

# Video Tutorials on Interrupted Time Series

## Analysis: Background Information Sheet

*This document is part of a video tutorial series that outlines the use of two statistical methods in the evaluation of routine data. This background document is on the first method, interrupted time series.*

### What is time series analysis?

Time series analysis is a statistical technique used for trend analysis or time series data. As the name implies, time is an important factor. Time is often the independent variable and can be monthly, weekly, daily, annual, or even biennial. This method is useful for aggregate-level analysis such as social statistics, including divorce rates and crime rates, and is often useful in evaluating the impact of social or political policies. In some instances, time series has been used for forecasting where historical values and associated patterns have been used to predict future activity.

The method has been used in social sciences, physical sciences, epidemiology, and economics. For example, in the epidemiology field, it has been used to study mortality rates, disease rates, and malaria incidence, while in the physical sciences, it has been used to study global temperatures and population levels.

Although there are several ways to use time series analysis, this video tutorial, background document, STATA command guide, and other materials provide focus on the interrupted time series (ITS) analysis.

### What questions can you answer using ITS analysis?

This method has been used to answer a variety of questions in public health including (see Table 1 for list of studies that have employed time series analysis):

- Does the “Project Fives Alive” influence

maternal and child health outcomes at scale?

- What is the impact of supplemental immunization activity campaign on routine child and maternal health services in South Africa?
- What is the impact of fixed-dose artesunate and mefloquine (ASMQ) combination on *P. falciparum* incidence, *P. vivax* and *P. falciparum* ratio, and on the number of hospital admissions in three municipalities in the Amazon Basin?
- What is the difference in level and monthly trend in mean health service utilization rates comparing observed rates from the Population Health Implementation and Training (PHIT)-supported health centers to the rates they would have had if they had not received the health systems strengthening intervention?

### When do you use ITS analysis?

ITS is used with time series data. Time series data is a series of data points ordered in time or data collected at different points in time. The data can be collected retrospectively or prospectively; however, it is important to have a clearly defined time at which the intervention or policy occurred and have at least three data points before and after the intervention or policy (Cochrane Effective Practice and Organisation of Care, 2017). Bernal et al. (2017) suggest that at least eight data points are needed before and after the intervention or policy. They argue that as many datapoints as possible should be used to accurately assess the trend. There are various ITS statistical approaches, and they can be used depending on the characteristics of the data, number of data points, and the research question being answered.

### **Important questions to consider when using routine data for ITS analysis:**

- Is there missing data?
  - How will you deal with missing data? What criteria will be used?
  - If possible, compare missing or unreasonable data to the original data collection form if available.
- Are there outliers (data points far away from your other data)?
  - It is helpful to use graphical methods of each variable over the observation period. This can also help to identify fluctuations.
  - Is there a need to match intervention and control facilities at baseline?
- Is there a trend?
  - Is the trend nonstationary or secular (data increasing or decreasing over

time irrespective of any intervention)?

- Is there seasonality or seasonal variations?
- Is there autocorrelation (data collected closely are correlated with each other)?

#### *Other things to think about:*

- Is there a comparison group?
  - If present, how will characteristics of facilities across intervention and control group be accounted for?
  - Will covariates be controlled for in the analysis and is the sample size adequate to do this?
- How will the data be presented?
  - Graphical representation?
  - Table of results?
  - Calculation of absolute and relative changes?

## Useful resources

Below is a compilation of useful resources on time series analysis and interrupted time series.

- Ashton, R. A., Bennett, A., Yukich, J., Bhattarai, A., Keating, J., & Eisele, T. P. (2017). Methodological considerations for use of routine health information system data to evaluate malaria program impact in an era of declining malaria transmission. *American Journal of Tropical Medicine and Hygiene*, 97(3 Suppl), 46–57. <https://doi.org/10.4269/ajtmh.16-0734>
- Beckett, S. (2020). *Introduction to Time Series Using Stata, Revised Edition*. Stata Press. College Station, TX. <https://www.stata-press.com/books/introduction-to-time-series-using-stata/>
- Bernal, J. L., Cummins, S., & Gasparrini, A. (2017). Interrupted time series regression for the evaluation of public health interventions: A tutorial. *International Journal of Epidemiology*, 46(1), 348–355. <https://doi.org/10.1093/ije/dyw098>
- Box-Steffensmeier, J. M., Freeman, J. R., Hitt, Matthew P., & Pevehouse, J. C. (2014). *Time Series Analysis for the Social Sciences (Analytical Methods for Social Research)*. Cambridge University Press. Cambridge, NY. <https://doi.org/10.1017/CBO9781139025287>
- Cochrane Effective Practice and Organisation of Care (EPOC). (2017). *Interrupted time series (ITS) analyses: EPOC Resources for review authors*. <https://www.coursehero.com/file/74328642/interrupted-time-series-analysesdocx/>
- Eccles, M., Grimshaw, J., Campbell, M., & Ramsay, C. (2003). Research designs for studies evaluating the effectiveness of change an improvement strategies. *Quality and Safety in Health Care*, 12(1), 47–52. <https://doi.org/10.1136/qhc.12.1.47>
- Ewusie, J. E., Blondal, E., Soobiah, C., Beyene, J., Thabane, L., Straus, S. E., & Hamid, J. S. (2017). Methods, applications, interpretations and challenges of interrupted time series (ITS) data: protocol for a scoping review. *BMJ open*, 7(6), e016018. <https://doi.org/10.1136/bmjopen-2017-016018>
- Hategaka, C., Ruton, H., Karamouzian, M., Lynd, L. D., & Law, M. R. (2020). Use of interrupted time series methods in the evaluation of health system quality improvement interventions: a methodological systematic review. *BMJ global health*, 5(10), e003567. <https://doi.org/10.1136/bmjgh-2020-003567>
- Hudson, J., Fielding, S. & Ramsay, C. (2019). Methodology and reporting characteristics of studies using interrupted time series design in healthcare. *BMC Med Res Methodol*, 19(137). <https://doi.org/10.1186/s12874-019-0777-x>
- Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal*, 15(2), 480–500. <https://www.stata-journal.com/article.html?article=st0389>
- Linden, A. (2017). A comprehensive set of postestimation measures to enrich interrupted time-series analysis. *The Stata Journal*, 17(1), 73–88. [https://www.stata-journal.com/article.html?article=st0389\\_3](https://www.stata-journal.com/article.html?article=st0389_3)
- Kontopantelis, E., Doran, T., Springate, D. A., Buchan, I., & Reeves, D. (2015). Regression based quasi-experimental approach when randomisation is not an option: interrupted time series analysis. *BMJ (Clinical research ed.)*, 350, h2750. <https://doi.org/10.1136/bmj.h2750>
- Penfold, R. B., & Zhang, F. (2013). Use of interrupted time series analysis in evaluating health care quality improvements. *Academic pediatrics*, 13(6 Suppl), S38–S44. <https://doi.org/10.1016/j.acap.2013.08.002>
- Pickup, M. (2014). *Introduction to Time Series Analysis (Quantitative Applications in the Social Sciences)* (1st ed., Vol. 174). SAGE Publications, Inc. Thousand Oaks, CA. <https://methods.sagepub.com/book/introduction-to-time-series-analysis>



## Webinar/Courses

Law, M. Policy Analysis Using Interrupted Time Series. *University of British Columbia*.

<https://www.edx.org/course/policy-analysis-using-interrupted-time-series>

Worges, M. Managing missing values in routinely reported data: One approach from the Democratic Republic of the Congo. *Data for Impact*.

<https://www.data4impactproject.org/resources/webinars/managing-missing-values-in-routinely-reported-data-one-approach-from-the-democratic-republic-of-the-congo/>

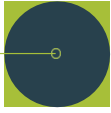
**Table 1: Summary of studies using interrupted time series**

Study	Title	Year	Research question or objective	Data source
Abimpaye M, Kirk C, Iyer H, Gupta N, Remera E, Mugwaneza P, Law M	<a href="#">The impact of “Option B” on HIV transmission from mother to child in Rwanda: An interrupted time series analysis</a>	2018	Evaluate the impact of the adoption of Option B/B+ in Rwanda on the transmission HIV from mother to child	National HIV reporting database
Ashton R, Bennett A, Al-Mafazy A, Abass A, Msellem M	<a href="#">Use of routine health information system data to evaluate impact of malaria control interventions in Zanzibar, Tanzania from 2000 to 2015</a>	2019	Estimate the impact of interventions on malaria case incidence at health facilities in Zanzibar from 2000 to 2015	HMIS reports
Delamou A, Ayadi A, Sidibe S, Delvaux T, Camara B, Sandouno S, Beavogui A, Rutherford G, Okumura J, Zhang W, De Brouwere V	<a href="#">Effect of Ebola virus disease on maternal and child health services in Guinea: a retrospective observational cohort study</a>	2017	Assess maternal and child health services, specifically use of antenatal care, institutional delivery, immunization services, before during and after Ebola in Guinea	Health facility data
Fournier P, Dumont A, Tourigny C, Philibert A, Coulibaly A, Traoré M.	<a href="#">The free caesareans policy in low-income settings: an interrupted time series analysis in Mali (2003-2012)</a>	2014	Evaluate the effect of the fee exemptions for cesareans on population cesarean rates taking into account different levels of accessibility.	(1) System GESYRE (Gestion du Systeme de Reference Evacuation); (2) census data
Hung Y, Law M, Cheng L, Abramowitz S, Alcayna-Stevens L, Lurton G, Mayaka S, Olekhovitch R, Kyomba G, Ruton H, Ramazani S, Grépin K	<a href="#">Impact of a free care policy on the utilisation of health services during an Ebola outbreak in the Democratic Republic of Congo: an interrupted time- series analysis</a>	2020	Evaluate the the effect of the impact of the free care policies on the use of health services at primary health centers	National HMIS
Iyer H, Hirschhorn L, Nisingizwe M, Kamanzi E, Drobac P, Rwabukwisi F, Law M, Muhire A, Rusanganwa V, Basinga P	<a href="#">Impact of a district-wide health center strengthening intervention on healthcare utilization in rural Rwanda: Use of interrupted time series analysis</a>	2017	What is the difference in level and monthly trend in mean health service utilization rates comparing observed rates from Population Health Implementation and Training (PHIT)-supported health centers to the rates they would have had if they had not received the HSS intervention?	Rwanda HMIS

Study	Title	Year	Research question or objective	Data source
Landoh E, Tchamdja P, Saka B, Tint K, Gitta S, Wasswa P, Christiaan de J.	<a href="#">Morbidity and mortality due to malaria in Est Mono district, Togo, from 2005 to 2010: a times series analysis</a>	2012	Assess the trends of malaria incidence and mortality due to malaria in Est Mono district from 2005 to 2010.	(1) Health facility reports; (2) Department of meteorology
Ngomane L, de Jager C	<a href="#">Changes in malaria morbidity and mortality in Mpumalanga Province, South Africa (2001-2009): a retrospective study</a>	2012	Assess the changes in malaria morbidity and mortality during the past eight malaria seasons in Mpumalanga Province, while taking into account the potential effect of factors such as climate and IRS, which might have influenced these changes.	(1) Provincial Integrated Malaria Information System; (2) computerized spraying management system; (3) South African Weather Service
Nyarango P, Gebremeskel T, Mebrahtu G, Mufunda J, Abdulmumini U, Ogbamariam A, Kosia A, Gebremichael A, Gunawardena D, Ghebrat Y, Okbaldet Y	<a href="#">A steep decline of malaria morbidity and mortality trends in Eritrea between 2000 and 2004: the effect of combination of control methods</a>	2006	Examine the impact of Eritrea's Roll Back Malaria Programme: 2000–2004	(1) HMIS; (2) quarterly and annual reports of the National Malaria Control Programme; (3) reports of the annual assessment workshops by NMCP; (4) published reports of the midterm evaluation of the Roll Back Malaria Programme 1999–2004
Okoli U, Morris L, Oshin A, Pate M, Aigbe C, Muhammad A	<a href="#">Conditional cash transfer schemes in Nigeria: potential gains for maternal and child health service uptake in a national pilot programme</a>	2014	Determine the impact of the Sure Program	(1) Program beneficiary database; (2) SURE-P MCH M&E data (facility level data)
Ruton H, Musabyimana A, Gaju E, Berhe A, Grépin K, Ngenzi J, Nzabonimana E, Law M	<a href="#">The impact of an mHealth monitoring system on health care utilization by mothers and children: an evaluation using routine health information in Rwanda</a>	2018	Evaluate the impact of RapidSMS both with and without this additional support on the use of important maternal and child health services.	(1) Database of messages sent by CHWs; (2) HMIS
Santelli A, Ribeiro I, Daher A, Boulos M, Marchesini P, dos Santos R, Lucena M, Magalhães I, Leon AP, Junger W, Ladislau J	<a href="#">Effect of artesunate-mefloquine fixed-dose combination in malaria transmission in amazon basin communities</a>	2012	Determine the impact of a fixed-dose artesunate and mefloquine (ASMQ) combination on P. falciparum incidence, P. vivax and P. falciparum ratio, and on the number of hospital admissions in three municipalities in the Amazon Basin	Routine collection through national surveillance system, SIVEP-malaria (2) rainfall data
Singh K, Speizer I, Handa S, Boadu R,	<a href="#">Impact evaluation of a quality improvement</a>	2013	Does the “Project Fives Alive” influence MCH outcomes at scale?	(1) Health facility data; (2) program records

Study	Title	Year	Research question or objective	Data source
Atinbire S, Barker P, Twum-Danso N	<a href="#">intervention on maternal and child health outcomes in Northern Ghana: early assessment of a national scale-up project</a>		<ul style="list-style-type: none"> <li>- Immediate impact</li> <li>- Long term impact</li> </ul>	
Verguet S, Jassat W, Bertram M, Tollamn S, Murray C, Jamison D, Hofman, K	<a href="#">Impact of supplemental immunisation activity (SIA) campaigns on health systems: findings from South Africa</a>	2013	Determine the impact of supplemental immunization activity campaign on routine child and maternal health services in South Africa.	DHIS
Wagenaar B, Augusto O, Beste J, Toomay S, Wickett E, Dunbar N, Bawo L, Wesseh C	<a href="#">The 2014–2015 Ebola virus disease outbreak and primary healthcare delivery in Liberia: Time-series analyses for 2010–2016</a>	2018	Estimate the immediate and lasting effects of the 2014–2015 Ebola virus disease outbreak on public-sector primary healthcare delivery in Liberia	Liberian MoH RHIS (integrated with DHIS 2)

DHIS – District Health Information Software; HMIS – Health Management Information System; MCH – maternal and child health; M&E – monitoring and evaluation; RHIS – routine health information system



## References

- Bernal, J. L., Cummins, S., & Gasparrini, A. (2017). Interrupted time series regression for the evaluation of public health interventions: A tutorial. *International Journal of Epidemiology*, 46(1), 348–355. <https://doi.org/10.1093/ije/dywo98>
- Cochrane Effective Practice and Organisation of Care [EPOC]. (2017). *Interrupted time series (ITS) analyses: EPOC Resources for review authors*.
- Hudson, J., Fielding, S., & Ramsay, C. R. (2019). Methodology and reporting characteristics of studies using interrupted time series design in healthcare. *BMC Medical Research Methodology*, 19(1). <https://doi.org/10.1186/s12874-019-0777-x>
- Jandoc, R., Burden, A. M., Mamdani, M., Lévesque, L. E., & Cadarette, S. M. (2015). Interrupted time series analysis in drug utilization research is increasing: Systematic review and recommendations. *Journal of Clinical Epidemiology*, 68(8), 950–956. <https://doi.org/10.1016/j.jclinepi.2014.12.018>

### For more information

D4I supports countries to realize the power of data as actionable evidence that can improve programs, policies, and—ultimately—health outcomes. We strengthen the technical and organizational capacity of local partners to collect, analyze, and use data to support their move to self-reliance. For more information, visit <https://www.data4impactproject.org/>

