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Research Article

Impact of Covid-19 Measures on Children Infection Related Hospitalization. Estimation of Causal Inference from observational Data, Using the Google Causal Impact, A Bayesian Structural Time-series Model

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Abstract

Introduction: Although covid-19 has numerous adverse effects on children, few beneficial effects have been observed such as adapting to learn in a new digital environment, coming closer to family, creating a bond of love, affection among the family members, and awareness of a novel disease. As a result of covid-19 measures such as, social distance, hand hygiene, use of a face mask, the common pediatric infectious diseases, namely, influenza, croup, and bronchiolitis significantly reduced. The aim of our study to examine the causal impact of covid-19 measures as factual probability and the counterfactual probability of average number of pediatric admissions due to Covid-19 measures, using the Google Causal Impact, a structural Bayesian time -series model and to explore the use of this model in healthcare research.

Method: **Study Design:** A retrospective observational study. Two-time series data collected from Dec-2016 to Oct-2018 as control, and Dec-2018 to Oct-2020 as the experimental group. Our hypothetical assumption, if all the 0bserved or unobserved covariate which influence the hospitalization of children due to respiratory illness are essentially static. Our assumption during the control period the observed mean admission and experimental period predicted mean admission should not differ in the absence of Covid-19 measures. Impact of covid-19 pandemic measures on pediatric admission during the post-intervention time could be drawn by subtracting the factual probability of admission from the counterfactual probability of mean monthly admission.

Setting: Imam Abdulrahman bin Faisal Hospital, under National Guard health affairs, located in Dammam, KSA. The Hospital is approximately 100-bed capacity, Pediatric ward bed capacity twenty with average annual admission 1200, winter season exceeded the bed capacity, monthly exceeding 140-150 admission.

Data collection: Monthly total number of admission data collected retrospectively from the Pediatric Ward admission log book the proposed time frame.

Results: During the control period, the observed and predicted mean admission was statistical, not significant (P- 0.171), in addition, the observed average admission during the control and predicted during the intervention, was the same. As a result of Covid-19 measures, the monthly admissions average value of 29. By contrast, in the absence of covid-19 pandemic measures, we would have expected an average admission of 87(9.4). counterfactual prediction CI [68-106]. Causal effects -58, CI (-78, -39), p values 0.001.

Conclusion: Admission was appreciably diminished as a positive impact of covid-19 measures indeed, it was the opposite direction of an adult, nevertheless, it was beyond expectation for admission for pediatric age group during a pandemic. On the other hand, the Google causal Impact algorithm well fitted to explore the casual Inference, and healthcare researchers could use it for causal effect estimation for any interventional time series setup.

Keywords: Positive Impact of Covid-19; Covid-19 in Children; Covid-19 Infection; Corona in Children; Structural Bayesian Time -series Model; Forecasting; Google Causal Impact

Abbreviation

ARIMA- Auto Regressive Integrated Moving Average, BSTS: Bayesian structural time series

Introduction

Indeed, covid-19 has a significant negative impact on children's health since the beginning of the pandemic particularly mental pressure, due to isolation, lack of face-to-face peer interaction, physical distance, and loneliness, inability to perform outdoor physical activity. Children's institutional education badly affected, inadequate learning due to the wide learning gap between low and high socioeconomic groups; furthermore, increase frustration. Although covid-19 have adverse effects on children, few beneficial effects have been observed such as adapting to learning in a new digital environment, coming more closer to family, creating a bond of love and affection among the family members, awareness of an unknown disease [1]; As a result of covid-19 measures, social distance, hand hygiene, face mask, closure of school and avoidance of social gathering, and unnecessary outing, noted to have positive impact on common pediatric infection Notably, three of the studied diseases, namely, influenza, croup, and bronchiolitis, essentially disappeared with social distance [2]. Not only that, even other common pediatrics infectious disease pneumonia, the common cold, croup, gastroenteritis, non-streptococcal pharyngitis, sinusitis, skin and soft tissue infections, and urinary tract infection also was significantly lower in a large pediatric primary care network y Massachusetts, compared with the same time period in 2019. It was reported weekly incidence of common pediatric respiratory illness dramatically decrease in contrast to pre-and post-social distance periods comparing the similar calendar periods in 2019 and 2020. Hence, social distancing appears to have had a dramatic impact on prevention of transmission of common childhood infectious diseases, especially other respiratory viral pathogens [2]. Changes in care-seeking behavior had a relatively modest effect on the observed declines rate [2,3]. The main bulk of pediatric admission in our hospital constitutes respiratory illness during the flu season. (Figure-1, 2, 3). Therefore, the mean number of admissions in our hospital decrease as a result of covid-19 measures which support the positive influence of covid-19 measures on common respiratory illness in children.

Method

A retrospective observational study. A number of monthly admission data collected as a time series events from general pediatric ward admission logbooks. Two-time series data collected from Dec-2016 to Oct-2018 as control, and Dec-2018 to Oct-2020 as experimental group. Control time series correspond with pre-covid-19 pandemic measures period and experimental times series during the pandemic. In the course of the control period, fifteen months' time-series data from Dec 2016 to Feb 2018 used to predict the monthly admission for March 2018 to Oct 2018. To check our assumption that during this time, observed monthly admission and predicted admission should not differ in the absence of covid-19 pandemic measures. By contrast, using the time series data points from Dec 2018 to Feb 2020, forecasting March 2020 to Oct 2020 should differ from observed monthly admission as a consequence of covid-19 pandemic measures. We use a "synthetic control" approach. The Bayesian structural approach has been shown to be useful for interventional effects through time series data in the absence of a randomized controlled trial. It estimates the pretreatment period using Gibbs sampling and then iterates each sampling trajectory forward using the estimated parameters to construct the post-intervention counterfactual forecasting. So, the model has the advantage that it does not require a set of dedicated control units and instead can use any sort of related time series to predict the counterfactual probability [4]. This forecasting result giving the impression that in the absence of the covid-19 pandemic measure, what supposed to happen as the counterfactual event. we have drawn our causal impact by subtracting the factual probability of admission from the counterfactual probability of average monthly admission.

Results

Time series data from Dec2016 to Oct 2020 revealed that we a seasonal seasonal increase a number of admissions which correspond with flu season (Figure 1-3). In our study, during the control period the observed and predicted average admission was not statistically significant (Table 1, Figure 4) in the absence of covid-19 measures. But post-intervention as a result of covid-19 measures, the monthly average admission 29. By contrast, in the absence of an intervention, we would have expected an average admission 87(9.4), CI [30.94, 51.94]. Estimated causal effect, absolute and relative are significant with p values 0.001 (Table 2, Figure 5). Cumulative total observed admission 231 and predicted admission 693(75.4).

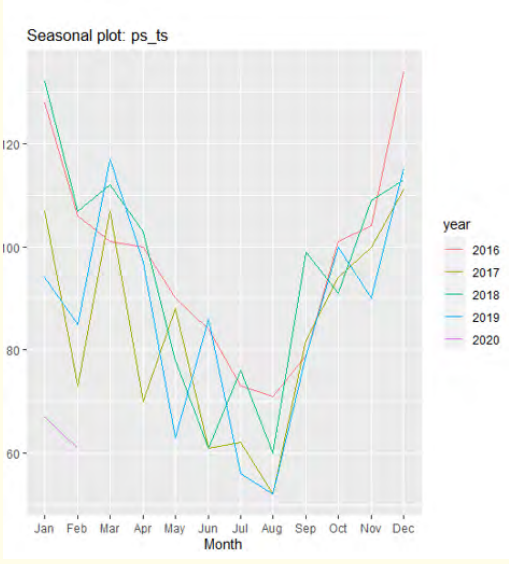

Figure 1: Seasonal variation of Admission in Pediatric Ward. Number of admissions during flu. Season starting September to March each year.

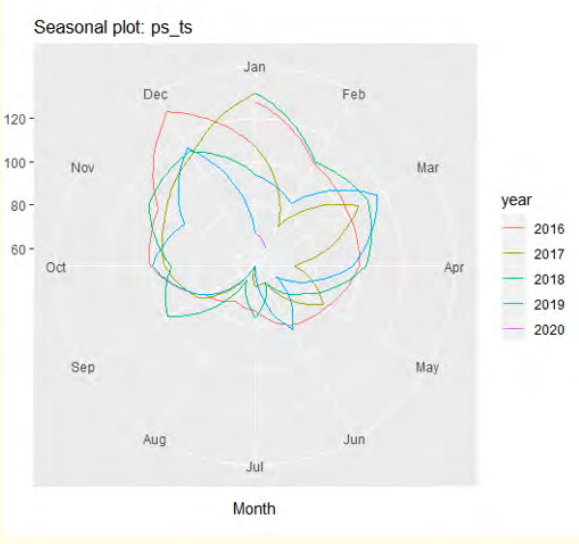

Figure 2: Seasonal variation of Admission in Pediatric Ward. Number of admissions during flu. Season starting September to March each year.

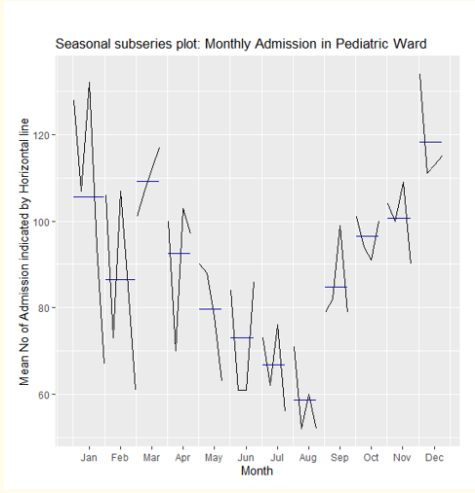

Figure 3: Seasonal variation of Admission in Pediatric Ward. Mean number of admissions during flu. Season starting September to March each year. 2016-2020 Feb.

Control period

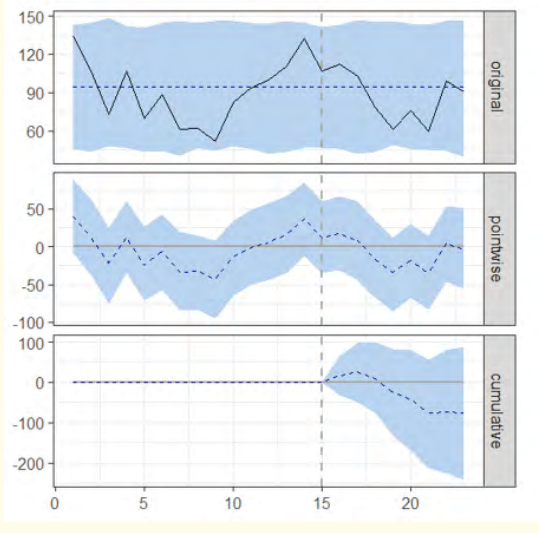

Figure 4: Illustrated Causal impact model (control). The first part shows the data monthly admission and a prediction of admission for the control period. The second panel shows the difference between observed monthly admission and counterfactual monthly admission predictions in the absence of any influence of covid-19 pandemic measures, a pointwise causal effect, as estimated by a structural Bayesian time -series model. The lowest part adds up the pointwise contributions from the second panel, resulting in a plot of the cumulative effect in the absence of covid-19 measures on admission.

	Average	Cumulative
Actual	85	680
Prediction (s.d.)	95(11)	756(85)
95% CI	[74, 116]	[588, 926]
Absolute effect (s.d.)	-9.5(11)	-76.1(85)
95% CI	[-31,11)]	(-246, 92)
Relative effect (s.d.)	-10% (11%)	-10% (11%)
95% CI	[-33%, 12%]	[-33%, 12%]
Posterior tail-area probability p	0.171	

Table 1: Causal Impact -posterior inference by structural Bayesian time -series model output results. Time frame -1 during the control period.

During intervention period

	Average	Cumulative
Actual	29	231
Prediction (s.d.)	87(9.4)	693(75.4)
95% CI	[68, 106]	[545, 852]
Absolute effect (s.d.)	-58 (9.4)	-462 (75.4)
95% CI	[-78, -39]	[-621, -314]
Relative effect (s.d.)	-67% (11%)	-67% (11%)
95% CI	[-90%, -45%]	[-90%, -45%]
Posterior tail-area probability p	0.001	
Posterior prob. of a causal effect:	99.9%	

Table 2: Causal Impact -posterior inference by structural Bayesian time -series model output results. Time frame -2 during the intervention period/covid-19 pandemic impact on admission.

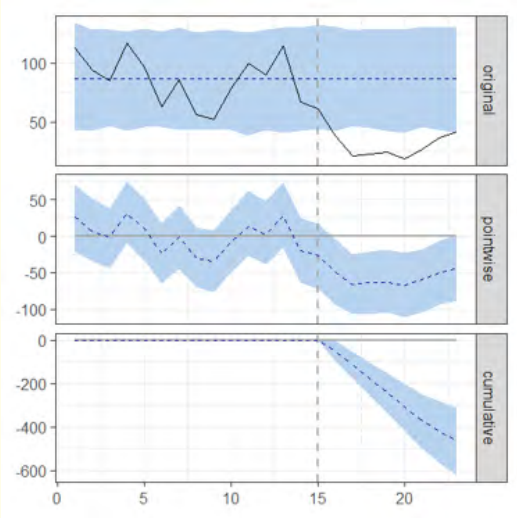

Figure 5: Illustrated Causal impact model (Intervention). The first part shows the data monthly admission and a prediction of admission for the intervention period. The second panel shows the difference between observed monthly admission and factual monthly admission predictions in the influence of covid-19 pandemic, a pointwise causal effect, as estimated by a structural Bayesian time -series model. The lowest part adds up the pointwise contributions from the second panel, resulting in a plot of the cumulative negative effect of covid-19 measures influence on admission.

Discussion

Our finding strongly supports the hypothesis that covid-19 pandemic measures have significant effect on reduction of number of respiratory illness in pediatrics age population, hence the monthly total admissions which start from the month of Oct to Feb/March each year. The beauty of this model is that it can generates a forecasting regarding future, what is going to happen based on prior knowledge, meaning pre period data create a predicted, what supposed to happen. Our model forecasted based on data, we have the probability of monthly average admission 87(9.4), CI (68-106), cumulative admission during this time from 1st March 2020 to 30th Oct, 2020 total 693(75.4). As a result of covid-19 measures, admission restricted to 29 per months with cumulative total admission reduced to 231. Statistically it can be explained based on Google

Causal Impact, a structural Bayesian time -series model., difference between counterfactual and factual probability as absolute effect –58, CI [-78, -39], P values 0.001. During the control period Dec 2016 to Oct 2018 and experimental period Dec 2018 to Oct 2020, constitutes same calendar time series period. Our first model (Table 1, Figure 4) explores how the algorithm appropriately forecasted, the observed and precited average admission, and it was not statistically significant in the absence of any intervention during the control period. On the other hand, during the experimental period secondary to COVID- 19 pandemic measure, observed admission significantly reduced than predicted which implied in the absence of covid-19 pandemic measures what we suppose to observed (Table 2, Figure 5). Hospital admissions during COVID-19 restrictions, 77% decrease compared with the previous same calendar month. Our data revealed 80% of admission during this time are related to respiratory illness under the age of one years. Common pathogens like RSV, Rhino/Entero, Parainfluenza, Influenzas, Adenovirus. Similar finding reported from in patient admission data. Quarantine, social distancing, and isolation of infected populations did not control the epidemic fully, but it has significant beneficial effect on controlling other common respiratory illness [5]. The Royal Children's Hospital Melbourne during April 1–May 31, 2019 and 2020, admissions compared with the same period in 2019 from 2005 patients to 1264. There was a proportional decrease in infection- related admissions from 41% (818) to 30% (375) [relative risk (RR): 0.73, 95% confidence interval (CI): 0.66–0.80, P < 0.001] [3]. Even Emergency Department (ED) attendances have fallen markedly by the COVID-19 pandemic measures [3]. Five hundred GP from Royal College of General Practitioners, England reported significantly common cold, flu, and bronchiolitis, other respiratory viral illness reduced as a result of social distancing measures over the last several months and an increased public emphasis on maintaining good hygiene have probably played their part, in addition, they expected to see a drop in influenza-like illness during the forthcoming warmer months [6]. The measures taken to fight against the covid-19 pandemic from temporary lockdowns to mask wearing, social distancing, enhanced personal hand hygiene, and restricted travel had a huge effect on the other common respiratory illnesses too., even as global COVID-19 cases continued to climb. Positive Flu test decrease by 98% in United states. Infections didn't rise even lockdown eased, but they raised rapidly after schools started again in September. Although the under- lying cause of this behavior aren't apparently clear, Probably the movement restriction, in addition to increased flu vaccination rate might contribute [7]. More ever, it was observed a 71% to 78% decrease asthma related admissions in children hospital, compared with the same time periods in the last 3 years. Because of 51% to 68% case of asthma exacerbation due to acute respiratory tract infections [8], even in the specialist Paediatric respiratory clinic visit decrease markedly [9]. The Rhinovirus have seasonal picks in spring and autumn and are transmitted same manner as SARS-CoV-2. Children are the main drivers of transmission of rhinovirus, with subsequent transmission to adults causing exacerbation of adult air way disease and hospitalization. 3898 adult patients were tested by PCR multiplex for Respiratory panel between March 23 and Sept 20, 2020, infection rate significantly lower compare same calendar months for 2019. Approximately, 2 weeks after the concurrent re-opening of state primary and secondary schools in early September, there was a sharp raised of positive PCR multiplex for adult as previous year [10]. Study reported that the need for antiviral drugs [11] in many resources limited countries markedly reduced as a consequence of measures taken for combating the covid-19.

Google causal impact algorithm developed for assessing the marketing events, particularly after promotion of Google advertisement to measure the impact on sales, clicks or whatever other metric of interest [12]. It was not possible to create matching groups by using advanced statistical method such as propensity score matching or inverse probability score because of absence of untreated group. Therefore, we used BSTS model to create a synthetic control batch, variable number of monthly admissions pre period data. Bayesian setting allows incorporation of empirical priors on the parameters and takes model uncertainty into account when forecasting the counterfactual, which is not feasible by traditional regression or ARIMA model [4]. The model based on Bayesian Structural Time-Series algorithms is an excellent tool for causal inference in various field of research such as economics, epidemiology, biology or the political, and social sciences. This model successfully used in healthcare care research, to measure the causal impact of cigarette sale on partial and total bans on public smoking [13]. Another research article same model utilizes to forecast expected trends in annual alcohol-related hospital admission as well as alcohol related harms on population level [14]. Jason Liu and other colleagues, 2020 published an article, they utilize a customized

biomedical adaptor tool based on Google Causal Impact, the Bayesian structural time series framework to evaluate an exercise intervention's impact on normalizing blood glucose in a diabetic dataset. They showed the robustness of the Bayesian structural time series framework when applied to biomedical sensor data, highlighting its increasing value for current and future datasets [15]. Christoph F. Kurz1in Germany used claims data from health insurance provider, measured the causal impact of bariatric surgical procedures on healthcare expenditures for fives year time series period [16]. Therefore, BSTS is an excellent tool for causal inference in time series data.

Conclusion

Covid-19 pandemic measures has significant impact on reduction of respiratory illness, in addition to combat rapid spread of covid-19 infection. Indeed, children respiratory illness related admission during flu season can be reduced, if we maintain good hand hygiene particularly in school and day care unit, avoid unnecessary exposure of children to overcrowded area, instruct the parents to keep their children at home if they get flu. Structural time series models are being used in an increasing number of applications at Google, and we anticipate that the algorithm will prove equally useful in many analysis efforts elsewhere particularly health care

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Conflict of interest

I do not have any Conflict of interest

Ethical Approval

This study did not used any human subjects, but because of Data was used for research purpose, institutional approval was taken.

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