



OPEN ACCESS



Check for updates

Effect of a doctor working during the festive period on population health: natural experiment using 60 years of *Doctor Who* episodes (the TARDIS study)

Richard D Riley

Institute of Applied Health Research, College of Medical and Dental Sciences, University of Birmingham, Birmingham, UK

Correspondence to:

r.d.riley@bham.ac.uk
(or @Richard_D_Riley on Twitter;
ORCID 0000-0001-8699-0735)

Additional material is published online only. To view please visit the journal online.

Cite this as: *BMJ* 2023;383:e077143

<http://dx.doi.org/10.1136/bmj-2023-077143>

Accepted: 22 September 2023

ABSTRACT

OBJECTIVE

To examine the effect of a (fictional) doctor working during the festive period on population health.

DESIGN

Natural experiment.

SETTING

England, Wales, and the UK.

MAIN OUTCOME MEASURES

Age standardised annual mortality rates in England, Wales, and the UK from 1963, when the BBC first broadcast *Doctor Who*, a fictional programme with a character called the Doctor who fights villains and intervenes to save others while travelling through space and time. Mortality rates were modelled in a time series analysis accounting for non-linear trends over time, and associations were estimated in relation to a new *Doctor Who* episode broadcast during the previous festive period, 24 December to 1 January. An interrupted time series analysis modelled the shift in mortality rates from 2005, when festive episodes of *Doctor Who* could be classed as a yearly Christmas intervention.

RESULTS

31 festive periods from 1963 have featured a new *Doctor Who* episode, including 14 broadcast on Christmas Day. In time series analyses, an association was found between broadcasts during the festive period and subsequent lower annual mortality rates.

In particular, episodes shown on Christmas Day were associated with 0.60 fewer deaths per 1000 person years (95% confidence interval 0.21 to 0.99; $P=0.003$) in England and Wales and 0.40 fewer deaths per 1000 person years (0.08 to 0.73; $P=0.02$) in the UK. The interrupted time series analysis showed a strong shift (reduction) in mortality rates from 2005 onwards in association with the *Doctor Who* Christmas intervention, with a mean 0.73 fewer deaths per 1000 person years (0.21 to 1.26; $P=0.01$) in England and Wales and a mean 0.62 fewer deaths per 1000 person years (0.16 to 1.09; $P=0.01$) in the UK.

CONCLUSIONS

A new *Doctor Who* episode shown every festive period, especially on Christmas Day, was associated with reduced mortality rates in England, Wales, and the UK, suggesting that a doctor working over the festive period could lower mortality rates. This finding reinforces why healthcare provision should not be taken for granted and may prompt the BBC and Disney+ to televise new episodes of *Doctor Who* every festive period, ideally on Christmas Day.

Introduction

On 23 November 1963, the day after President John F Kennedy was assassinated, the BBC televised the first episode of the science fiction programme *Doctor Who*. The show became a cultural phenomenon, and today millions of viewers still follow it worldwide.¹ The series follows a Time Lord called the Doctor, who travels through space and time fighting villains and intervening to save others and make people better. Viewers “hide behind the sofa” when the Doctor and various companions encounter monsters such as the Daleks, Cybermen, and even killer Santa robots.

The global impact of the programme has been immense—*Doctor Who* holds the Guinness World Record for the most episodes of a science fiction programme, and at the time of writing, 871 episodes encompassing 300 stories have been televised. In 2013, the anniversary episode “The Day of the Doctor” that celebrated 50 years of the programme was watched by 12.8 million people in the UK, topped the iTunes US and Amazon charts, and was simultaneously broadcast in 94 countries—earning it a Guinness World Record as “the world’s largest ever simulcast of a TV drama” in 2013.² The programme celebrated its 60th anniversary in 2023, with its continued success evident by multiple special episodes being broadcast by the BBC and Disney+, with the latter the programme’s new home outside of the UK and Ireland.

The Doctor’s characteristics, views, and conduct are closely aligned with what are expected of healthcare

WHAT IS ALREADY KNOWN ON THIS TOPIC

Healthcare is available between Christmas and the New Year in the UK, which means many doctors work over the festive period

The impact of doctors working over the festive period is unclear

Over the past 60 years, new episodes of the BBC television series *Doctor Who* are sometimes shown over the festive period, following a character called the Doctor, who travels through space and time fighting villains and intervening to save lives

WHAT THIS STUDY ADDS

Episodes of *Doctor Who* broadcast over Christmas acted as a potential proxy for a single doctor working during the festive period

An association was found between the (fictional) doctor working over the festive period and lower mortality rates in the subsequent year in England, Wales, and the UK

In particular, the (fictional) doctor working on Christmas Day was strongly associated with subsequent lower mortality rates

This reinforces why healthcare provision should not be taken for granted, and may prompt the BBC and Disney+ to broadcast new episodes of *Doctor Who* on Christmas Day

professionals. Here is a selection of quotes from the Doctor as examples:

In 900 years of time and space, I've never met anyone who wasn't important before

"A Christmas Carol," 2010

Never be cruel, never be cowardly . . . Remember—hate is always foolish, and love is always wise. Always try to be nice, but never fail to be kind

"Twice Upon a Time," 2017

There's one thing I'm certain of—when people need help, I never refuse

"The Woman Who Fell to Earth," 2018

The show even suggests that the Doctor's influence throughout history led to organisations such as the British Medical Association adopting the word doctor, as noted by the character Professor River Song:

Doctor: the word for healer and wise man throughout the universe. We get that word from you, you know

"A Good Man Goes to War," 2011

Many of the Doctor's most memorable adventures are broadcast over the festive period, and sometimes their heroic actions to save others results in regeneration, whereby severe injuries cause the Doctor's body to renew and change (hence why multiple actors have played the Doctor). This dedication mirrors that of medical doctors and healthcare professionals, many of whom work over the festive period and miss out on celebrations with family and friends. Such healthcare provision should never be taken for granted. If hospitals were closed from 24 December to 1 January, this could have a detrimental effect on subsequent mortality rates.

Because *Doctor Who* has been broadcast for 60 years, it provides a natural experiment to investigate

the impact that one doctor could have when working over the festive period. The Doctor shares many of the attributes of medical doctors, so a new *Doctor Who* episode broadcast over Christmas in the UK could potentially serve as a proxy for a single doctor working during the festive period. This was the premise of the study called TARDIS (Televised festive broadcasts and Association with Rates of Death In Sixty years of *Doctor Who*)—the same acronym as the Doctor's space-time machine, which appears as a British police box from the 1960s (fig 1) that is bigger on the inside—similar to a medical doctor's Gladstone bag. The TARDIS study examined the association between *Doctor Who* episodes broadcast during the festive period—a potential proxy for a single doctor working during that period—and the subsequent year's mortality rates in England, Wales, and the UK.

Methods

Definitions and data sources

Annual mortality rates in the UK were obtained from vital statistics published by the Office for National Statistics up to 2021 (2022 rates had not been released at the time of the study). Annual mortality rates still include most deaths that occur during the previous festive season, as ONS figures are based on deaths registered, rather than occurring, in a calendar year. Most registry offices have reduced hours and capacity over the festive period, and so deaths in that period typically are registered in the New Year. Therefore, the impact of unavailable healthcare such as delayed diagnoses during a festive season likely will be carried over and become evident in the subsequent year.

The TARDIS study focused on mortality rates from 1963, the year *Doctor Who* was first broadcast, and used the original broadcast date for each episode.¹ Only new televised episodes were considered—as the Doctor said, "I hate repeats" ("The Big Bang," 2010). Televised spin-off series (eg, *K-9* and *Company*), books, comics, and audio stories were not included.

The festive period was defined as 24 December to 1 January. If an episode was broadcast on New Year's Day, it was classed as part of the festive period for the previous year. For example, the episode "Resolution" was broadcast on New Year's Day 2019 and therefore was classed within the festive period of 2018. The impact of multiple new *Doctor Who* episodes being televised in the same festive period was not examined, as this was rare (1965, 1966, and 2009 only).

Statistical analysis

The main outcome was age standardised mortality rate because, unlike crude rates, this allows a fairer comparison between populations with different age structures over time. The ONS standardises the data to the 2013 European standard population. Rates were analysed from 1964 (the year after *Doctor Who* was first broadcast) onwards, but to avoid confounding from the covid-19 pandemic, data after 2019 were not included. Analyses were first conducted using the age



Fig 1 | The TARDIS has even landed on a Christmas jumper

standardised mortality rates for England and Wales, and then repeated for the UK.

A time series analysis was conducted using a linear regression model, with annual rates as the outcome and accounting for general non-linear reduction over time using a series of cubic splines. As with statisticians,³ the Doctor endorses the modelling of non-linear trends:

A straight line may be the shortest distance between two points, but it is by no means the most interesting

“The Time Warrior,” 1973

For the analysis in England and Wales, knot locations (which join the cubic splines) were placed at 1964, 1981 (the year when the fourth Doctor regenerated), 1988 (*Doctor Who*'s 25th anniversary), 2005 (when *Doctor Who* returned for a first full series since 1989), and 2019. For the UK analysis, age standardised rates before 1981 were not routinely available from ONS (similar to the 97 episodes of *Doctor Who* that are currently missing from the television archives), and so knot locations of 1981, 1988, 2005, and 2019 were used. The regression also accounted for autocorrelation (ie, serial correlation) of yearly rates and residual variance heteroskedasticity using the Newey-West approach,⁴ and it was fitted using maximum likelihood estimation through the newey command in Stata version 17.⁵ The autocorrelation was considered for three lag years, based on a previous recommendation to select number of lags based on sample size (number of years) to the power of 0.25.⁶

To answer the research question, the regression also included a binary covariate for festive broadcast group (was *Doctor Who* broadcast during the previous festive period? 1 yes, 0 no), to estimate whether *Doctor Who* festive broadcasts are associated with a change in the subsequent annual mortality rate, after accounting for the general non-linear reduction in rates over time. This was then repeated to examine the binary covariate

of “was *Doctor Who* broadcast on Christmas Day in the previous year?”

Finally, the regression was adapted to an interrupted time series analysis assessing whether a systematic shift occurred in the trend of rates since 2005, when *Doctor Who* was broadcast during every festive period (mainly on Christmas Day) until 2019. For the purposes of the TARDIS study, such events could be classed as a Christmas intervention to help improve population health.

Patient and public involvement

At Wales Comic Con in December 2022, the TARDIS study was discussed with *Doctor Who* fans. Without even blinking, they agreed on the importance of the study and the urgency to disseminate the findings. Sylvester McCoy, who played the seventh Doctor, was also at the convention (fig 2). The moment had been prepared for by rewatching episodes in which he featured, and his character clearly understood the implications of clinical decision making when he said:

Every great decision creates ripples, like a huge boulder dropped in a lake. The ripples merge, rebound off the banks in unforeseeable ways. The heavier the decision, the larger the waves, the more uncertain the consequences

“Remembrance of the Daleks,” 1988

A Dalek involvement and engagement (DIE) group was formed, but as the members exhibited severe megalomania their involvement was exterminated.

Results

Trend in mortality rates to 2019

Figure 3 shows the trend in annual age standardised mortality rates (annual number of deaths per 1000 person years) in England and Wales during 1964-2019 (see supplementary figure S1 for numbers in the UK, 1981-2019). Rates gradually reduced over time, from about 19 deaths per 1000 person years in 1964 to about 10 deaths per 1000 person years in 2019.

Festive *Doctor Who* episodes from 1963

Between 1963 and 2022 a new *Doctor Who* episode was broadcast during 31 festive periods, including 14 episodes shown on Christmas Day. The first festive broadcast, “The Daleks: The Survivors,” was broadcast on 28 December 1963, and the earliest Christmas Day episode, “The Daleks’ Master Plan: The Feast of Steven,” was broadcast in 1965. Thirteen of the 14 Christmas Day episodes were consecutive from 2005 to 2017.

Association of mortality rates with *Doctor Who* festive broadcasts

The regression analyses used data up to 2019 and adjusted for the non-linear trend in rates over time. Some evidence suggested an association between *Doctor Who* episodes broadcast during the festive period and a subsequently lower annual age standardised mortality rate. When *Doctor Who* was shown any time during the previous festive period,



Fig 2 | Lead researcher (top left) and family members with actor Sylvester McCoy (holding umbrella) who played the seventh Doctor in *Doctor Who*, and actor Sophie Aldred (with baton) who played the Doctor's companion, Ace

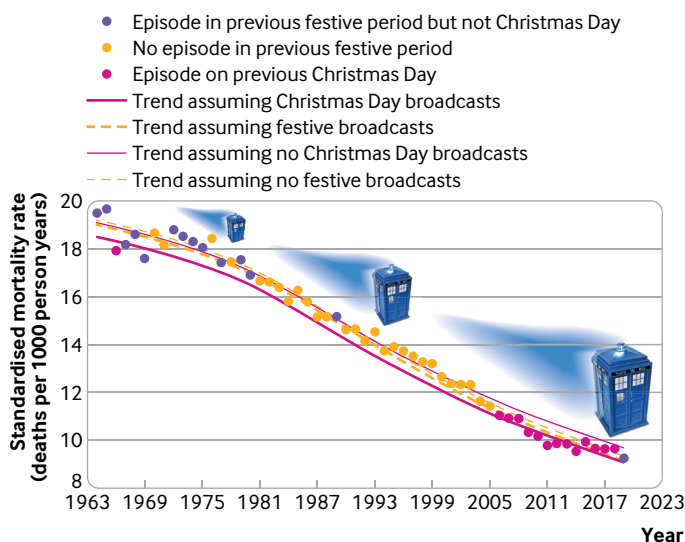


Fig 3 | Trend in annual age standardised mortality rates in England and Wales between 1964 and 2019 in relation to festive episodes of *Doctor Who* broadcast over the previous festive period (24 December to 1 January)

there were 0.20 fewer deaths per 1000 person years (95% confidence interval -0.066 to 0.46 , $P=0.14$) in England and Wales and 0.36 fewer deaths per 1000 person years (-0.018 to 0.75 ; $P=0.06$) in the UK.

The finding appeared to be driven by *Doctor Who* episodes broadcast on Christmas Day, which showed strong evidence of an association with subsequent reduced mortality rates. When *Doctor Who* was broadcast on Christmas Day during the previous festive period, there were 0.60 fewer deaths per 1000 person years (0.21 to 0.99 ; $P=0.003$) in England and Wales and 0.40 fewer deaths per 1000 persons years (0.08 to 0.73 ; $P=0.02$) in the UK.

Figure 3 shows the estimated trends from these regression models for four scenarios. These scenarios assume that *Doctor Who* is always shown on Christmas Day, always shown at some time during the festive

period, never shown on Christmas Day, or never shown during the festive period.

Interrupted time series analysis

The interrupted time series analysis showed strong evidence of a downward shift (reduction) in mortality rates from 2005, when *Doctor Who* returned with a run of festive broadcasts, mainly on Christmas Day. The shift associated with this Christmas intervention corresponded to a mean reduction of 0.73 deaths per 1000 person years (0.21 to 1.26 ; $P=0.01$) in England and Wales (fig 4) and a mean reduction of 0.62 deaths per 1000 person years (0.16 to 1.09 ; $P=0.01$) in the UK (supplementary figure S2).

Discussion

By analysing data collected from 1963, the TARDIS study suggests that a doctor (well, the Doctor—the original you might say) working over the festive period is associated with lower mortality rates in the subsequent year for England, Wales, and the UK. The strongest association was when *Doctor Who* was televised on Christmas Day, with an estimated reduction of about six deaths per 10 000 person years in England and Wales and four deaths per 10 000 person years in the UK. The reduction was even higher when *Doctor Who* was consistently shown over the festive periods from 2005 to 2019 (fig 4), mainly on Christmas Day. If this is the impact a single doctor can have when working during the festive period, imagine how fantastic the impact would be of the entire healthcare workforce in attendance. The lead researcher experienced the benefit of such healthcare around Christmas 2020 when his son was admitted to hospital with a burst appendix and sepsis - the fantastic surgery and care received saved his life, and thankfully he was discharged in time to watch that year's festive episode of *Doctor Who*.

Strengths and limitations of this study

Adversaries of the Doctor might consider that the study's findings do not show causality, with rates over time merely in flux and any associations due to chance. They may point to festive episodes of *Doctor Who* being broadcast mainly during 2005–19, when the UK's mortality rate happened to be lower for other unrelated reasons. To account for population differences over time, however, the analysis examined age standardised mortality rates and used a flexible spline function to adjust for a non-linear trend of reduced rates over time. A plausible causal explanation for the findings is that viewers of *Doctor Who* over the festive period are vicariously watching (consulting with) a doctor who is caring for people, which could then encourage health seeking behaviour. This Christmas intervention was supported by the findings of the interrupted time series analyses (fig 4), with a statistically significant shift towards lower mortality rates from 2005 when *Doctor Who* was regularly broadcast each festive period, mainly on Christmas Day. The DIE group

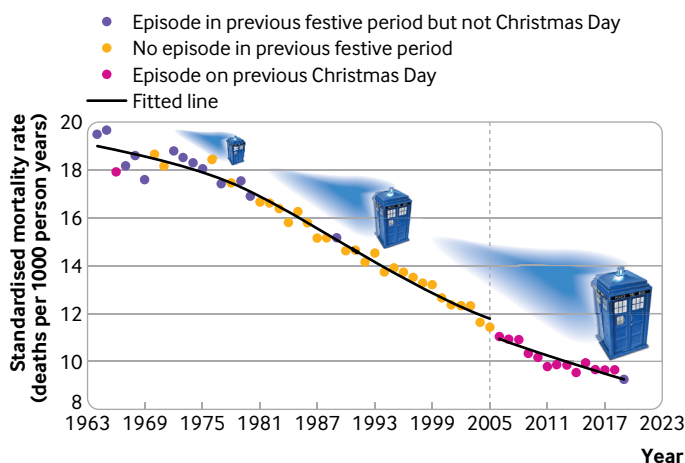


Fig 4 | Interrupted time series analysis of mortality rates between 1964 and 2019 to examine the impact of *Doctor Who* returning with consecutive festive broadcasts from 2005 (dashed line) in England and Wales

(before they were exterminated) also queried that the TARDIS findings relate to one unique doctor and so do not generalise to all medical doctors in the human race (who are more restricted by dimensions in time⁷). As with the Doctor in the TARDIS, however, medical doctors go the extra mile to intervene for good, have the upmost respect for human life, and act to “never give up, never give in”⁸; the observed associations are affirmative with these traits. Further research is, however, needed to establish causality. As the 10th Doctor acknowledged, causality is difficult to grasp:

People assume that time is a strict progression of cause to effect, but actually, from a non-linear, non-subjective viewpoint, it's more like a big ball of wibbly-wobbly, timey-wimey . . . stuff

“Blink,” 2007

Policy implications

Decision makers at the BBC and Disney+ should reach enlightenment from the study’s findings owing to a possible health benefit of watching *Doctor Who*. As the BBC is principally funded by a licence fee paid by British households, it seems a reciprocal arrangement to potentially reduce the nation’s death rate by broadcasting new episodes of *Doctor Who* each festive period. Perhaps this could become part of the BBC Charter? Also, assuming the TARDIS findings generalise beyond the UK, Disney+ (the international broadcaster of new episodes) has the opportunity to reduce mortality rates worldwide if it streams new *Doctor Who* episodes during the festive period. Even the Doctor’s arch enemy, the Master, would agree:

This country has been sick, this country needs healing, this country needs medicine—in fact I’d go so far as to say that what this country really needs right now is a Doctor

“The Sound of Drums,” 2007

While the television schedule for the upcoming festive season is unknown at the point of writing, the BBC has confirmed that the first episode featuring the 15th Doctor will air during Christmas 2023. Like a humble curator, showrunner Russell T Davies also told *Doctor Who Magazine* that he is writing a Christmas special for 2024. This is excellent news, as those festive episodes may help lower mortality rates in 2024 and 2025. If the BBC and Disney+ are aware of the TARDIS findings, they might even consider choosing a Christmas Day broadcast slot for these episodes.

Comparison with other studies

Only mortality outcomes were considered in the TARDIS study. A follow-up study called ADRIC (ADverse Reactions In Children) is planned to examine the impact of excessively watching *Doctor Who*—although funding requests have been knocked back four times. Some studies suggest prolonged television viewing is associated with higher risks of adverse outcomes, such as dementia⁹ and all cause and cardiovascular disease mortality.¹⁰ The impact of watching doctors

in other shows or films was also not considered,¹¹ and neither was viewing figures or audience’s appreciation. However, a previous survey found that for 398 of 575 responders (69.2%), *Doctor Who* contributed to their ideas about science and life choices.¹² For example, one participant noted that “*Doctor Who* shows people solving problems through cleverness, compassion, and cooperation, using non-violent means. This inspires me to do the same”; another participant noted that *Doctor Who* encouraged their evidence based problem solving.

Lives are saved by the Doctor’s companions too, and they are equally important to the show’s success (fig 2). Similarly, the contributions of other healthcare professionals to clinical practice must be emphasised. Improvements in mortality rates are not solely related to doctors or their working patterns (eg, day, night, or time of shifts). Nurses, dentists, midwives, pharmacists, and other allied health professionals also work over the festive period and yet they do not receive the same coverage on television or in film. For example, a study that examined the portrayal of nursing in reality television¹³ concluded that much effort is still required to accurately reflect the work and contribution of nurses on television.

Conclusion

Finally, for those readers who believe this study is a fake and belongs in a junkyard or question the author’s badge for mathematical excellence, it seems apt to conclude with two quotes from the Doctor:

I love humans. Always seeing patterns in things that aren’t there

“The TV Movie,” 1996

There’s no point in being grown up if you can’t be childish sometimes

“Robot,” 1975

Contributor: RDR conceived the study, undertook the analyses, and wrote the article—usually at the weekend after watching *Doctor Who*: The Collection boxsets. He is the guarantor. He attests that that no others meeting the author criteria have been omitted, and acknowledges helpful feedback from editors, reviewers, and close family on earlier versions of the article.

Funding: No specific funding.

Competing interests: The author has completed the ICMJE uniform disclosure form at <https://www.icmje.org/disclosure-of-interest/> and declares: he is a statistical editor for *The BMJ*, is an avid watcher of *Doctor Who*, and has a deep gratitude for medical doctors and the NHS. The author has no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; and no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: Not required.

Data sharing: UK death rates are available from <https://www.ons.gov.uk/> and broadcast dates for *Doctor Who* are available from <https://guide.doctorwhonews.net/>.

The lead author (RDR) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: The findings will be disseminated via social media throughout space and time.

Provenance and peer review: Not commissioned; externally peer reviewed.

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

- 1 Doctor Who Guide. <https://guide.doctorwhonews.net/>
- 2 Lynch K. Doctor Who—Day of the Doctor sets world record for biggest TV drama simulcast. 2013. https://www.guinnessworldrecords.com/news/2013/11/doctor-who-day-of-the-doctor-sets-world-record-for-biggest-tv-drama-simulcast-53133/?fb_comment_id=1436384939917699_1632761886946669
- 3 Riley RD, Cole TJ, Deeks J, et al. On the 12th day of Christmas, a statistician sent to me. *BMJ* 2022;379:e072883. doi:10.1136/bmj-2022-072883
- 4 Newey WK, West KDA. Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica* 1987;55:703-8. doi:10.2307/1913610.
- 5 StataCorp. Stata Statistical Software: Release 17. College Station, TX; 2021.
- 6 Greene WH. Econometric analysis. 7th ed. Boston: Prentice Hall; 2012. xxxix, 1188pp.
- 7 Senior T. On not being a Time Lord. *Br J Gen Pract* 2022;72:81. doi:10.3399/bjgp22X718481
- 8 Dicks T, Hulke M. The Making of Doctor Who. Target Books; 1976.
- 9 Takeuchi H, Kawashima R. Effects of television viewing on brain structures and risk of dementia in the elderly: Longitudinal analyses. *Front Neurosci* 2023;17:984919. doi:10.3389/fnins.2023.984919
- 10 Teramoto M, Yamagishi K, Shirai K, et al. Television Viewing Time and All-cause and Cardiovascular Disease Mortality Among Japanese Adults with and without a History of Stroke or Myocardial Infarction. *J Atheroscler Thromb* 2023; published online 23 May. doi:10.5551/jat.63959
- 11 Smith A. Doctors on film. *BMJ* 2022;379:o2720. doi:10.1136/bmj.o2720
- 12 Orthia LA. How does science fiction television shape fans' relationships to science? Results from a survey of 575 'Doctor Who' viewers. *J Clin Outcomes Manag* 2019;18:A08. doi:10.22323/2.18040208.
- 13 Hayward BA. Nurses are background actors in medical reality television: A character network analysis and call for authentic action. *J Adv Nurs* 2023;79:3035-46. doi:10.1111/jan.15583

Supplementary information: Figures S1 and S2