Reduced Mortality During Holidays and the COVID-19 Pandemic in Israel

Roni Rasnic1*, Danielle Klinger2*, Dan Ofer2, Yoav Comay3, Michal Linial2& and Eitan Bachmat4&

1The Rachel and Selim Benin School of Computer Science and Engineering, The Hebrew University of Jerusalem, Israel
2Department of Biological Chemistry, Institute of Life Sciences, The Hebrew University of Jerusalem, Jerusalem, Israel
3Faculty of Health Science, School of Medicine, Ben Gurion University, Beer-Sheva, Israel
4Department of Computer Science, Ben-Gurion University, Beer-Sheva, Israel.

*Equal contribution: Roni Rasnic and Danielle Klinger

&Corresponding authors: michall@cc.huji.ac.il (ML); ebachmat@cs.bgu.ac.il (EB)

Abstract
Evidence suggests varied trends in mortality surrounding the holiday period. Most studies support an association between increased mortality rates and holidays. We compare the effect of the number of holiday days per week on the overall mortality rate in the Israeli population. Between the years 2000-2020, we see a significantly reduced mortality rate in weeks containing national holidays. We observed the same trend in all-cause mortality during the 3-weeks COVID-19 pandemic lockdown. As the Israeli health care system, and specifically the hospitals function at a very high capacity year-round, we propose that a reduced medical service utilization during the holidays and the COVID-19 lockdown period may contribute to lower mortality rates.

Introduction
Evidence suggests varied trends in mortality surrounding the holiday period. Most studies support an association between increased mortality rates and holidays. The Israeli holidays offer a unique perspective on this reported phenomenon. Based on a lunar cycle, they enable accounting for a year-to-year variability, while aligning the dates to the Gregorian civil calendar. We compare the effect of the number of holiday days per week on the overall mortality rate in the Israeli population over the past 20 years. We also focused on the pronounced changes in all-cause mortality during the 3-weeks COVID-19 mandatory lockdown. We propose that a reduced medical service utilization during national holidays and the COVID-19 lockdown period may contribute to lower mortality rates.

Methods
The data consists of a weekly count of all-cause mortality in the population of Israel between 01/2000 and 05/2020, acquired from weekly epidemiological reports of the Israeli ministry of health. This includes the 2020 COVID-19 pandemic months, and the mandatory national

NOTE: This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice.
lockdown (weeks 12-14). The data was aligned with the Gregorian calendar (aligned 1-53 weeks). Weekly deaths were normalized by the population size. Israeli holiday dates were inserted and the total number of consecutive holiday days were summed per week, varying between 0 - 2.5 (holiday half-days were calculated as 0.5). The mean weekly mortality rate in weeks with holidays and during COVID-19 lockdown weeks, were examined in comparison with holiday-free weeks, in a two-sided t-test. Israeli’s holiday days varied between 8.5-14 per year, spanning over 9-10 weeks a year. We measured the effect of the number of vacation days on weekly mortality in a univariate linear regression model. We conducted a multivariable linear regression using the year and week number as covariates. Analyses were performed using R.

Results
Between the years 2000-2020, we see a significantly reduced mortality rate in weeks containing national holidays. The mean mortality rate was significantly lower in weeks with holidays, in comparison with holiday-free weeks with a p-value of 1.5e-13 (Fig 1A). The weekly mortality rate also showed a significant association with the number of holiday days in a given week, p=2.2e-16 (Fig 1B). The mean weekly mortality rate was significantly lower in weeks with COVID-19 lockdowns than the same weeks holiday-free, p=2.9e-9 (Fig 1C). Applying linear regression showed that ‘holiday weeks’ is the coefficient with the strongest effect (beta coefficient) and second most significant p-value, second to the year coefficient (Estimate = -8.43; p = 3.74E-18, Fig 2).

**Fig 1.** Statistical analysis of mortality rate in COVID-19 pandemic, holiday-free, and holiday weeks. (A) Mean weekly all-cause mortality rate in holiday-free (blue) and holiday (yellow) weeks. (B) Correlation of the number of additional holiday days per week with the weekly mortality rate. The shaded area represents the 95% confidence interval. (C) Mean weekly all-cause mortality rate in holiday-free (blue) and COVID-19 lockdown (yellow) weeks (weeks 12-14 scaled to the Gregorian calendar).
Discussion
Our findings suggest a significant difference in overall mortality in the Israeli population between weeks with and without holidays across the entire year. Notably, we observed the same phenomenon during the COVID-19 lockdown where all hospitals in Israel switched to a ‘holiday routine’ mode. During the holidays and the COVID-19 lockdown, both elective and emergency medical procedures were reduced dramatically. Importantly, holidays in Israel are associated with cross-generation social gatherings, such gatherings were strongly suppressed during the COVID-19 pandemic lockdown. The inverse trend in personal interactions allows us to examine competing hypotheses regarding the changes in mortality rates. A likely shared explanation is the reduction in medical service utilization. The Israeli health care system and specifically the hospitals function at a very high capacity year-round. In Israel, some 4,000-6,000 annual deaths are attributed to nosocomial infections, which are mainly associated with patients and staff crowding and the use of invasive devices. This study provides observational evidence covering >20 years in Israel. It provides evidence for the need for diffused and sparse medical services and the benefit of strengthening community and home medical services.

Fig 2. Multivariable linear regression analysis. Beta coefficients of the normalized lasso regression for the weekly mortality rate are shown. Blue lines represent the coefficients’ 95% confidence intervals. Note that the coefficients for ‘year’ and ‘holidays’ had the most significant estimates (p-value = 5.808e-39; p-value = 3.742e-18, respectively).
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