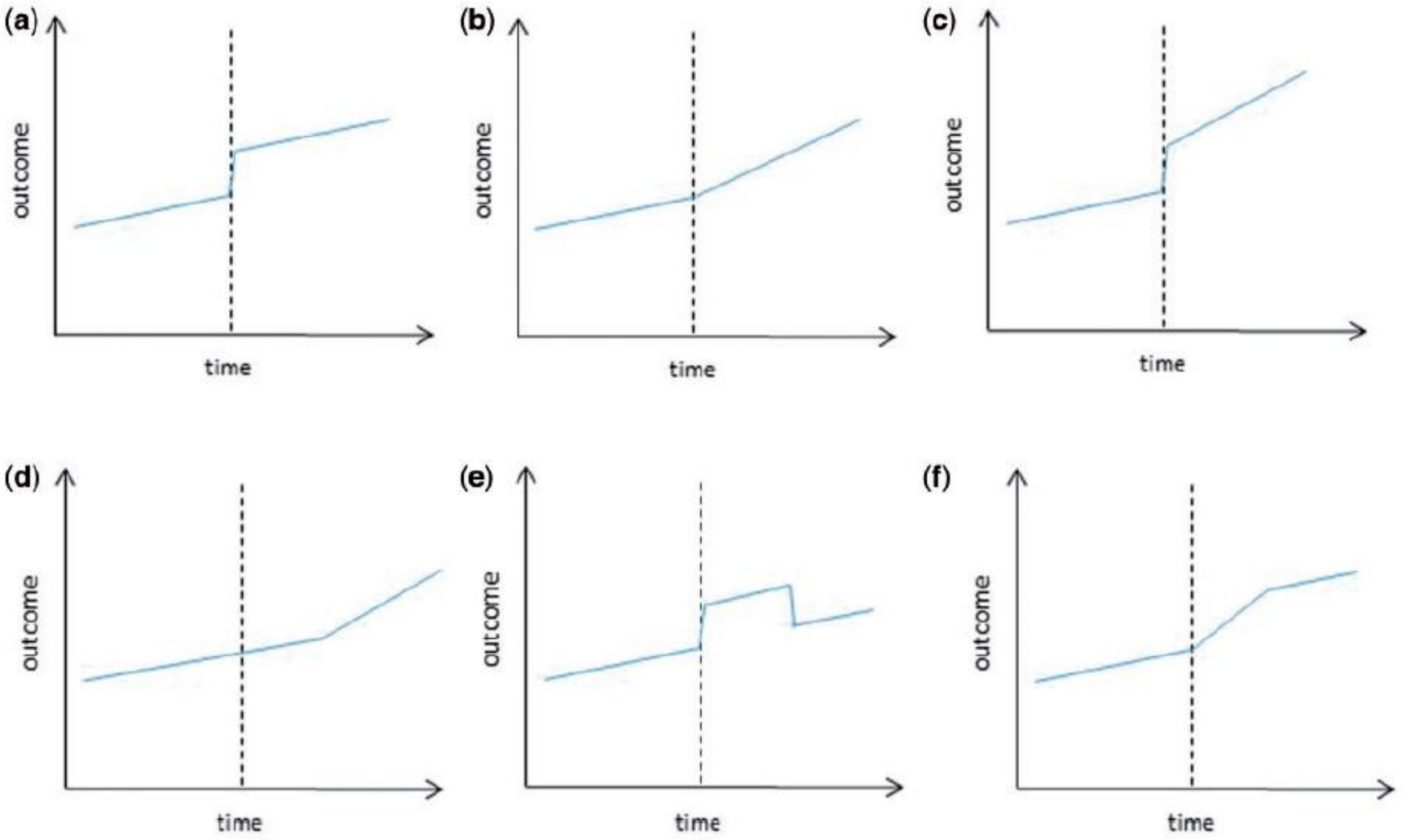


**Figure 2** Examples of impact models used in ITS

(a) Level change; (b) Slope change; (c) Level and slope change; (d) Slope change following a lag; (e) Temporary level change; (f) Temporary slope change leading to a level change.

# Summary

Randomization is not always feasible. A quasi-experimental approach using an ITS design can deliver robust results and the data requirements are relatively modest.

External validity of the design may be high as it occurs in a natural setting

ITS requires a clear differentiation of the pre-intervention period and the post-intervention period

ITS works best with short-term outcomes that are expected to change either relatively quickly after an intervention is implemented or after a clearly defined lag

# Summary cont.

Intuitive graphical representation

The basic time series design can be strengthened with the inclusion of appropriate controls

There are a number of distinctive issues with time series data that may need to be addressed in order to improve the robustness of the analysis

# A1: Studies using this design

Campbell D, Ross H. The Connecticut Crackdown on Speeding: Time-Series Data in Quasi-Experimental Analysis. *Law & Society Review.* 1968;3(1):33. doi: 10.2307/3052794

Martin J, Cunliffe J, Décary-Hétu D, Aldridge J. Effect of restricting the legal supply of prescription opioids on buying through online illicit marketplaces: interrupted time series analysis. *BMJ.* 2018;361:k2270. doi: 10.1136/bmj.k2270

Derde L, Cooper B, Goossens H, Malhotra-Kumar S, Willems R, Gniadkowski M *et al.* Interventions to reduce colonisation and transmission of antimicrobial-resistant bacteria in intensive care units: an interrupted time series study and cluster randomised trial. T*he Lancet Infectious Diseases.* 2014;14(1):31-39. doi: 10.1016/S1473-3099(13)70295-0

Hawton K, Bergen H, Simkin S, Dodd S, Pocock P, Bernal W *et al.* Long term effect of reduced pack sizes of paracetamol on poisoning deaths and liver transplant activity in England and Wales: interrupted time series analyses. *BMJ.* 2013;346:f403. doi: 10.1136/bmj.f403

Dennis J, Ramsay T, Turgeon A, Zarychanski R. Helmet legislation and admissions to hospital for cycling related head injuries in Canadian provinces and territories: interrupted time series analysis. *BMJ.* 2013;346:f2674-f2674. doi: 10.1136/bmj.f2674