

# Increased large vessel occlusive strokes following the Christchurch 2019 March 15 terror attack

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## INTRODUCTION

Sudden catastrophic events such as terror attacks have clear and immediate consequences for the people directly affected. However less is known about the impact on the physical health of local community members (Online supplemental material for further discussion). Acute psychological stress may cause a parallel physiological response increasing risk of cardiovascular events [1-3]. On March 15th 2019 a gunman shot and killed 51 people praying at the Al Noor and Linwood mosques in Christchurch city, New Zealand. We observed a rise in ischaemic stroke reperfusion treatments in the week starting Monday 18th March, three days after the terror attack. We hypothesised this observation could have occurred because of either an effect of the attack on total number of ischaemic strokes and/or the severity of these strokes, or coincidence. We investigated these possibilities by analysing the association between the terror attack and rate of stroke reperfusion treatment, proven intracranial large vessel occlusion (LVO) and total stroke admissions at Christchurch hospital as well as the national stroke dataset.

## METHODS

Detailed methodology is available in the supplemental material. Briefly, we used a Bayesian Poisson model to estimate the effect of the terror attack on ischaemic stroke admissions, occurrence of intracranial LVO and reperfusion therapy, in the week after the attack compared with weekly data from 1st January 2018 until 21st April 2019. These analyses were repeated for the rest of New Zealand excluding Christchurch data. The probability of the rate observed in the week following the terror attack being higher than the background rate was calculated for each measure, with a probability higher than 99.5% providing strong evidence of an effect. To ensure any observed effects were not simply related to the default weekly grouping window (Monday to Sunday), we calculated daily left-aligned (i.e. events in the week following the index day, inclusive) rolling weekly totals for proven Christchurch LVOs across this same time period, analysed using the same methods.

## RESULTS

In the week starting Monday following the terror attack there was no evidence of a difference in the total ischaemic stroke admissions at Christchurch hospital (Figure 1a,  $P=39\%$ ) or elsewhere in New Zealand (Figure 1c,  $P=80\%$ ). Rather, this effect was driven by an increase in intracranial LVOs at Christchurch Hospital (supplementary figure,  $P>99.9\%$ ). There was strong evidence of an increase in Christchurch reperfusion therapy (Figure 1b,  $P$  (probability higher than background rate)=99.9%) without strong evidence of an increase elsewhere in New Zealand (Figure 1b,  $P=96\%$ ). There was

There was also strong evidence ( $P>99.5\%$ ) of an increase in rolling weekly left-aligned LVO totals in Christchurch for four days in the period following the terror attack (Figure 1c). No other time periods reached

this level of evidence for an increase. There was no difference in the age, gender or rates of atrial fibrillation in ischaemic stroke patients in the week after the terror attack (supplemental material).

## DISCUSSION

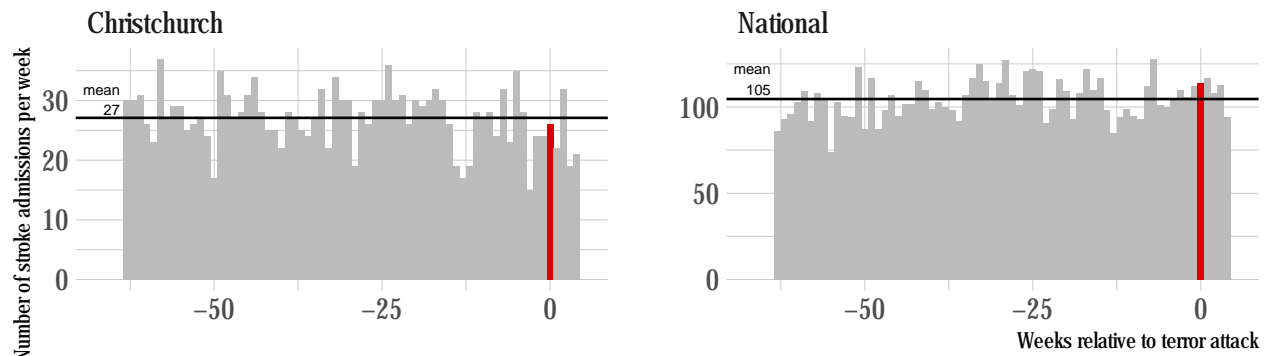
The March 15th Christchurch terror attack was associated with a marked increase in the number of local stroke reperfusion treatments which is very unlikely to be due to chance. This increase was driven by a significantly higher rate of patients presenting with LVO compared to stable baseline data – an objective marker of significant acute ischaemic stroke. This occurred despite no increase in the total number of ischaemic strokes presenting to Christchurch hospital in the same period, suggesting the effect of the terror attack was specific to mechanisms underpinning severe stroke syndromes associated with LVO. Although there was no strong effect on national ischaemic stroke admissions, there was a weak signal for increased national reperfusion treatments, suggesting that although the terror attack effect was mostly seen locally, a smaller more widespread impact remains possible.

What physiological explanation could underpin the observed rise in LVO? Although LVO is more common with increasing age[4] and atrial fibrillation[5], we did not observe a difference in these variables in the affected week compared to baseline. It is plausible transient arrhythmias were undetected during hospitalisation as extreme psychological stress could result in cardiac arrhythmias as observed in the aftermath of the September 11 attack on the World Trade Center[6, 7]. Extreme psychological stress may promote thrombosis through sympathetic nervous system activation, haemoconcentration, platelet activation and increased fibrin production [1, 2]. Although unproven, it is plausible the combination of psychophysiological factors and pro-arrhythmogenicity associated with acute stress likely triggered ischaemic stroke due to LVO in patients admitted in the week after the terror attack. Such a mechanism may also account for the apparent lag, by a few days, in the increase in LVO presentations.

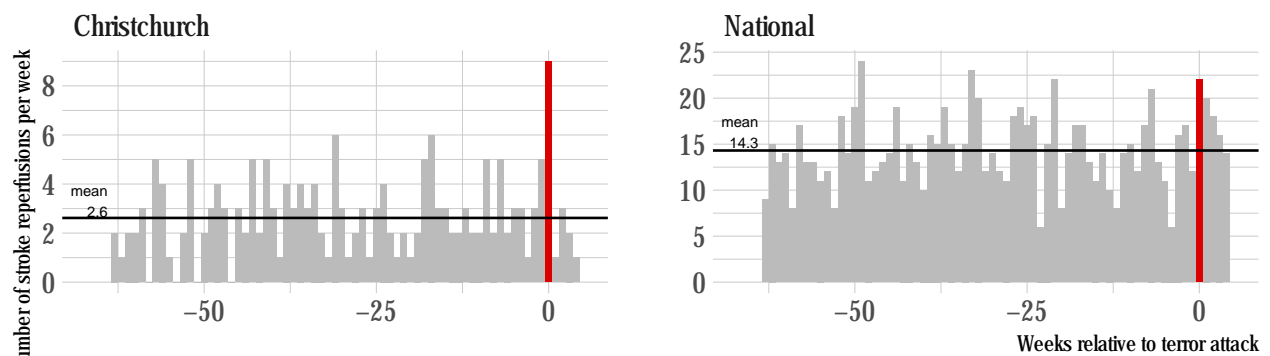
Study limitations include the absence of data for LVO rates outside of Christchurch Hospital, and the absence of markers of physiological or psychological stress, meaning we can only postulate regarding mediators of the observed LVO and terror attack association.

We demonstrate that sudden catastrophic events such as terror attacks may increase the numbers of patients developing intracranial LVO requiring stroke reperfusion therapies within the affected community.

## A Stroke admissions



## B Stroke reperfusion



## C Large vessel occlusion – Christchurch rolling weekly total

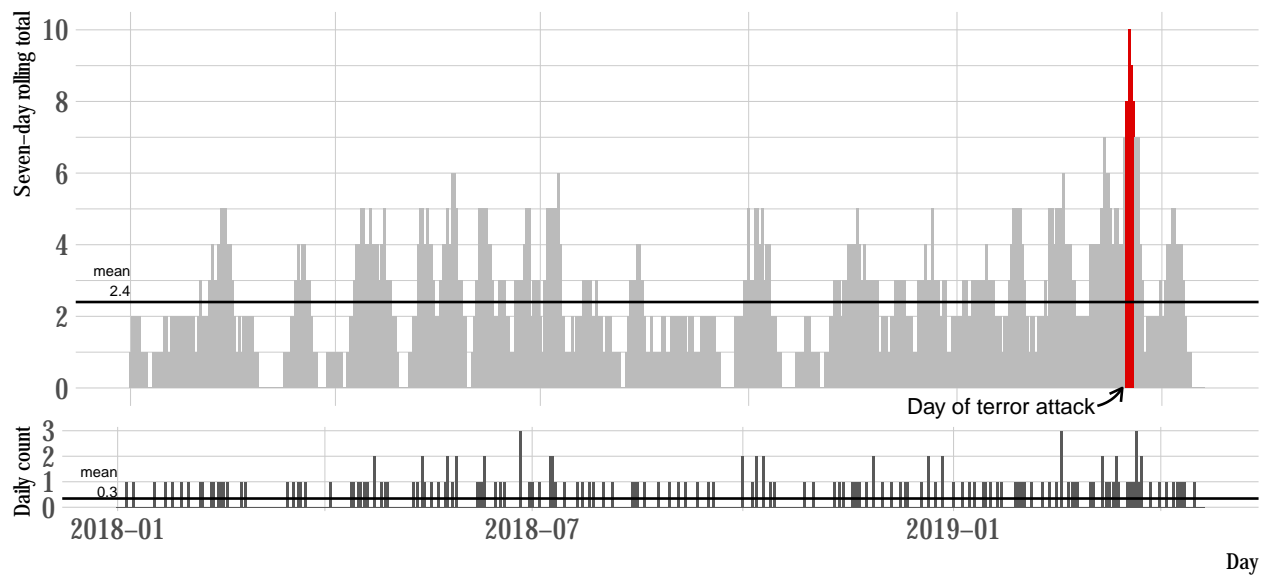


Figure 1: Figure 1

## Figure 1 Caption

A) Number of ischaemic strokes per week (Monday-Sunday) at Christchurch Hospital (left panel) and elsewhere in New Zealand (right panel) with the week following the terror attack highlighted at week 0. The average number of strokes per week is shown by the black horizontal line. There was no evidence for increase in total ischaemic stroke admissions the week after terror attack in Christchurch Hospital ( $n=26$ , mean rate = 27,  $P = 39\%$ ) or elsewhere in New Zealand ( $n=118$ , mean rate = 105,  $P = 80\%$ ). B) Total weekly (Monday-Sunday) number of stroke reperfusion treatment at Christchurch Hospital (left panel) and elsewhere in New Zealand (right panel) with the week following the terror attack highlighted at week 0. There was strong evidence for increase in reperfusion treatment in Christchurch (week after terror attack = 11, mean rate = 2.6,  $P = 99.9\%$ ) without strong evidence for an increase elsewhere in New Zealand (week after = 22, mean rate = 14,  $P = 96\%$ ). C) Rolling left-aligned weekly total large vessel occlusions in Christchurch by day. Counts where there was strong evidence of an increase in the total LVOs were shaded red. Figure by Myall (2020), distributed at <https://doi.org/10.6084/xx> under an open CC-BY 4.0 license..

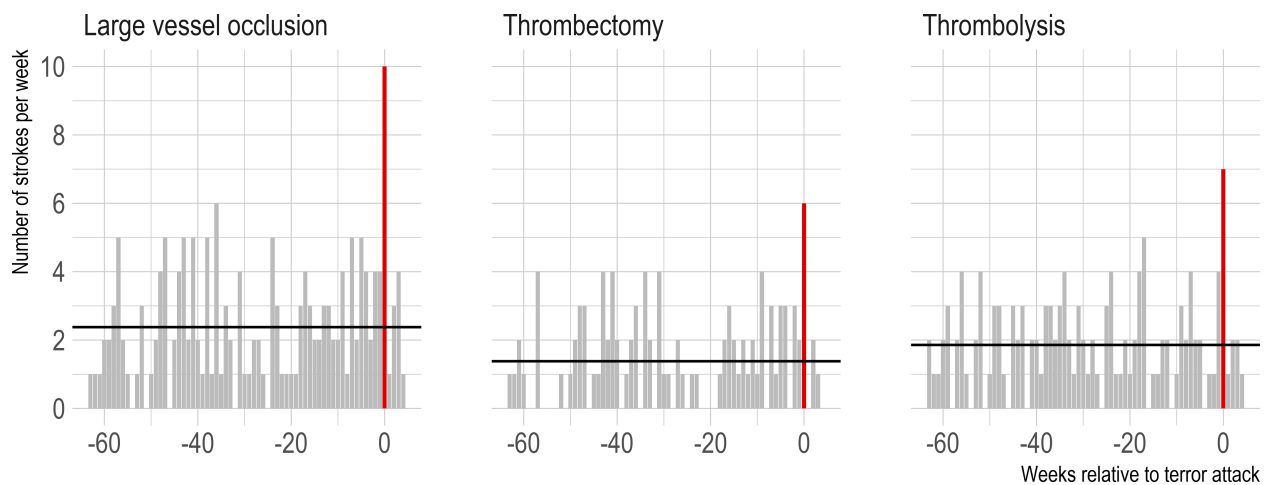


Figure 2: Figure 2

## Supplementary Figure Caption

Number of strokes per week by type at Christchurch Hospital, with the week starting on Monday following the terror attack highlighted at week 0. The average number of strokes per week is shown by the black horizontal line.

// Following plots are redundant

## References