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Pandemic impacts on healthcare utilisation: a systematic review

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Title Pandemic impacts on healthcare utilisation: a systematic review

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Abstract

Objectives: To determine the extent and nature of changes in utilisation of healthcare services during COVID-19 pandemic.

Design: Systematic review

Eligibility: Eligible studies compared utilisation of services during COVID-19 pandemic to at least one comparable period in prior years. Services included visits, admissions, diagnostics, and therapeutics. Studies were excluded if from single-centres or studied only COVID-19 patients.

Data sources: PubMed, Embase, Cochrane COVID-19 Study Register, and pre-prints were searched, without language restrictions, until August 10, using detailed searches with key concepts including COVID-19, health services and impact.

Data analysis: Risk of bias was assessed by adapting ROBINS-I and Cochrane Effective Practice and Organization of Care tool. Results were analysed using descriptive statistics, graphical figures, and narrative synthesis.

Outcome measures: Primary outcome was change in service utilisation between pre-pandemic and pandemic periods. Secondary outcome was the change in proportions of users of healthcare services with milder or more severe illness (e.g. triage scores).

Results: 3097 unique references were identified, and 81 studies across 20 countries included, reporting on >11 million services pre-pandemic and 6.9 million during pandemic. For the primary outcome, there were 143 estimates of changes, with a median 37% reduction in services overall (interquartile range -51% to -20%), comprising median reductions for visits of 42%(-53% to -32%), admissions, 28%(-40% to -17%), diagnostics, 31%(-53% to -24%), and for therapeutics, 30%(-57% to -19%). Among 35 studies reporting secondary outcomes, there were 60 estimates, with 27(45%) reporting larger reductions in utilisation among people with a milder spectrum of illness, and 33 (55%) reporting no change.

Conclusions: Healthcare utilisation decreased by about a third during the pandemic, with considerable variation, and with greater reductions among people with less severe illness. While addressing unmet need remains a priority, studies of health impacts of reductions may help health-systems prioritise higher-value care in the post-pandemic recovery.

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Strengths and limitations of this study

- The review is the first broad synthesis of global studies of pandemic related changes in utilisation across all categories of healthcare services.
- The review provides novel findings informing design of future studies of pandemic-related changes in utilisation and its impacts.
- Limitations include the possibility of publication bias and the potential of our eligibility criteria to exclude important data sources such as studies in single-centres and unpublished datasets from health systems.
- Heterogenous designs and settings precluding meta-analysis.

Introduction

As the COVID-19 pandemic continues, many studies have reported major changes in utilisation of healthcare services because of such measures as lockdowns and stay-at-home orders. [1-3] These changes include large reductions in services, particularly in places hit hard by the pandemic, but also some selective increases, such as for telemedicine. [4] Many people have missed out on much needed care, such as vaccination or life-extending interventions for cancer. [2,5,6] A World Health Organization survey found disruption to healthcare services greatest among lower income countries, [7] and there are estimates that reduction of essential maternal and child health interventions may cause more than a million additional child deaths. [8] Concurrently the pandemic may also have resulted in some people being spared unnecessary or inappropriate care with has the potential to cause harm. [9,10] The problem of too much medicine is well documented, [11-17] and multiple global campaigns are addressing this challenge, such as Choosing Wisely, which is active in more than 20 countries. [18] As some nations are forced to do more with less in the post-pandemic period, learning from this "natural experiment" in reduced care may help health systems identify and address unnecessary care, and move towards greater sustainability. [9,10]

Investigating the impact of changes in healthcare utilisation on health outcomes and costs presents major methodological challenges. First, there are many reasons why people have missed care, including fear of becoming infected while visiting a care facility, inability to access care due to lockdown policies, and suspension and cancellation of services such as elective surgery. Second, disentangling populations who have missed necessary care from those who have avoided unnecessary care requires sensitive and nuanced analysis, with adjustment for multiple potentially confounding variables. For instance, simply showing no adverse outcomes in the short term from missing an episode of care does not prove it was unnecessary. Notwithstanding these challenges, quantifying and characterising the unprecedented recent changes in utilisation, and their impact on health outcomes and costs, may help health systems optimise post-pandemic use of resources.

To this end, we conducted what is, to our knowledge, the first systematic review of studies reporting on pandemic-related changes in overall healthcare utilisation. In undertaking this review, we also sought to inform and optimise the design of future investigations of both the on-going changes in utilisation, and the impacts of this natural experiment with less care on health outcomes and costs.

Methods

As per a detailed protocol registered on PROSPERO [19] and uploaded to the Open Science Framework [20] (Supplementary File 1) we found, appraised, and synthesised studies that compared healthcare utilisation during the COVID-19 pandemic with a corresponding pre-pandemic period. Our abstract and full review follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statements. [21,22] (Supplementary File 2)

Eligibility Criteria and Search Strategy

Inclusion and exclusion criteria

We included studies which compared utilisation of healthcare services over a period of time during the pandemic, as defined by their authors, (the intervention) with a corresponding period at least one year before the pandemic, (the comparator). Healthcare service utilisation included but was not limited to visits or presentations, admissions or hospitalisations, diagnostic services, and therapeutic or preventive interventions. Letters or pre-prints were included if providing enough data for extraction. We excluded surveys of practitioners, studies reporting only on utilisation by patients diagnosed with COVID-19, studies reporting utilisation data for less than one week, from a single centre only, or for non-medical allied health services, and modelling studies that predicted impacts on utilisation.

Outcome measures

The primary outcome was the change in utilisation of a healthcare service – such as a visit to a hospital or receipt of diagnostic imaging – between the pre-pandemic and pandemic periods, expressed as a change in absolute numbers and/or percentage change. The secondary outcome was change in the proportions of people using the service, across different levels of disease severity, as reported by authors of the primary study, using for example a triage score.

Data sources, searches, screening

We searched PubMed, Embase, the Cochrane COVID-19 Study Register, and pre-print servers via Europe PMC, from inception until 10th August, 2020, with search strings that included the following broad concepts: COVID-19, health services, admissions, and impact. (Supplementary File 3) No restrictions by language were

imposed. Following screening of articles for inclusion, we conducted a backwards (cited) and forwards (citing) citation analysis in Scopus/Web of Science on all included studies, and additional articles were screened for inclusion. We also consulted experts for other public reports.

Pairs of review authors (RM, SS, ZM, AS, JC, EK, ET, LA) independently screened the titles and abstracts against the inclusion criteria, and repeated the process following full-text retrieval. Any screening disagreements were resolved by discussion, or reference to a third author (RM or LA). A list of studies in single centres, excluded at screening stage, was recorded and is available on request from authors.

Data Collection and Analysis

Data extraction

Pairs of authors (RM, SS, ZM, AS, ET, LA) independently extracted data from included studies and resolved discrepancies, with referral, as necessary, to a third author (LA, RM). We developed, piloted, and used a data extraction form in Microsoft Excel for study characteristics and outcome data. We extracted data on study location, design, setting, (e.g. hospital) pandemic period and comparator, and primary and secondary outcomes.

Pairs of review authors (RM, SS, ZM, AS, LA, ET) independently assessed the risk of bias for each included study using a risk of bias tool adapted from the ROBINS-I tool [23,24] as per guidance provided by Cochrane for assessing risk of bias in uncontrolled before-after studies including interrupted time series, [23] and a tool developed by the Cochrane Effective Practice and Organization of Care group. [25] All disagreements were resolved by discussion or referral to a third author (RM, LA, SS). The domains assessed included bias related to: confounding (a. the possibility that extraneous events occurring around the time of the pandemic may have influenced the outcome, b. how well the study accounted for pre-intervention trends in utilisation); selection of participants; outcome measurement; and selective reporting of results. (Supplementary file 4) Each potential source of bias was graded as low, high or unclear, with the exception of grading for the pre-intervention trends, which was graded as low, moderate or high.

Data synthesis and analysis

As anticipated in the protocol, the considerable clinical and statistical heterogeneity in settings, outcome measures, and methods precluded a formal quantitative meta-analysis. Hence, we summarised the results using descriptive statistics (percentage change expressed as median and interquartile range), graphical figures and a narrative synthesis. In line with the "Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline" [26] we summarised findings for the primary outcome grouped by four service types: visits or presentations; admissions or hospitalisations; diagnostic or imaging investigations; and therapeutic or preventive interventions.

For the secondary outcome, we developed and report three categories which relied on the indicators of disease severity employed by primary study authors: a larger or smaller reduction among those with milder forms of illness, compared to people with more severe forms of illness; and no change. An example of a secondary outcome for a study of emergency department, ED, visits would be the triage scores, used to assess severity of those attending. Two authors (RM, LA) independently assigned a category for each secondary outcome, informed where possible by statistics provided in primary studies, with oversight and resolution of any discrepancies from within the clinical authorship team, (IS, EL, MJ).

As per details in the protocol, we planned to conduct a limited meta-analysis and sensitivity analysis in situations where there was a sufficient number of clinically and statistically homogeneous studies. Also, as per protocol, we restricted our analysis to data in the primary studies, rather than correlating findings with external information, such as stages of lockdown.

Patient and public involvement

The chief executive officer of a peak state-based consumer health organisation had input into the interpretation of the review data, and the revising and approval of the draft manuscript.

Ethics

No ethics approval was required.

Changes from protocol

Several minor changes comprised: during data extraction we could not confidently assess whether each utilised service was not provided or just deferred; finalisation of the adapted tool for risk of bias resulted in five domains, not six (two domains related to outcome measurement were combined), with one domain assessed as low, moderate, high, rather than unclear, low and high, with each grade supported by a comment; and given the very large number of included studies, we included data from studies reporting only a percentage change in service utilisation, without contacting authors requesting the absolute numbers.

Results

Study selection

We identified 4817 records through electronic database searching, 323 more through forward-backward citation analysis, and one from other sources, for a total of 3097 unique records. After screening titles and abstracts, we excluded 2929 records, and selected 179 records for full-text screening, of which 98 were excluded with reasons recorded. This left 81 studies which were included in the review. (Figure 1)

Characteristics of included studies

The 81 included studies collectively report on more than 6.9 million in the pandemic and over 11 million in the comparator pre-pandemic period. Studies reported across multiple locations: 3 were multi-national; 20 originated from the United States (US); 15 from Italy; 8 from France; 6 from Germany; 5 from the United Kingdom; 3 from Spain; 2 from each of Taiwan, Hong Kong, Greece, Denmark, Qatar, Australia; and 1 from each of Argentina, China, Canada, Brazil, Belgium, Chile, Monaco, Turkey, and Portugal. Four studies were from low- or middle- income countries. The healthcare setting were: hospitals only (41; 51%); both ED and hospitals (12; 15%); ED only (15;19%); and primary care and/or community (9;11%). More than one third of studies reported on healthcare services related to cardiovascular diseases (n=33; 41%); 14 (17%) to emergency services; 12 (15%) to general services such as immunization and primary care; and 22 (27%) on services related to different conditions including orthopaedic and trauma services, gastroenterology, and mental health. Of the included studies, 14 (17%) were national studies and 9 (11%) used time-trend data (Table 1; Supplementary file 5).

Risk of bias assessment

For the majority of studies there was insufficient information on which to judge the possibility that extraneous events occurring between pre-pandemic and pandemic

periods may have influenced healthcare utilisation, or to assess the risk of bias arising from differences between those eligible to utilise healthcare services in the pre-pandemic and pandemic periods (76/81; 94%). 69% (56/81) of studies were considered to be at high risk of bias due to insufficient data for characterising pre-pandemic utilisation. In contrast, three studies (4%) were judged to be at low risk of bias on this domain due to adequate data and analysis to permit characterisation of pre-pandemic trends in utilisation. 63% (51/81) of studies were judged to be at high or unclear risk of bias from using different methods used to assess utilisation in the pre-pandemic and pandemic period, or lacking information on which to judge this domain. Most studies (n= 74; 91%) were judged to be at low risk of bias in selective reporting of results.

Main findings

The 81 studies reported 143 estimates of changes in healthcare utilisation between pandemic and pre-pandemic periods, of which 136 (95.1%) were a reduction. The percentage change ranged between a 49% increase and an 87% decrease with a median 37.2% reduction (interquartile range -50.5% to -19.8%). For the 64 estimates about changes in cardiovascular service utilisation, from 33 studies, the median reduction was 29.3% (-41.3% to -17%). For the 13 estimates from the 9 studies using time-trend data, the median reduction was 37.3% (-45% to -25.2%). For all studies, the weekly median percentage changes starting from mid-February until late May 2020 are plotted graphically in Figure 3, showing greatest reductions through March and April. (Full data in Supplementary file 5)

We categorized the 143 estimates of change into 4 groups according to the type of healthcare service: 41 estimates for healthcare visits; 43 estimates for admissions; 12 estimates for diagnostics (e.g. imaging, pathology, screening investigations); and 47 estimates for therapeutics (e.g. surgery, vaccinations). All medians are reported in Table 2, with results of individual studies reported in Supplementary file 5.

Changes in visits

The percentage change for healthcare visits or presentations ranged between a 49% increase and an 86% decrease, with a median 42.3% reduction (-52.8% to -31.5%). Major reductions in visits to EDs were seen in multiple studies, such as a large national US study from the Centres for Disease Control and Prevention reporting a 42% reduction during April, rising to a 26% reduction at the end of May, compared to 2019. [1] That study found the largest absolute reduction involved people presenting with abdominal pain, with over 66,000 fewer ED visits per week for this complaint

during April. In terms of age group, the largest reduction (-72%) was seen for children 10 years and under. [1] A metanalysis of a subgroup of six studies of ED visits that reported adequate data for meta-analysis (effect estimates and 95% CIs) was attempted, but demonstrated considerable heterogeneity (I^2 >95%).

Changes in admissions

The percentage change in the number of admissions ranged between a 20% increase and an 87% decrease, with a median 28.4% reduction (-40.4% to -17.4%). For example, a large study of the weekly admission rates for acute coronary syndrome in England showed a substantial reduction by the end of March (-40%) which partly rebounded by the last week of May 2020, (-16%). [27]

Changes in diagnostics

The percentage reduction ranged between 10% and 85%, with a median 31.4% reduction (-52.5% to -23.8%); no study reported any increase in the use of diagnostic and imaging procedures. The magnitude of reductions in diagnostic tests and imaging followed a trend over time similar to those observed in the previous categories, but with a far smaller number of estimates. (See Figures 5.4a-d, Supplementary file 5) For example, a study of imaging case volumes within the largest healthcare system in New York State found a 28% reduction in imaging volumes for March to mid-April 2020 across all locations and imaging modalities, [28] while a separate US study found volumes recovering through late April, but still 36% lower in the third week of May, compared to 2019. [29]

Changes in therapeutics

The percentage change in therapeutic and preventive care ranged between a 27% increase and an 80% decrease, with a median 29.6% reduction (-56.8% to -19.2%). For example a large study of routine childhood vaccination in England found fewer children receiving the first MMR dose, with a reduction of 24% in the final week of March, which rose to a 27% increase in the third week of April, compared to the same period in 2019. [5]

Secondary Outcome

Thirty-eight of the included studies reported a total of 60 secondary outcomes relating to potential changes in healthcare utilisation according to the disease severity of the service user. Despite the considerable heterogeneity in settings and services, for almost half of these outcomes, (27 of 60; 45%) we observed a pattern of larger reductions in utilisation among those with milder or less severe illness

compared to those with more severe disease. For 33 of 60 outcomes (55%) there was no change. (Figure 4)

A national Italian study of urgent endoscopy reported a 40% reduction in utilisation overall, with bigger reductions in the proportion of patients with a negative finding on upper endoscopy between pre-pandemic and pandemic periods. [3] A study of three psychiatric emergency services in Paris found a 55% overall reduction in presentations in the first 4 weeks of lockdown, with greater reductions for consultations for anxiety and stress, and smaller reductions for consultations for psychotic disorders. [30] Authors speculated that "some people may find new strengths and coping strategies during disasters" and "the current results may arise from an elevation in resilience." Most strikingly, multiple studies reporting reduced acute coronary syndrome presentations found these reductions were much greater for the less severe non-ST-segment elevation myocardial infarction (NSTEMI) events compared to ST-segment elevation myocardial infarctions, (STEMIs). [27, 31] An example is a large English study reporting reductions in admissions of 42% for NSTEMI events versus 23% for STEMI. [27] In contrast, other studies found no change in presentations according to severity, including a national Portuguese study reporting a 48% reduction in ED episodes – from an expected 570 000 to an observed 295 000 in March 2020 – but no significant change in proportions of different triage categories. [32]

Discussion

This review of 81 studies involving over 19.8 million services provided across 20 countries found consistent evidence of major reductions in the utilisation of healthcare services during the pandemic period up to May 2020, compared to previous years, despite some studies reporting increases. Although a meta-analysis was not possible, we found a median reduction of 37% of services overall, which was highest for visits (42%) and slightly lower for admissions (28%), diagnostics (31%) and therapeutics (30%). Many studies also found larger reductions in utilisation among populations with milder or less severe illness. Few studies were assessed as having a low risk of bias, with lowest risk of bias for studies using time-trend data to establish trends in the years leading up to 2020. For the 9 studies using time-trends, the median reduction in utilisation was 37%.

Our review has several strengths. First, we synthesized the most recent data reported in primary studies up to the end of May 2020, which corresponds to the peak of the pandemic in many countries, and provides a baseline for longer-term data on on-going changes in utilisation and the cumulative deficit of care. Second,

the review constitutes the first broad synthesis of global studies of pandemic related changes in utilisation across all categories of healthcare services. Third, the review adhered to rigorous Cochrane, [24] PRISMA [21, 22] and SWiM [26] standards. Study limitations include the inability to undertake a meta-analysis because of considerable heterogeneity, the possibility of publication bias, the potential of our eligibility criteria to exclude important data sources such as studies in single-centres and unpublished datasets from health systems, subjectivity in our assessments of the secondary outcomes, and the use of an adapted but unvalidated risk of bias tool.

The massive global reduction in healthcare utilisation summarised in this review makes a compelling case for prioritising efforts that address the unmet needs of those with non-COVID 19 illness. Consistent messages from the primary studies include calls for monitoring the long-term impacts of this missed care, public campaigns to urge people to seek medical care when they need it, and better preparedness for reducing the extent of missed care in future waves of the pandemic. Evidence of excess population mortality, in addition to deaths from COVID-19, and related phenomena such as increases in out-of-hospital cardiac arrests and contacts with emergency phone-lines [33,34] make these calls to action even more urgent. Conversely, the review's finding that reductions often tended to be greater for milder or less severe forms of illness, combined with existing evidence about too much medicine, [11-17] suggest that for some people, missing care may not have caused harm.

This unprecedented pandemic-induced natural experiment in reduced healthcare utilisation provides a genuine opportunity to learn more about what services populations and healthcare systems came to regard as lesser priorities, when redistribution of resources towards more essential services was needed to minimize mortality in a crisis. As others have suggested, [35,36] greatly reduced ED attendances around the world for non-urgent complaints indicate an opportunity to inform and implement new strategies and models of care that maximise the appropriateness of visits in the future. Even at the heart and height of the epidemic in Northern Italy, in paediatric EDs doctors found reductions in the mildest presentations accounted for more of the decrease in overall presentations, suggesting that "most of the non-relevant pathologies usually seen at our EDs have been avoided" thus freeing resources to "provide critical services to patients suffering from medical emergencies in a timely manner." [36] Our review adds weight to the view that the post-pandemic recovery provides a rare window of opportunity for systematic changes in

healthcare systems aimed at reducing low-value care, including overtreatment and overdiagnosis. [9,10,37]

Many questions about the causes and impacts of the changes in healthcare utilisation documented in our review call for careful analysis and further research. (See Box 1) High quality time trend analyses are needed to better understand the extent and nature of on-going changes in utilisation, as are long-term cohort studies for collecting patient-centred outcomes to assess impacts on health, costs, and equity. Consultations with consumers during the pandemic highlight the need to understand how the pandemic may differentially impact the most vulnerable, and the need to prioritise those at most need. [38,39] Rigorous qualitative research investigating people's experience of avoiding or missing care, and professional responses to changes in process and practice, will also be important. We found no study which explicitly examined changes in utilisation of low-value healthcare services, which warrants further research. The extent and effects of substitution, such as with telehealth or self-care also requires investigation. Experience with SARS almost 20 years ago revealed significant drops in healthcare service utilisation in the most affected regions [40] and long periods before some rates returned to baseline. [41] Given the growing evidence about unnecessary care since then, it may be more beneficial for populations and their health systems if utilisation rates of some services do not return to pre-pandemic levels. Addressing genuine unmet need and winding back the harm and waste of unnecessary care are not conflicting interests, but rather two sides of a coherent strategy to efficiently improve human health.

Summary Box

Section 1: What is already known on this topic

-Multiple primary studies have reported reductions in utilisation of various healthcare services during the COVID-19 pandemic

Section 2: What this study adds

-This systematic review is the first to quantify and characterise reductions in health service utilisation on a global scale, across countries, settings, and service types

-The review identifies major reductions in use of services across 20 nations, with a median reduction of 37% overall and reductions of similar magnitude across key service categories of visits, admissions, diagnostics, and therapeutics

-Importantly, reductions in utilisation have tended to be greater among populations with milder or less severe symptoms or conditions

-While controlling the COVID-19 pandemic and tackling unmet needs of those with non-COVID illness remain priorities, examining changes in utilisation may also offer learnings on identifying and reducing unnecessary care in the post-pandemic recovery

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Tables, Figures, Box

Supplementary Files

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Conception/design: RM, LA, SS, ZM,AS, JC,MJ; Acquisition, analysis or interpretation of data: RM, SS, ZM, AS, JC, ET, MJ, EK, MF, MJ, EL, AD, IS, LA; First draft of manuscript: RM, LA; Manuscript drafting, revision, approval: RM, SS, ZM, AS, JC, ET, MJ, EK, MF, MJ, EL, AD, IS, LA. Overall guarantors: RM, LA. The guarantor accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Competing Interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work. RM has helped organise Preventing Overdiagnosis international scientific conferences.

Patient and Public Involvement

The most senior officer from a state peak consumer health organisation is a co-author on this review and was involved in the study before the protocol was finalised. The consumer representative provided feedback on the protocol and draft manuscripts, was consulted during the process of the review, was involved with

interpretation of results, and will advise on methods for dissemination of study results to the public.

Data sharing

We have provided all data about all included studies, and a list of those studies, in the Supplementary files.

Transparency Statement

The lead and senior authors RM and LA affirm 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 protocol as originally planned and registered have been explained in a special section in the Methods.

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Tables

Table 1. Summary characteristics of included studies (n=81)

Characteristics of included studies	No (%)
Scope	
National	14 (17%)
Multi-centre	67 (83%)
Disease categories	
Cardiovascular	33 (41%)
Emergency Services (adult and paediatric)	14 (17%)
General (including vaccination and hospice)	12 (15%)
Digestive	5 (6%)
Orthopaedic and Trauma	5 (6%)
Others (e.g. mental health, urology, neurology)	12 (15%)
Setting	
Hospitals (or inpatient care)	41 (51%)
Emergency	15 (19%)
Emergency and Hospital	12 (15%)
Community and/or outpatient	9 (11%)
Hospital and outpatient	4 (5%)
Study design*	
Time trend	
Time trend – multiple prior year	5 (6%)
Time trend – single prior year	4 (5%)
Same period (before – after)	
Same period – multiple prior year	16 (20%)
Same period – single prior year	56 (69%)
Country	
Multi-national	3 (4%)
Americas	24 (30%)
Europe	45 (56%)
Asia & Australia	9 (11%)

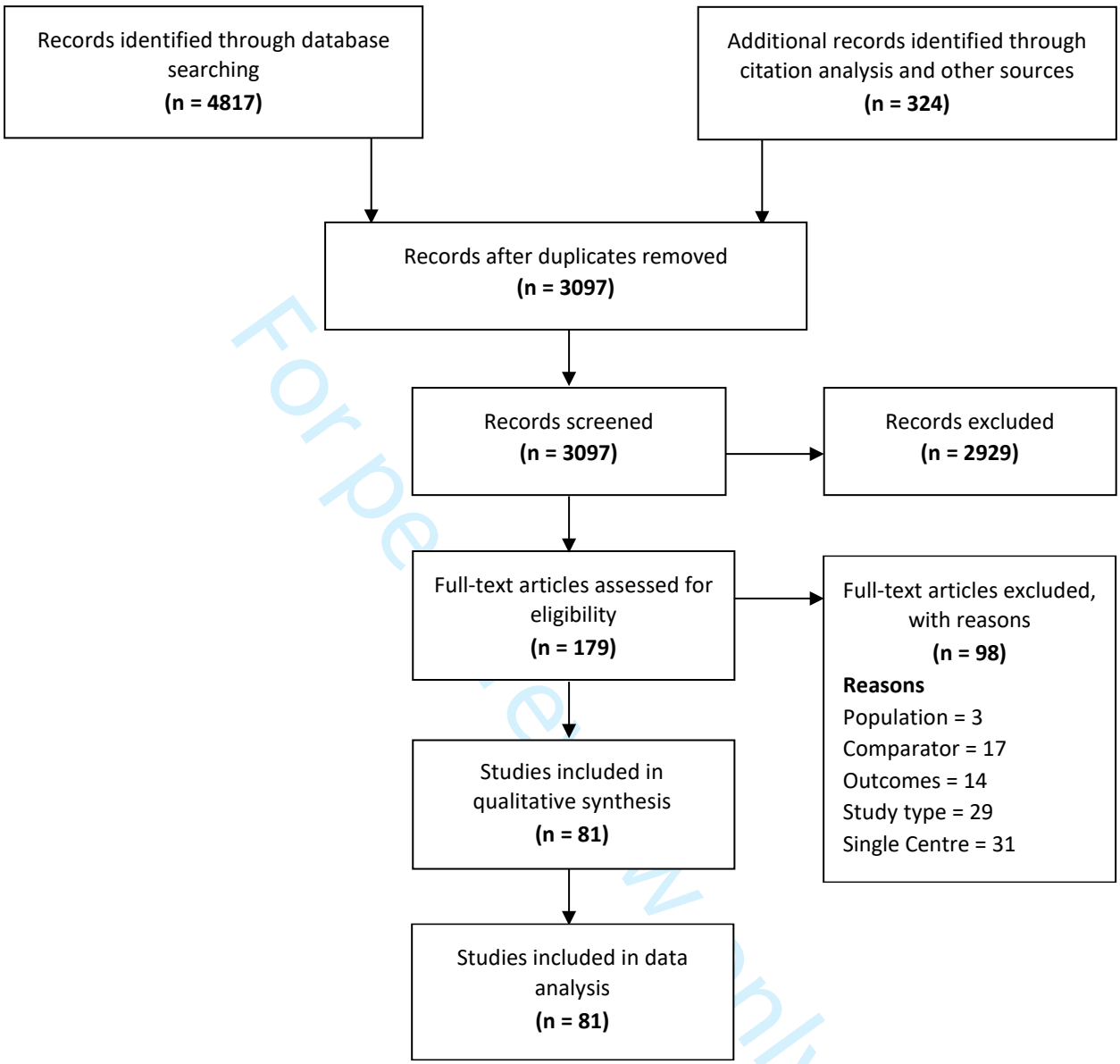
*This refer to the type of data used in included studies rather than the type of analysis

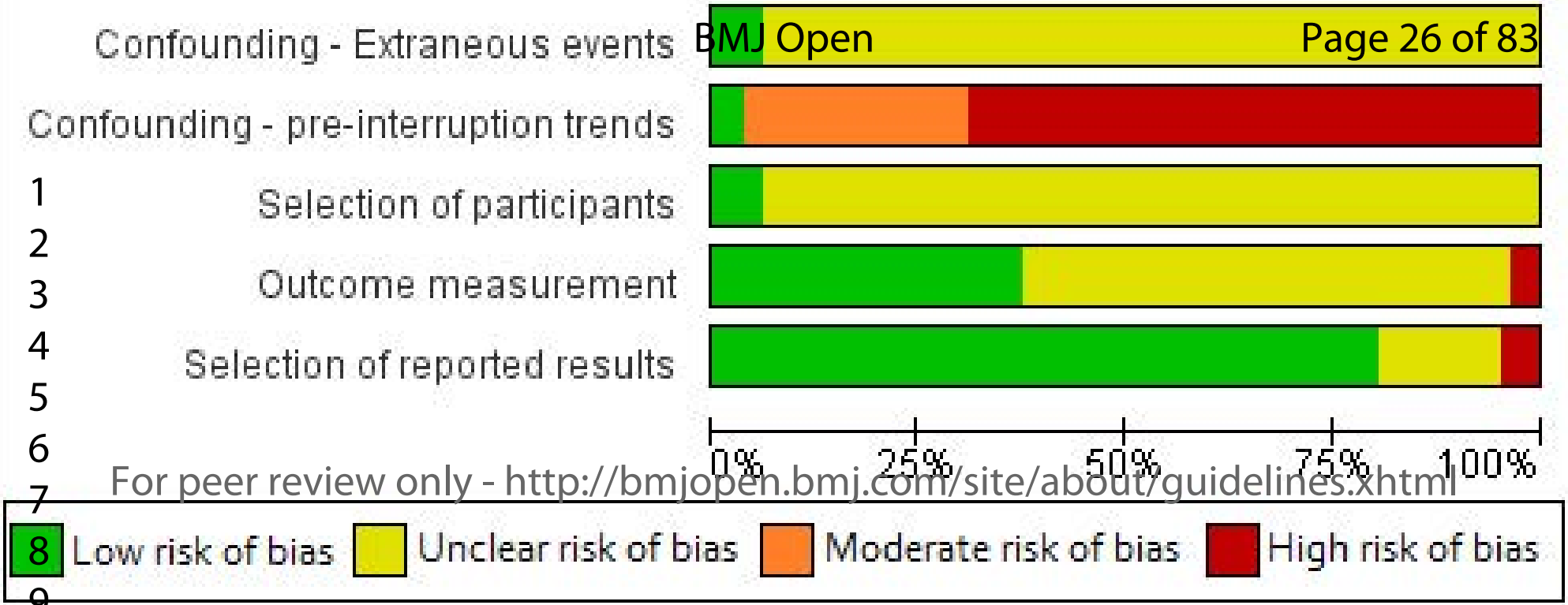
Table 2. Median changes in utilisation across categories of healthcare services

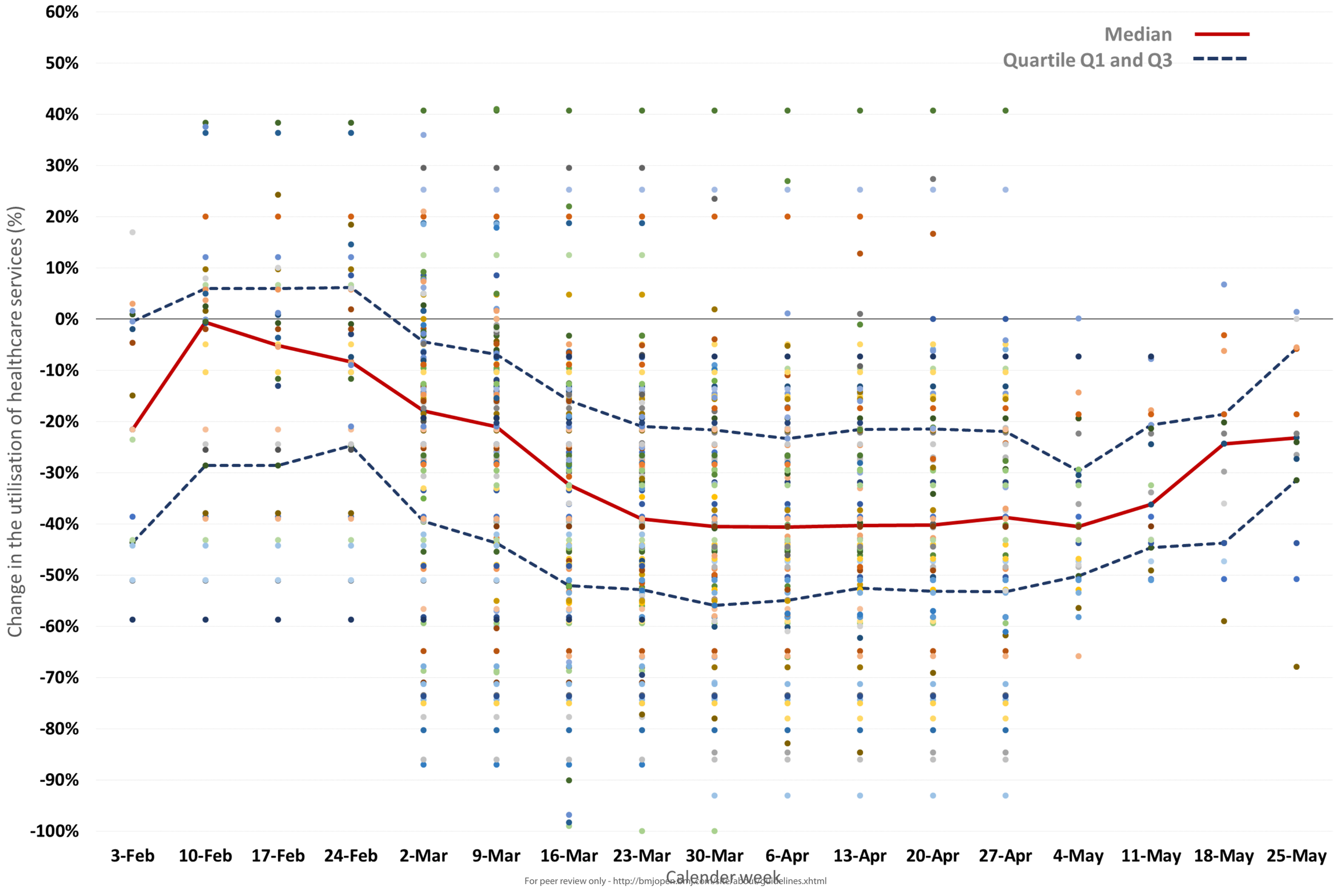
Healthcare Service	No. estimates (No. studies)	Total volume of services (Pandemic and Comparator)	Median change	Interquartile range
Total	**143 estimates (81 studies)**	**19,808,921 P: 6,948,834; C: 11,102,936**	**-37.2%**	**-50.5% to -19.8%**
Healthcare services categories*				
Visits	41 estimates (33 studies)	14,090,495 P: 4,631,899; C: 7,723,639	-42.3%	-52.8% to -31.5%
Admissions	43 estimates (32 studies)	1,690,021 P: 749,942; C: 939,737	-28.4%	-40.4% to -17.4%
Diagnostics	12 estimates (7 studies)	1,692,388 P: 640,885; C: 1,051,503	-31.4%	-52.5% to -23.8%
Therapeutics	47 estimates (28 studies)	2,336,017 P: 926,108; C: 1,388,057	-29.6%	-56.8% to -19.2%
Disease categories				
CVD	64 estimates (33 studies)	2,586,270 P: 1,166,610; C: 1,400,041	-29.3%	-41.3% to -17.0%
Emergency services	17 estimates (14 studies)	10,572,517 P: 3,252,399; C: 5,585,161	-44.0%	-48.0% to -31.5%
Study design and data				
Studies using time-trend data	13 estimates (9 studies)	6,263,331 P: 1,974,605; C: 3,425,412	-37.3%	-45.0% to -25.2%

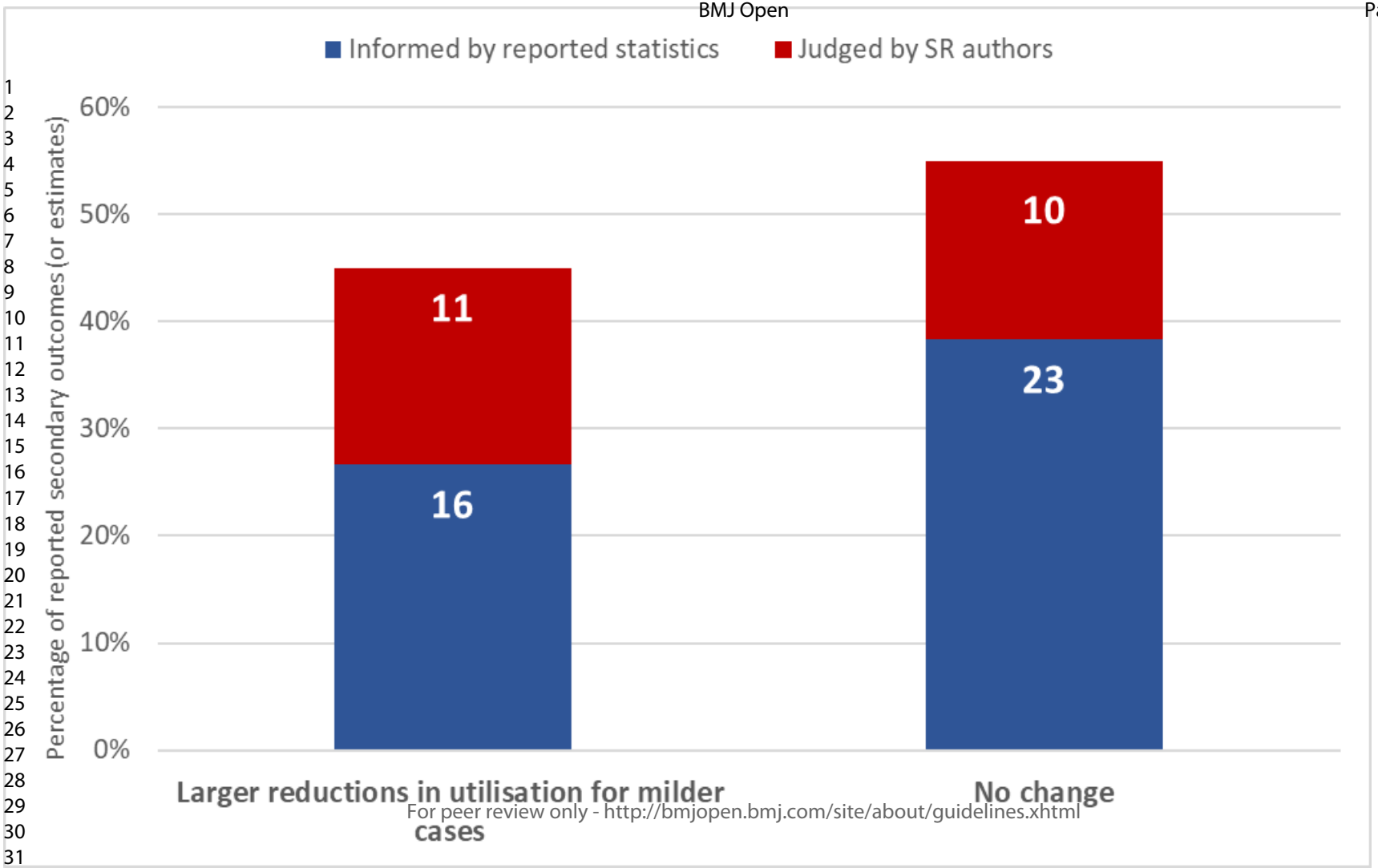
Abbreviations: C: comparator pre-pandemic period; P: pandemic period. *Each study could have included services across multiple categories. Note: In order to calculate the total volume of healthcare services, we used numbers as reported in the primary studies, whenever available. If not explicitly reported, we estimated these numbers using data plotted in the figures reported in the primary studies, when available. For studies that have not reported these absolute numbers anywhere – but only reported a percentage change – their services have not been included in these totals. In addition, there will be some discrepancy between the total numbers, and the sum of pandemic and pre-pandemic periods, because in some cases, a study may have included a total number of services, but without breaking it down into any absolute numbers for the pandemic or pre-pandemic periods.

Box 1: Future research
For future studies of changes in healthcare utilisation during the pandemic
Aim for time-series analyses; multiple years pre-pandemic as comparator
Aim to detect impacts on equity, such as different groups differentially affected
Need to cautiously interpret drivers and impacts of changes
Aim to analyse local, provincial, and national datasets
Consider potential for multi-national research collaborations with health systems
For future studies of impacts of the "natural experiment" in reduced care
Aim for long term cohort studies, with focus on specific conditions, or interventions
Seek strong clinical, patient, and public input, independence of commercial interests
Qualitative analyses with patients and public on reasons for and impacts of missing care
For those interested in opportunity to address problem of too much medicine
Studies of pandemic related changes in rates of overtreatment and overdiagnosis
Urgent need to learn from "natural experiment" before rates return to prior levels
Correlate condition-specific granular analyses, with existing data on medical overuse
Consider using pandemic learnings to guide trials of de-implementation strategies
Consider potential researcher-clinician-consumer-health system collaborations









Pandemic changes in healthcare utilisation: a protocol for a systematic review

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BACKGROUND

As the covid-19 pandemic continues, increasing numbers of studies are reporting major changes in utilisation of healthcare services, including large drops in services during certain periods,[1-3] as well as some increases, such as the use of telemedicine.[4] While many people have missed much needed care, such as vaccination or life-saving interventions,[2] others may be avoiding unnecessary or inappropriate care which would have caused them more harm than good.[3] A large and growing evidence base suggests the problem of too much medicine is widespread, including low value care which may carry no benefit, and overdiagnosis, which can cause more harm than good. [5-11] Multiple global campaigns are attempting to address this challenge, such as Choosing Wisely, which is active in more than 20 nations.[12] As nations are forced to do more with less, post-pandemic, learning from this "natural experiment" in less care may help health systems address the challenges of unnecessary care, and move towards more sustainability.[13,14]

Understanding the impact of these large changes in healthcare utilisation, on health outcomes and costs, will present a great methodological challenge. First, there are many

[1] non-first/last authors are indicative order only

reasons why people have missed care, including fear of visiting hospitals during the pandemic, inability to visit due to lockdown circumstances, or the unavailability of a service such as suspended elective surgery. Second, disentangling those groups who have missed needed care, from those who have avoided unnecessary care, will require sensitive and sophisticated analysis, considering multiple potentially confounding variables. Moreover, simply showing no adverse outcomes from missed care – such as a missed visit to a general practitioner – does not automatically mean that episode of missed care was unnecessary. Notwithstanding these challenges, understanding the unprecedented recent changes in utilisation and their impact, may help health systems, and the societies which fund them, optimise resource-use post-pandemic.

As a first step to that understanding, we aim to conduct a systematic review of studies which have reported on pandemic-induced changes in healthcare utilisation. We aim to examine the extent and nature of changes, particularly any reported changes in the severity of symptoms of people seeking or receiving care.[3] The broader purpose is to inform any future investigations of the impact of this natural experiment in less care on health outcomes and costs.

METHODS

We aim to find, appraise, and synthesise studies that assessed the impact of the covid-19 pandemic on the utilisation of healthcare services, compared to a corresponding period of time prior to the pandemic. This systematic review will be reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[15] The review protocol was developed prospectively and was registered on the Open Science Framework (https://osf.io/) and on Prospero (https://www.crd.york.ac.uk/prospero/). We will also follow the "2 week systematic review" (2weekSR) processes for this review.[16] In relation to the PICO for this systematic review, the P will be a population of people seeking or using a service within the healthcare system, the I will be the pandemic period as defined by primary study authors, the C will be a comparable period at least one year prior to the study period, and the O will be change in utilisation (primary outcome) and change in disease severity of the people using the service, (secondary outcome).

Studies to be included

Population

We will include studies that report changes in the utilisation of healthcare services by patients and public, irrespective of age. We will exclude studies that reported on the utilisation of healthcare services by patients diagnosed with covid-19.

Interventions and Comparators

We will include studies which compare utilisation during any period within the pandemic, with a similar period in at least one year before the pandemic. We will therefore include studies which compare – for example – April 2019 utilisation with April 2020 utilisation, but due to concerns about reliable comparisons, we will exclude studies which use the immediate pre-pandemic period as a comparator, (e.g. November 2019). We will include studies which report data from national or regional sources, of more than one centre, so we will exclude studies within a single unit or single hospital, due to limitations on

generalisability.

Outcomes

The primary outcome is the extent of changes in utilisation of a healthcare service between the pre-pandemic comparison period and the pandemic period. Healthcare service will include but not be limited to *consultation healthcare services* such as presentations or admissions to hospitals or visits to primary care; *diagnostic healthcare services* such as diagnostic imaging/investigations, laboratory testing; and *therapeutic or preventive healthcare services* such as prescriptions, or surgeries or utilisation of vaccinations. These healthcare services can be broad and may include packages of, rather than single isolated, healthcare services. Therefore, in the case of a broad package, the primary outcome for the purposes of our review will be the initial indication for the healthcare services utilisation, if that data is available in the primary study, (e.g. admission due to a stroke is an initial indication for a subsequent series of healthcare services including diagnostic investigations and therapeutic services).

The secondary outcome is the nature of the changes in relation to the people using the service, specifically changes in disease severity or diagnostic spectrum, (e.g. any changes in proportions of patients with mild or severe illness).

We will exclude studies which report utilisation for a time period less than one week in duration, because of the brevity of the time period, and the possibility of differences on different days of the week. We will exclude studies which do not include data on changes in routine healthcare utilisation, but rather only describe changes in healthcare processes, incidence/prevalence of conditions/diseases only, the nature of new practices, or the impacts of covid-19 on individual patients. We will exclude non-medical allied health services.

Study design

We will include any observational studies using clinical, hospital or health system administrative data and/or medical records reporting utilisation in a period after the pandemic was declared, and at least one corresponding period in the years prior to the pandemic. This will include before-after studies and interrupted time series studies. We will exclude surveys of healthcare practitioners, cross-sectional studies, any trials, or studies using modelling to predict impacts on utilisation.

Rational for selection and prioritisation of outcomes

We selected and prioritised the outcomes based on (i) a review of the outcomes reported in a sample of potentially included studies collected before the Systematic Review by 2 review authors (RM, LA); (ii) a discussion among the whole review team, which includes clinical advisors, methodological experts, and a patient and public (consumer) representative. Primary and secondary outcomes directly address the Systematic Review question, which is investigating the extent and nature of changes in healthcare utilisation due to the pandemic.

Search strategies to identify studies

Database search strings

We will search PubMed, Embase and the Cochrane COVID-19 Study Register and pre-print servers via Europe PMC, from inception until Monday 10th August, 2020, with an update close to date of submission. We designed a search string in pubmed that included the following concepts: Covid-19 AND Health services AND Admissions AND Impact. This search string was translated for use in other databases using the Polyglot Search Translator.[17] The complete search strings for all databases are provided in Appendix 1.

Restriction on publication type

No restrictions by language or publication date will be imposed. We will include publications that were published in full, as well as letters, or pre-prints, where data on the primary outcome is sufficient for data extraction. We will seek expert advice on the existence of other public reports unavailable in peer-reviewed journals and they will be included if all inclusion criteria are met.

Other searches

We will conduct a backwards (cited) and forwards (citing) citation analysis in Scopus/Web of Science on the included studies identified by the database searches, and these will be screened against the inclusion criteria.

Study selection and screening

Pairs of review authors [RM, SS, ZM, AS, JC, EK, ET, LA] will independently screen the titles and abstracts in Endnote for inclusion against the inclusion criteria. One review author [JC] will retrieve full-text, and pairs of authors [RM, SS, ZM, AS, JC, EK, ET, LA] will screen the full-texts for inclusion. Any screening disagreements will be resolved by discussion, or reference to a third author [RM or LA]. The selection process will be recorded in sufficient detail to complete a PRISMA flow diagram and a list of excluded (full-text) studies with reasons for exclusions. A list of studies in single-centres, excluded at title and abstract screening stage, but which otherwise meet inclusion criteria, will be recorded and made available on request from authors.

Data extraction

We will develop and use a data extraction form for study characteristics and outcome data, which will be piloted on 2-3 studies in the review. Pairs of authors [RM, SS, ZM, AS, LA, EK, ET] will independently extract the following data from included studies, resolve discrepancies and refer any unresolved to a third author [LA, RM]:

1. Methods: study authors, location, nature of service, period and length of study, period of comparator/s, disease (if applicable), and whether the changes in utilised services were likely due to them being omitted, delayed (or unclear).
2. Primary Outcome(s): percentage change in utilisation of health services and 95% CI, in pre and pandemic periods, and changes in absolute numbers of utilization, where data allow for calculation of percentage of change and 95% CI. In relation to the earlier point about packages of care, including care which flows from an initial indication or admission, when the data permits, we will consider the initial indication for the healthcare services utilisation as our primary outcome.

3. Secondary Outcome(s): change in the nature/characteristics of the users of health services (e.g. disease severity; disease spectrum/mix, or diagnostic yield; admissions to acute care)

Assessment of risk of bias in included studies

Pairs of review authors [RM, SS, ZM, AS, LA, EK, ET] will independently assess the risk of bias for each included study. We will use a modification of two risk of bias tools designed to assess before-after studies and interrupted time series analyses, the ROBINS-I tool [18-19] and a tool developed by the Cochrane EPOC group. [20] All disagreements will be resolved by discussion or by referring to a third author [RM, LA, AS, SS]. The following domains will be assessed:

1. Bias due to confounding (extraneous events)
2. Bias due to confounding (pre-intervention trends)
3. Bias in selection of participants
4. Bias due to missing data
5. Bias in measurement of the outcome
6. Bias in selection of reported result

Each potential source of bias will be graded as low, high or unclear, and each judgement was supported by a quote from the relevant trial. If secondary review outcomes require specific assessment on risk of bias domains this will be identified during further testing of the tool. Assessments of risk of bias will be presented for individual studies and across studies and will be incorporated into the results of the systematic review.

Data synthesis

We anticipate a wide heterogeneity in the population, settings, outcome measures, and methods used in the included studies, such that we do not expect to be able to perform a formal quantitative synthesis, i.e. a meta-analysis. Therefore, we plan to summarise the results narratively by using descriptive statistics, graphical figures, and a narrative synthesis. We will summarise the findings of included studies for the primary outcome grouped by service types: e.g. visits/admissions/consultations; diagnostic investigations; therapeutic/preventive interventions. If further sub-categorisation is needed, it will be by service locations: e.g. emergency department; primary care; and/or service specialty e.g. cardiology. We will calculate the mean difference and 95% confidence intervals for the change in the primary outcomes for each included study as appropriate.

If there is a sufficient number of sufficiently similar studies with acceptable levels of heterogeneity, and the data enable it, we would then aim to conduct a meta-analysis. In that case, we will use a random-effects model as the default to incorporate the assumption of heterogeneity between studies. We will evaluate statistical heterogeneity using both Chi^2 test (i.e. P value less than 0.10 was considered to be statistically significant heterogeneity) and the I^2 statistic (i.e. I^2 value of 0-40% was considered to be low heterogeneity, 40-60% moderate heterogeneity, 60-90% substantial heterogeneity, over 90% to be considerable heterogeneity).[19]

We anticipate that reporting of the secondary outcomes in each of the included studies will likely be expressed in a multitude of ways, specific to each study setting, disease category, patient population and category of utilisation. However, we will aim, if possible, to develop different categories for reporting of secondary outcomes.

Data Management

We will manage data using Endnote files, word documents and excel spreadsheets.

Dealing with missing data

If any primary studies only include changes as proportions, but do not include changes in absolute numbers of services, we will contact investigators or study sponsors to provide missing data.

Subgroup and sensitivity analyses

If there is a sufficient number of sufficiently similar studies with acceptable levels of heterogeneity to quantitatively synthesise the results, and the data enable it, we aim to conduct a sensitivity analysis (i) including only studies at an overall low risk of bias (eg low risk of bias in at least four of the six domains or interrupted time series studies vs pre-post pandemic studies); and (ii) including studies of longer duration (eg >6 weeks).

Assessment of reporting or publication biases

We plan to consider the possibility of the presence of reporting and/or publication bias and will take into account its likely influence when interpreting the review findings. If ten or more studies are included in a meta-analysis, we plan to examine the possibility of publication or small study bias using funnel plots. [19]

Additional analyses

We considered a range of analyses to explore correlations between study outcomes and other potentially relevant variables available outside the study data, such as nation-specific data about the stage of lockdown in the host nation at the time of the primary study. However, due to complexities in the large number of variables and potential discrepancies between official policy on restrictions and actual behaviour of people, as well as complex variation in the behaviours of different entities within the healthcare systems across the world, we decided, at protocol stage, to restrict our analysis to data within the publications.

Registration

We will register this protocol in the Open Science Framework, and in Prospero.

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August 11, 2020

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APPENDIX 1 – DATABASE SEARCH STRINGS

PubMed

("COVID-19"[Supplementary Concept] OR “COVID-19”[tiab] OR COVID19[tiab] OR “COVID 19”[tiab] OR “SARS-CoV-2”[tiab] OR “2019-nCoV”[tiab] OR “Novel coronavirus”[tiab] OR “Coronavirus 2019”[tiab] OR “Coronavirus 19”[tiab] OR “COVID 2019”[tiab] OR "2019 ncov"[tiab] OR “Wuhan coronavirus”[tiab])
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Embase (via Elsevier)

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Cochrane COVID-19 Study Register
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Europe PMC preprints
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Checklist of items to include when reporting a systematic review or meta-analysis

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3-4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6,7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supp. file 3

Section/topic	#	Checklist item	Reported on page #
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6,7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7,8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	9,10
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and	10-12

Section/topic	#	Checklist item	Reported on page #
		confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Figure 2, and Supp. File 4
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression) (see Item 16).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	12
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	12,13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	13, 14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Abstract

Supplementary File 3 – DATABASE SEARCH STRINGS

PubMed

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	Confounding - Extraneous events	Confounding - pre-interruption trends	Selection of participants	Outcome measurement	Selection of reported results
Abdulmalik	?	?	?	+	+
Andersson	+	-	+	+	+
ANGOULVANT	+	+	?	+	+
Antonucci	?	-	?	+	+
Athiel	?	-	?	+	+
Baum	?	?	?	+	+
Bayles	?	?	+	+	+
Benazzo	?	-	?	?	+
Bollmann	?	-	?	?	+
Bozovich	?	-	?	?	+
Braiteh	?	-	?	?	+
Bramer	?	?	?	?	+
Butt	?	-	?	+	+
Cano-Valderrama	?	-	?	+	+
Cheek	?	-	?	?	+
Chou	?	-	?	?	+
Claeys	?	?	+	+	+
Clerici	?	-	?	?	?
Collado-Mesa	?	?	?	?	+
CVD-COVID	?	-	?	?	?
De-Filippo	?	-	?	?	+
de Havenon	?	?	?	?	+
De Rosa	?	-	?	?	+
Diegoli	+	-	+	?	+
Egol	?	-	?	-	+
Enache	?	-	?	+	+
Franco	?	-	?	?	?
Frankfurter	?	-	?	?	+
Garcia	?	?	?	?	+
Gawron	?	?	?	+	+
Giuntoli	?	-	?	+	+
Gruttadauria	?	?	?	-	?
Hartnett	?	-	?	+	+
Houshyar	?	-	?	?	+
Hoyer	?	-	?	?	+
Isba	?	-	?	?	+
Jasne	?	-	?	?	+
Kadavath	?	-	?	-	-
Kerleroux	?	-	?	+	+
Kessler	?	-	?	+	+
Kim	?	-	?	+	-
Kolbaek	?	-	?	?	?
Krenzlin	?	?	?	+	+
Langdon-Embry	?	-	?	?	?
Lantelme	?	?	?	?	+
Lazaros	?	-	?	+	+
Lazzerini	?	?	?	+	?
Li	?	-	?	?	?
Lui	?	?	?	+	+
Mafham	+	-	?	+	+
Manzoni	?	-	?	?	+
Mazzatenta	?	?	?	?	-
McDonald	?	-	?	+	+
Mitchell	?	+	?	+	+
Naidich	+	-	?	+	+
Norbash	?	-	?	?	-
Novara	?	-	?	?	+
Onteddu	?	-	?	?	+
Papafaklis	?	-	?	?	+
Pignon	?	-	?	?	+
Pinar	?	-	?	+	+
Polo Lopez	?	-	?	?	+
Pop	?	-	?	?	+
Qasim	?	-	?	+	+
Range	?	?	?	?	?
Reeves	?	?	?	?	+
Requena	?	-	?	?	?
Romaguera	?	-	?	+	+
Salerno	?	-	?	?	+
Santana	?	+	?	+	+
Scaramuzza	?	-	?	?	?
Scholz	?	?	?	+	+
Secco	?	-	?	?	+
Seiffert	?	-	+	?	+
Smalley	?	-	?	?	+
Tinay	?	-	?	?	+
Toro	?	?	?	?	?
Toyoda	?	?	?	?	+
Wong	?	?	?	?	+
Xu	?	?	?	?	+
Zhao	?	-	?	?	+

Title: Pandemic impacts on healthcare utilisation: a systematic review

Authors names: R Moynihan, S Sanders, ZA Michaleff, AM Scott, J Clark, EJ To, M Jones, E Kitchener, M Fox, M Johansson, E Lang, A Duggan, IA Scott, L Albarqouni.

Supplementary File 5 –

5.1 Table of Study Characteristics and reference list of all included studies.

5.2 Table of Results of the primary outcome of the included studies

5.3 Table of Results of secondary outcomes of the included studies

5.4 Figures of changes in healthcare utilisations reported in included studies

Supplementary Table. Characteristics of Included Studies of pandemic related changes in healthcare utilization

Author; Country; Scope; Design	Setting; Population	Pandemic and comparator periods*	Primary Outcomes	Secondary Outcomes
Abdulmalik; Qatar; National; Same period single year	Outpatient/Primary care; 27 primary health care centres	March - May; 2020 vs. 2018-19	Overall utilization of all primary healthcare services across all health centres	N/A
Andersson; Denmark; National; Same period single year	Hospital; Danish Nationwide Patient Registry	March 12 - March 31; 2020 vs. 2019	Incidence rates of new-onset HF and hospitalization for worsening HF	Mortality
Angoulvant; France; Multi-centre; Time trend multiple years	ED & Hospital; 6 Paediatric EDs from academic hospitals being part of Assistance Publique – Hôpitaux de Paris	March 18 - April 19; 2020 vs. 2017-19	Number of hospital visits and admissions	N/A
Antonucci; Italy; Multi-centre; Same period single year	ED & Hospital; 3 high volume urology departments in Rome, Italy	March - April; 2020 vs. 2019	Number of ED admissions for urolithiasis; Number of hospitalisations	N/A
Athiel; France; Multi-centre; Same period single year	ED & Hospital; 12 gynaecological emergency units of the Greater Paris University Hospitals	March - May; 2020 vs. 2019	Number of emergency gynaecological hospitalisations	N/A

Baum; USA; National; Time trend single year	Hospital; Veterans Affairs Hospitals' Corporate Data Warehouse, a national repository of electronic health records from visits to any VA facility	March 11 – April 21; 2020 vs 2019	All admissions for any condition	N/A
Bayles; USA; Multi-centre; Same period single year	ED; 3 acute care facilities from the Marin County Department of Health and Human Services	March 17 - May 4; 2020 vs. 2018-19	Average number of daily ED visits	N/A
Benazzo; Italy; Multi-centre; Same period single year	ED & Hospital; 15 orthopaedic and trauma units	February 23 - April 4; 2020 vs. 2019	Outpatient consultations; Trauma ED visits; Surgeries	N/A
Bollman; Germany; Multi-centre; Same period single year	Hospital; 66 Helios hospitals	March 1 - April 30; 2020 vs. 2019	Admissions for heart failures and arrythmias	N/A
Bozovich; Argentina; Multi-centre; Same period single year	ED & Hospital; 31 private hospitals	April 1 - April 30; 2020 vs. 2019	ED consultations and procedures	N/A
Braiteh; USA; Multi-centre; Same period single year	Hospital; 4 hospitals	March - April; 2020 vs. 2019	Admissions for any cause; Presentations for Acute Coronary Syndrome (also describes as admissions)	Rates of STEMI versus NSTEMI

Bramer; USA; Multi-centre; Same period single year	Community; vaccinations from one state immunization system	May; 2020 vs. 2017-19	Proportion of children with up-to-date status for all recommended vaccines	N/A
Butt; Qatar; Multi-centre; Same period single year	ED; 2 hospitals in Qatar that see over 80% of patients in Qatar with suspected Acute Coronary Syndrome	March - April; 2020 vs. 2019	Total ED visits; ED presentations with cardiac symptoms	Rates presenting with Acute Coronary Syndrome (ACS)
Cano-Valderrama; Spain; Multi-centre; Same period single year	Hospital; 3 tertiary care centres	March 16 - April 26; 2020 vs. 2019	Acute care surgeries	SOFA scores
Cheek; Australia; Multi-centre; Same period single year	ED; 2 tertiary hospitals and 2 urban district hospitals	March 22 - May 23; 2020 vs. 2019	Number of attendances at paediatric ED; Number of attendances at paediatric ED for mental health diagnoses; Number of neonatal presentations	N/A
Chou; Taiwan; Multi-centre; Same period single year	Community/Primary care; Hospice homecare services, hospice inpatient services and non-hospice services provided by 2 branches of health care organisation in Northern Taiwan	January - April; 2020 vs. 2019	Number of hospice home care visits; Number of new enrolments in hospice home care; Bed occupancy rates in hospice and non-hospice units; Monthly patient days in hospice and non-hospice units	N/A
Claeys; Belgium; National; Same period single year	Hospital; 36 of the 49 PCI-capable hospitals in the Belgian STEMI database and Belgian Coronary Stent Registry	March 13 - April 3; 2020 vs. 2017-19	Number of STEMI admission	Mortality; % cardiac arrest; Killip class

Clerici; Italy; Multi-centre; Same period single year	Hospital; 7 general hospital psychiatric wards in the Lombardy region of Italy	February 21 - March 31; 2020 vs. 2019	Average daily number of admissions by week, total number of weekly admissions; Annual rates of admissions/1000 adults	Number of voluntary and involuntary admissions
Collado-Mesa; USA; Multi-centre; Same period single year	Community/Outpatient; five breast imaging centres	April; 2020 vs. 2018-19	Number of breast imaging examinations; Number of image-guided procedures	Proportion of positive biopsy of image guided biopsy
CVD-Covid-UK Consortium; UK; Multi-centre; Same period single year	Hospital; 9 hospitals in England and Scotland	March 23 - May 10; 2020 vs. 2018-19	Number of ED attendances and hospital admissions	procedures for cardiac, cerebrovascular, other vascular conditions
De Filippo; Italy; Multi-centre; Same period single year	Hospital; 15 hospitals in Northern Italy	February 20 - March 31; 2020 vs. 2019	Incidence rate ratio for hospital admissions for ACS	Incidence rate ratio for STEMI/NSTEMI
de Havenon; USA; Multi-centre; Same period single year	Hospital; 65 academic and community hospitals	February - March; 2020 vs. 2018-19	Number of hospitalisations for stroke and ACS; Number of procedures for stroke and ACS	N/A
De Rosa; Italy; Multi-centre; Same period single year	Hospital; cardiac care units at 54 Italian hospitals affiliated with Italian Society of Cardiology	March 12 - March 19; 2020 vs. 2019	Number of admissions for acute myocardial infarction	Case fatality rates; Number of admissions per diagnosis (STEMI/NSTEMI)

Diegoli; Brazil; Multi-centre; Same period single year	Hospital; 6 hospitals in Joinville, Brazil	March 17 - April 15; 2020 vs. 2019	Admissions for stroke/100000 inhabitants	Admissions for severe stroke (NIH stroke scale score)
Egol; USA; Multi-centre; Same period single year	ED & Hospital; The NYU Langone Orthopaedic Department is responsible for the musculoskeletal care at 7 different hospitals within the New York City area.	February 1 - April 15; 2020 vs. 2019	Number of ED presentations with hip fracture	Mortality; Non/operative case
Enache; Monaco; National; Same period single year	ED & Hospital; Monaco public health care system	March; 2020 vs. 2019	Number cardiovascular and emergency admissions	N/A
Franco; Italy; Multi-centre; Same period single year	Hospital; 10 cardiology centres in Northern Italy	February 23 - March 28; 2020 vs. 2019	Number of hospitalisations for NSTEMI	N/A
Frankfurter; Canada; Multi-centre; Same period single year	ED & Hospital; University Health Network (Toronto General Hospital and Toronto Western Hospital), in Toronto, Canada	March 1 - April 19; 2020 vs. 2019	Number ED visits and hospitalised with heart failure	ICU admission; Mortality; Hospitalisation; NYHA class III-IV
Garcia; USA; Multi-centre; Time trend single year	Hospital; 18 sites representing primary percutaneous coronary intervention (PPCI) hospitals and healthcare systems across the US	March - April; 2020 vs. 2019	Monthly volume of cardiac catheterisation leading to intervention (angiography)	N/A

Gawron; USA; National; Time trend single year	Hospital & Outpatient; 170 medical centres and 1074 outpatient sites	March - April; 2020 vs. 2019	Average number of upper gastrointestinal endoscopies per month	N/A
Giuntoli; Italy; Multi-centre; Same period single year	Hospital; three of the major trauma and elective orthopaedic surgery centres of north-west Tuscany	March; 2020 vs. 2019	Number of patients treated	Hospitalisation
Gruttadauria; Italy; Multi-centre; Same period single year	Hospital; 22 Italian Liver Transplant Programs.	March 1 - March 15; 2020 vs. 2018-19	Number of liver transplants	N/A
Hartnett; USA; Multi-centre; Same period single year	ED; subset of hospitals in 47 states capturing approximately 73% of ED visits in the USA	March 29 - April 25; 2020 vs. 2019	Mean weekly ED presentations	N/A
Houshyar; USA; Multi-centre; Same period single year	ED & Hospital; 5 University of California Health Centres with academic radiology programs.	March 19 - April 2; 2020 vs. 2019	Daily number of ED radiologic examinations	N/A
Hoyer; Germany; Multi-centre; Same period single year	ED & Hospital; 4 German comprehensive stroke centres.	March 16 - April 12; 2020 vs. 2019	Numbers of patients admitted with final diagnoses of ischemic stroke or TIA	TIA/ Stroke

Isba; UK; Multi-centre; Same period single year	ED; 2 hospitals in greater Manchester	February - March; 2020 vs. 2019	Weekly PED attendances	N/A
Jasne; USA; Multi-centre; Same period single year	ED & Hospital; 3 hospitals in New Haven, Connecticut	March 1 - April 28; 2020 vs. 2019	Weekly stoke code calls	N/A
Kadavath; USA; Multi-centre; Same period single year	Hospital; 12 fellowship training sties	March 1 - April 15; 2020 vs. 2019	Number of invasive cardiac procedures	N/A
Kerleroux; France; Multi-centre; Same period single year	Hospital; 32 centres in all French administrative regions.	February 15 - March 30; 2020 vs. 2019	Number of patients receiving MT between study periods	% unwitnessed onset; Baseline NIHSS; ASPECTs
Kessler; Germany; Multi-centre; Same period single year	Hospital; 15 cardiac care centres distributed across Germany providing 24/7 interventional cardiac care.	March 1 - April 30; 2020 vs. 2019	Number of patients presenting with Acute Coronary Syndrome	STEMI/NSTEMI
Kim; USA; Multi-centre; Same period single year	ED; seven EDs include one urban academic hospital, five suburban community hospitals, and one free-standing ED.	March 8 - May 2; 2020 vs. 2019	Weekly Emergency Department visits	N/A

Kolbaek; Denmark; Multi-centre; Same period single year	Community/Outpatient; Psychiatric services	February 23 - May 2; 2020 vs. 2019	Number of referrals to psychiatric service	N/A
Krenzlin; Germany; Multi-centre; Same period single year	Hospital; Two major neurosurgical departments in Germany	March 16 - April 19; 2020 vs. 2018-19	Number of emergency admissions	N/A
Langdon-Embry; USA; Multi-centre; Same period single year	Community; childhood immunisation facilities in New York City	March 16 – May 31; 2020 vs. 2019	Number of childhood vaccine doses administered; Number of unique facilities reporting administration of at least one childhood vaccine	N/A
Lantelme; France; Multi-centre; Same period single year	Hospital; 3 public centres in Lyon.	March 9 - April 5; 2020 vs. 2019	Weekly rate of hospital admissions for myocardial infarction	N/A
Lazaros; Greece; Multi-centre; Same period single year	Hospital; 2 large hospitals of the National Health System belonging to the larger Metropolitan area of Athens	March 12 - May 7; 2020 vs. 2019	Number of cardiac surgery procedures	Emergency vs non-emergency
Lazzerini; Italy; Multi-centre; Same period single year	ED; 5 Pediatric ED (three third-level referral hospitals and two second-level hospitals)	March 1 - March 27; 2020 vs. 2019	Number of paediatric emergency department visits	N/A

Li; Taiwan; Multi-centre; Same period single year	Hospital; 40 major hospitals	February - April; 2020 vs. 2019	Number of patients admitted for STEMI	N/A
Lui; Hong Kong; National; Same period single year	Hospital; all public hospitals	January 21 - March 31; 2020 vs. 2017-19	Upper and lower endoscopies	Positive rate for colon cancer and gastric cancer
Mafham; UK; National; Same period single year	Hospital; 147 acute NHS hospital trusts	January 6 - May 30; 2020 vs. 2019	Admissions for Acute Coronary Syndromes	Proportions of STEMI vs NSTEMI
Manzoni; Italy; Multi-centre; Same period single year	ED; 2 emergency paediatric departments	March - April; 2020 vs. 2019	Volume of ED visits	Hospitalisation
Mazzatenta; Italy; Multi-centre; Same period single year	Hospital; 5 neurosurgery departments and 1 paediatric centre	March 13 - April 13; 2020 vs. 2018-19	Outpatient consultations; Surgical activities	Urgent/nonurgent surgery
McDonald; UK; National; Same period single year	Community; electronic patient records of vaccination	March 2 - April 25; 2020 vs. 2019	Hexavalent vaccines; MMR first vaccination	N/A

Mitchell; Australia; Multi-centre; Time trend multiple years	ED & Hospital; 2 Emergency Departments	March 26 - April 25; 2020 vs. 2017-19	Daily number of ED presentations	Triage category
Naidich; USA; Multi-centre; Same period single year	Hospital & Outpatient; 92 centres across NY state	March 2 - April 18; 2020 vs. 2019	Volume of imaging	N/A
Norbash; USA; Multi-centre; Same period single year	Hospital & Outpatient; 6 academic medical systems	January 6 - May 23; 2020 vs. 2019	Volume of imaging	N/A
Novara; Italy; Multi-centre; Same period single year	ED; EDs within 8 academic and non-academic urology centres	March 12 - March 16; 2020 vs. 2019	ED urological consults	Triage category/ hospitalisation
Onteddu; Multi-national; Multi-centre; Same period single year	Hospital; TriNetX, a global health collaborative clinical research platform collecting real-time electronic medical record data from a network of health care organizations	January 20 - May 16; 2020 vs. 2019	Number of ischemic stroke patients	N/A
Papafakis; Greece; Multi-centre; Same period single year	Hospital; Greek public hospitals with PCI capability, including a primary PCI service	March 2 - April 12; 2020 vs. 2019	Number of patients admitted for Acute coronary syndrome	ACS presentation

Pignon; France; Multi-centre; Same period single year	ED; 3 psychiatric emergency services	March 17 - April 13; 2020 vs. 2019	Emergency psychiatric consultations	Rates of hospitalisation
Pinar; France; Multi-centre; Same period single year	Hospital; 8 academic urology departments	March 12 - March 27; 2020 vs. 2019	Urological surgeries	N/A
Polo Lopez; Spain; Multi-centre; Same period single year	Hospital; 13 public hospitals where most congenital heart disease surgery in Spain is performed	March 13 - May 13; 2020 vs. 2019	Number of congenital heart disease surgeries	N/A
Pop; France; Multi-centre; Same period single year	Hospital; 3 hospitals with stroke units	March 1 -March 31; 2020 vs. 2019	Stroke alerts (following initial consult)	Proportion of alerts resulting in admissions for stroke; Initial NIHSS score
Qasim; USA; Multi-centre; Same period single year	ED; 4 adult and 2 paediatric Level 1 Trauma centres	March 9 - April 19; 2020 vs. 2019	Trauma contacts	Rates of highest acuity ("alerts")
Range; France; Multi-centre; Time trend single year	Hospital; 12 interventional cardiology centres	March 15 - April 4; 2020 vs. 2019	Patients enrolled in Percutaneous Coronary Intervention registry (follows all STEMI patients undergoing PCI)	N/A

Reeves; UK; Multi-centre; Time trend multiple years	Hospital; University hospitals in one NHS Foundation Trust	March 22 - April 25; 2020 vs. 2016-19	Admissions for STEMI and stroke	N/A
Requena; Multi-national; Multi-centre; Same period single year	Community; 2 fertility facilities in Spain and 1 in Italy	February 3 - March 23; 2020 vs. 2019	Fertility related procedures	N/A
Romaguera; Spain; Multi-centre; Same period single year	Hospital; 10 percutaneous coronary intervention hospitals	March 1 - April 19; 2020 vs. 2019	STEMI admissions	Proportion of more severe Killip classes; Proportion of sudden cardiac death; mortality
Scaramuzza; Italy; Multi-centre; Same period single year	ED; 2 paediatric emergency departments	February 20 - March 30; 2020 vs. 2019	Presentations to paediatric ED	Reductions across different triage categories
Salerno; Italy; National; Same period single year	Hospital; 35 endoscopy units in Italy	March; 2020 vs. 2019	Number of urgent endoscopic procedures	Proportion of positive procedures (i.e. diagnostic yield) for urgent EGDs and lower endoscopy
Santana; Portugal; National; Time trend multiple years	ED; emergency services in mainland Portugal	March; 2020 vs. 2019	Number of emergency episodes	Triage category

Scholz; Germany; Multi-centre; Same period single year	Hospital; 41 percutaneous coronary intervention centres participating in a trial	March; 2020 vs. 2017-19	Number of STEMI patients treated	Mortality; TIMI score
Secco; Italy; Multi-centre; Same period single year	Hospital; 3 high volume centres in North and Central Italy	March; 2020 vs. 2019	Number of admissions for ACS	Type of ACS; TIMI score; GRACE score; Admission peak hs-troponin; Mortality
Seiffert; Germany; National; Same period single year	Hospital; Health insurance claims from second largest insurer in Germany	March 2 - May 31; 2020 vs. 2019	Rate of admissions/100000 insured for cardiovascular or cerebrovascular emergencies	Number per diagnosis (STEMI, NSTEMI, stroke, TIA); Number of invasive procedures; Mortality
Smalley; USA; Multi-centre; Same period single year	ED; 20 EDs across a large Midwest integrated healthcare system	March 25 - April 24; 2020 vs. 2019	Number of ED encounters; Number of behavioural health visits to the ED	N/A
Tinay; Turkey; Multi-centre; Same period single year	Hospital; Surgical urologic oncology practices	March 11-April 11; 2020 vs. 2019	Number of nondeferrable uro-oncological procedures	ASA score
Toro; Chile; National; Time trend multiple years	ED; public health hospitals, emergency care services in 16 regions of Chile	March 8 - April 18; 2020 vs. 2015-19	Number of emergency service consultations	N/A

Toyoda; Multi-national; Multi-centre; Same period single year	Hospital; 3 liver speciality clinics	February 1 - May 1; 2020 vs. 2018-19	Number of clinic visits; Number of ultrasounds performed; Number of CT/MRIs performed	Visits in advanced disease patients
Wong; Hong Kong; National; Same period single year	Hospital & Outpatient; 43 Hong Kong public hospitals and 122 outpatient clinics	January 25 - March 27; 2020 vs. 2016-19	Mean weekly orthopaedic operations; Mean weekly orthopaedic emergencies treated operatively	Elective and emergency operations
Xu; USA; Multi-centre; Same period single year	Outpatient; retinal care centres	March 8 - May 16; 2020 vs. 2018-19	Mean weekly office visits; Mean weekly intravitreal injections; Mean weekly optical coherence tomography, fluorescein angiography and indocyanine green testing	N/A
Zhao; China; Multi-centre; Same period single year	Hospital; 280 stroke centres across China participating in Big Data Observatory platform	January - February; 2020 vs. 2019	Number of stroke admissions; Number of thrombolysis treatments; Number of thrombectomy treatments	N/A

Abbreviations: CT: Computed Tomography Scan; ED: Emergency Department; MRI: Magnetic resonance imaging; N/A: Not applicable; NIHSS:NIH Stroke Scale Score; NSTEMI: Non-ST elevation myocardial infarction; PED: Paediatric Emergency Department; STEMI: ST-elevation myocardial infarction; TIA: Transient Ischaemic Attack.

Note: *This is the period of time analysed in this Systematic Review, not necessarily all of the time period reported in each study. For a few studies that did not clearly define the pandemic period, we defined that period using any indication/reference in the same article for a lockdown or a surge in the number of COVID-19 cases.

Study design label explanations: ‘Same period single year' - Preinterruption measurement at a comparable time period in 2019 only with basic pre-post analysis (unadjusted or adjusted comparison of mean utilisation across the two comparator periods). An example is a study comparing utilisation in the month of March 2020 with utilisation in the month of March 2019; 'Same period multiple years' - Preinterruption measurement at comparable time periods in prior years (2 or more) with basic pre-post analysis. An example is a study comparing utilisation for weeks 10-16 of 2020 with utilisation during weeks 10-16 in 2019 and 2018 (using the average utilisation from the comparator years) ; 'Time trend single year' – This category refers to studies considering data

from an entire year preinterruption time period rather than a single month or period of weeks. An example is a study documenting utilisation for the period January 2019 to some time point in 2020. In these studies preinterruption utilisation trends may be modelled using data from the prior year to estimate predicted utilisation. This category also includes studies that do not model prior data but average utilisation across the prior year for comparison to a postinterruption period. An example is a study comparing the monthly average utilisation for the period Jan 1 2019 to Feb 29 2020 with the monthly average utilisation for March in 2020. Both these types of studies would be rated as moderate risk of bias; 'Time trend multiple years' – This category refers to studies considering data from more than one entire year prior to the pandemic interruption. An example is a study documenting utilisation from the period January 2014 to some point in 2020. In these studies preinterruption utilisation trends may be modelled using observations from previous years to estimate utilisation that would have occurred in the absence of the pandemic.

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5.2 Table Percentage change in healthcare utilisation for each individual study grouped by category of healthcare utilisation.

Study	Outcome	Comparator time period*	Weeks being compared	Total volume of services	% Change (95% CI)
Admissions					
Andersson	Worsening HF	2019	12 to 13	568 (C: 353; P: 215)	-30
Angoulvant	Ped ED Hospitalisation	2017/18/19**	12 to 16	NR	-45 (-32.4 to -57.0)
Athiel	Gynaecological ED Hospitalisation	2019	10 to 22	1761 (C: 976; P: 785)	-20
Baum	Admissions for any cause	2019	11 to 16	130353 (C: 85326; P: 45027)	-43 (-36.0 to -49.0)
Bollmann	HF	2019	10 to 18	6424 (C: 3604; P: 2820)	-21.8 (-18.0 to - 26.0)
Bollmann	Bradycardia	2019	10 to 18	624 (C: 334; P: 290)	-13.2 (-26.0 to +1.0)
Bollmann	Atrial Fibrillation	2019	10 to 18	2962 (C: 1640; P: 1322)	-19.4 (-13.0 to -25.0)
Bollmann	Supraventricular tachycardia	2019	10 to 18	525 (C: 283; P: 242)	-14.5 (-28.0 to +1.0)
Bollmann	Ventricular tachyarrhythmia	2019	10 to 18	433 (C: 251; P: 182)	-27.5 (-13.0 to -40.0)
Braiteh	ACS	2019	10 to 18	180 (C: 113; P: 67)	-40.71
Braiteh	Admissions for any cause	2019	10 to 18	6108 (C: 3496; P: 2612)	-25.29
Claeys	STEMI	2017/18/19	12 to 14	NR	-26

Clerici	Psychiatric hospitalisation	2019	8 to 13	618 (C: 354; P: 264)	-25.42
CVD-Covid-UK Consortium	Total	2018/19	6 to 19	1113075 (C: 599372; P: 513703)	-58.2 (-57.5 to -58.9)
De Filippo	ACS	2019	9 to 13	1320 (C: 775; P: 545)	-29.6 (-22.0 to -37.0)
de Havenon	Stroke	2018/19	6 to 13	33867 (C: 17380; P: 16487)	-5.14
de Havenon	ACS	2018/19	6 to 13	24441 (C: 12111; P: 12330)	1.81
De Rosa	AMI	2019	12 to 19	937 (C: 618; P: 319)	-48.4 (-44.6 to-52.5)
De Rosa	HF	2019	12 to 19	236 (C: 154; P: 82)	-46.8 (-39.5 to -55.3)
De Rosa	Atrial Fibrillation	2019	12 to 19	129 (C: 88; P: 41)	-53.4 (-43.9 to -64.9)
De Rosa	Pulmonary Embolism	2019	12 to 19	29 (C: 17; P: 12)	-29.4 (-0.14 to -0.61)
Diegoli	Stroke	2019	8 to 16	1169 (C: 713; P: 456)	-36.15 (-7.7 to -64.6)
Egol	Hip fracture	2019	6 to 16	253 (C: 115; P: 138)	20
Enache	Cardiovascular disease	2019	10 to 13	765 (C: 419; P: 346)	-17.42
Franco	STEMI	2019	9 to 13	215 (C: 105; P: 110)	4.8
Franco	NSTEMI	2019	9 to 13	1249 (C: 1105; P: 144)	-87
Frankfurter	Worsening HF	2019	10 to 16	256 (C: 149; P: 107)	-39.3 (-8.6 to -78.5)
Hoyer	Strokes admissions	2019	10 to 15	NR	-15.2
Hoyer	TIA admissions	2019	10 to 15	NR	-38.5
Jasne	Strokes admissions	2019	8 to 17	863	-37.2

				(C: 530; P: 333)	
Kessler	ACS	2019	10 to 18	5920 (C: 3411; P: 2509)	-27 (-23.0 to -30.0)
Lantelme	AMI	2019	11 to 14	240 (C: 142; P: 98)	-30.99
Li	STEMI	2019	6 to 18	2130 (C: 1092; P: 1038)	-4.95
Mafham	ACS	2019	2 to 22	120076 (C: 65375; P: 54701)	-40 (-37 to -43)
Manzoni	Ped	2019	10 to 18	91 (C: 73; P: 18)	-75
Onteddu	Strokes	2019	4 to 20	104615 (C: 66674; P: 37941)	-43.09
Papafaklis	ACS	2019	10 to 15	1848 (C: 1077; P: 771)	-28.41 (-21.0 to -35.0)
Reeves	STEMI	2016/17/18/19	13 to 17	155 (C: 85; P: 70)	-17.3
Reeves	Stroke	2016/17/18/19	13 to 17	230 (C: 175; P: 155)	-15.6
Romaguera	STEMI	2019	10 to 16	919 (C: 524; P: 395)	-24.6 (-14.0 to -34.0)
Secco	ACS	2019	10 to 13	246 (C: 162; P: 84)	-48.15 (-33.0 to -61.0)
Seiffert	Cardiovascular or cerebrovascular emergencies	2019	10 to 22	67443 (C: 35841; P: 31602)	-14.97
Zhao	Stroke	2019	6 to 9	56306 (C: 34725; P: 21581)	-37.9
Diagnostics					
Collado-Mesa	Breast imaging	2018/19	14 to 18	8239 (C: 7142; P: 1097)	-84.64
Houshyar	ED volume of all imaging	2019	13 to 14	5871 (C: 3552; P: 2319)	-34.7 (-12.0 to -57.4)

	(MRI, CT, x-ray, US, fluoroscopy)				
Lui	Upper endoscopies	2017/18/19	4 to 13	2700 (C: 1813; P: 887)	-51.1
Lui	Lower endoscopies	2017/18/19	4 to 13	1681 (C: 1190; P: 491)	-58.7
Naidich	Total imaging volume	2019	10 to 16	408067 (C: 237388; P: 170679)	-28.1
Naidich	ED imaging volume	2019	10 to 16	195160 (C: 112579; P: 82581)	-26.6
Naidich	Inpatient imaging volume	2019	10 to 16	147070 (C: 78902; P: 68168)	-13.6
Naidich	Outpatient imaging volume	2019	10 to 16	65837 (C: 45907; P: 19930)	-56.6
Norbash	All radiological requests	2019	2 to 21	282749 (C: 203132; P: 79617)	-21.8
Toyoda	Abdominal US	2018/19	6 to 18	4506 (C: 2566; P: 1940)	-24.4
Toyoda	Abdominal CT/MRIs	2018/19	6 to 18	3553 (C: 1874; P: 1679)	-10.38
Xu	Optical coherence tomography, indocyanine green, fluorescent angiography	2018/19	11 to 20	566955 (C: 355458; P: 211497)	-40.5 (-26.4 to -54.7)
Therapeutics, Procedures, Surgeries					
Benazzo	Trauma surgeries	2019	9 to 14	1011 (C: 559; P: 452)	-19.2
Benazzo	Femoral neck fracture surgeries	2019	9 to 14	656 (C: 349; P: 307)	-12.2
Bollmann	Catheter ablations	2019	10 to 18	472 (C: 264; P: 208)	-21.2 (-6.0 to -44.0)
Bollmann	CRM device implantations	2019	10 to 18	675 (C: 365; P: 310)	-15.1 (-1.0 to -27.0)

Bozovich	Coronary angioplasties	2019	14 to 18	1330 (C: 946; P: 384)	-59.41 (-50.0 to -67.0)
Bozovich	Heart surgeries	2019	14 to 18	400 (C: 282; P: 118)	-58.16 (-46.0 to -100)
Bozovich	PCI	2019	14 to 18	2501 (C: 1850; P: 651)	-64.81 (-50.0 to -78.0)
Bozovich	General surgeries	2019	14 to 18	24805 (C: 19600; P: 5205)	-73.44 (-62.0 to -75.0)
Bozovich	Chemotherapy and radiotherapy	2019	14 to 18	9227 (C: 5005; P: 4222)	-15.64 (-3.0 to -52.0)
Bozovich	GI endoscopies	2019	14 to 18	8549 (C: 7137; P: 1412)	-80.22 (-77.0 to -93.0)
Bramer	Non-influenza immunisation for children	2017/18/19	1 to 18	NR	-21.5
Cano-Valderrama	Acute surgeries	2019	12 to 17	402 (C: 285; P: 117)	-58.95
de Havenon	MT	2018/19	6 to 13	725 (C: 319; P: 406)	27.3
de Havenon	tPA	2018/19	6 to 13	570 (C: 266; P: 304)	14.3
de Havenon	PCI	2018/19	6 to 13	2596 (C: 1330; P: 1266)	-4.81
Garcia	Cardiac catheterisation	2019	10 to 18	1332 (C: 779; P: 553)	-29.1
Gawron	Gastrointestinal endoscopies	2019	10 to 18	34053 (C: 23455; P: 10598)	-54.81
Gawron	Colonoscopies	2019	10 to 18	57183 (C: 43371; P: 13812)	-68.15
Giuntoli	Scheduled orthopaedic procedures	2019	10 to 13	583 (C: 444; P: 139)	-68.69

Giuntoli	Trauma orthopaedic procedures	2019	10 to 13	488 (C: 270; P: 218)	-19.26
Gruttadauria	Liver transplantation and related procedures	2018/19	10 to 11	98 (C: 61; P: 37)	-39.34
Kadavath	Invasive cardiac procedures	2019	10 to 16	7219 (C: 4671; P: 2548)	-45.45
Kerleroux	MT for stroke	2019	8 to 13	1512 (C: 844; P: 668)	-21 (-18.0 to -24.0)
Langdon-Embry	Routine childhood immunisation	2019	12 to 22	590000 (C: 344000; P: 246000)	-28.49
Lazaros	Cardiac surgery procedures	2019	12 to 19	330 (C: 246; P: 84)	-65.85
Mafham	PCI after the admission day	2019	2 to 22	17469 (C: 8055; P: 9414)	-47 (-37 to -52)
Mafham	PCI on the admission day	0	2 to 22	19277 (C: NR; P: NR)	-16 (-7 to -24)
Mafham	CABG	2019	2 to 22	3196 (C: 2663; P: 533)	-80 (-68 to -87)
Mafham	Angiography	2019	2 to 22	16079 (C: 11485; P: 4594)	-60 (-53 to -65)
Mazzatenta	Non-urgent surgical procedures	2018/19	12 to 15	918 (C: 713; P: 205)	-71.25
Mazzatenta	Urgent surgical procedures	2018/19	12 to 15	274 (C: 161; P: 113)	-29.6
McDonald	Hexavalent vaccine (first does)	2019	10 to 17	62692 (C: 31475; P: 31217)	-0.82
McDonald	MMR vaccine (first does)	2019	10 to 17	59809 (C: 30989; P: 28820)	-7
Onteddu	tPA	2019	4 to 20	1841	-50.93

				(C: 1235; P: 606)	
Onteddu	MV	2019	4 to 20	644 (C: 399; P: 245)	-38.6
Pinar	Urological surgeries	2019	12 to 13	1439 (C: 995; P: 444)	-55.4
Polo Lopez	Congenital heart diseases surgeries	2019	12 to 20	193 (C: 142; P: 51)	-51
Range	Coronary angiography for STEMI	2019	10 to 13	430 (C: 246; P: 184)	-25.2
Requena	Frozen embryo transfer	2019	6 to 12	4461 (C: 2500; P: 1961)	-21.5
Requena	IVF	2019	6 to 12	5441 (C: 3007; P: 2434)	-19.1
Requena	IUI	2019	6 to 12	1301 (C: 564; P: 467)	-17.3
Salerno	Urgent GI endoscopic procedures	2019	10 to 13	2305 (C: NR; P: NR)	-39.49
Tinay	Non-deferrable uro-oncological procedures	2019	11 to 15	290 (C: 200; P: 90)	-55
Wong	Orthopaedic operations	2016/17/18/19	5 to 13	928278 (C: 595814; P: 332464)	-44.2 (-54.7 to -33.7)
Xu	Intravitreal injections	2018/19	11 to 20	454765 (C: 235996; P: 218769)	-7.3 (2.2 to -16.8)
Zhao	Thrombolysis	2019	6 to 9	5930 (C: 3422; P: 2508)	-25.5
Zhao	Thrombectomy	2019	6 to 9	2268 (C: 1298; P: 970)	-22.7
Visits					
Abdulmalik	All primary care services	2018/19	10 to 22	1384037 (C: 872691; P: 511346)	-41.41

Angoulvant	Ped ED	2017/18/19**	12 to 16	871543 (C: NR; P: NR)	-68 (-55.8 to -81.2)
Antonucci	ED urological	2019	10 to 18	304 (C: 201; P: 103)	48.8
Athiel	Gynaecological ED	2019	10 to 22	39690 (C: 24982; P: 14708)	-41
Bayles, preprint	ED	2018/19	12 to 18	21527 (C: 17230; P: 4297)	-50.1 (-39.5 to -60.7)
Benazzo	Orthopaedic outpatient	2019	9 to 14	17041 (C: 6863; P: 10178)	-48.3
Benazzo	ED trauma	2019	9 to 14	14772 (C: 6050; P: 8722)	-44.17
Benazzo	Elective orthopaedic surgeries	2019	9 to 14	8113 (C: 3065; P: 5048)	-64.7
Bozovich	ED	2019	14 to 18	268899 (C: 213947; P: 54952)	-74.32 (-65.0 to -79.0)
Butt	ED	2019	10 to 18	102033 (C: 58858; P: 43175)	-26.7
Cheek	ED	2019	13 to 21	41041 (C: 26871; P: 14170)	-47.27 (-44.2 to -50.3)
Chou	Hospice home care visits	2019	1 to 18	1516 (C: 777; P: 739)	-4.89
CVD-Covid-UK Consortium	ED	2018/19	6 to 19	942169 (C: 506516; P: 435653)	-52.8 (-52.2 to -53.5)
CVD-Covid-UK Consortium	ED cardiac	2018/19	6 to 19	NR	-40.2 (-35.6 to -45.0)
CVD-Covid-UK Consortium	ED cerebrovascular	2018/19	6 to 19	NR	-31.8 (-26.2 to -38.0)

CVD-Covid-UK Consortium	ED vascular	2018/19	6 to 19	NR	-40.6 (-31.5 to -50.3)
Frankfurter	Symptoms suggestive of HF	2019	10 to 16	1906 (C: 800; P: 1106)	38.3 (26.3 to 51.6)
Frankfurter	HF	2019	10 to 16	314 (C: 186; P: 128)	-43.5 (-14.8 to -79.4)
Giuntoli	Orthopaedic first aid visits	2019	10 to 13	1679 (C: 1301; P: 378)	-70.95
Hartnett	ED	2019	11 to 22	3319945 (C: 2099734; P: 1220211)	-31.47
Isba	Ped ED	2019	6 to 13	NA (C: NA; P: NA)	-17.74
Kim	ED	2019	11 to 18	68384 (C: 38712; P: 29672)	-44 (-33.0 to -53.0)
Kolbaek	Referrals to psychiatric services	2019	9 to 18	7982 (C: 4419; P: 3563)	-19.4
Krenzlin	ED Neurosurgery	2018/19	12 to 16	2646 (C: 1824; P: 822)	-44.7 (-42.6 to -46.8)
Lazzerini	Ped ED	2019	10 to 13	10826 (C: 8818; P: 2008)	-77.72 (-73.0 to -88.0)
Manzoni	Ped ED	2019	10 to 18	1654 (C: 1428; P: 226)	-86 (-32.0 to -55.0)
Mazzatenta	Outpatient neuro-surgical	2018/19	12 to 15	2234 (C: 1768; P: 466)	-73.6
Mitchell	ED	2017/18/19	14 to 17	14059 (C: 8643; P: 5416)	-37.3 (-33.0 to -41.0)
Novara	ED urological	2019	12	399 (C: 275; P: 124)	-54.9
Pignon	ED psychiatric	2019	12 to 15	1777 (C: 1224; P: 553)	-54.8
Pop	Stroke	2019	10 to 13	462	-39.6

				(C: 288; P: 174)	
Qasim	Trauma	2019	11 to 16	2386 (C: 1328; P: 1058)	-20.3
Santana	ED	2019**	10 to 13	863414 (C: NR; P: NR)	-47.98
Scaramuzza	Ped ED	2019	9 to 13	3912 (C: 2958; P: 954)	-67.8
Scholz	STEMI	2017/18/19	10 to 13	1716 (C: 1329; P: 387)	-12.64
Smalley	ED	2019	13 to 17	87840 (C: 56453; P: 31387)	-44.4
Toro	ED	2015/16/17/18/19	10 to 18	5045647 (C: 3198508; P: 1847139)	-42.25
Toro	Circulatory system ED	2015/16/17/18/19	10 to 18	105471 (C: 58439; P: 47032)	-19.52
Toro	Stroke ED	2015/16/17/18/19	10 to 18	11004 (C: 6385; P: 4619)	-27.66
Toyoda	Liver clinics	2018/19	6 to 18	8568 (C: 5335; P: 3233)	-39.4
Xu	Retinal outpatient clinics	2018/19	11 to 20	813585 (C: 485433; P: 328152)	-32.4 (-20.4 to - 44.4)

*this is the comparator year that studies included in their comparison to the 2020 time period; **these studies compared the expected/forecasted utilisation for 2020 from data from these years

Abbreviations: ED: emergency department; HF: Heart Failure; IVF: In vitro fertilisation; IUI: Intrauterine insemination; MT: Mechanical thrombectomy; tPA: tissue Plasminogen Activator; CABG: Coronary artery bypass grafting; ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; STEMI: ST Elevation Myocardial Infarction; MRI: Magnetic Resonance Imagine; CT: computerized tomography; US: Ultrasonography; CRM: Cardiac rhythm management; PCI: Percutaneous Coronary Interventions; GI: Gastrointestinal

For studies that reported the changes in healthcare services as incidence rate ratios, IRR, we estimated the % change in healthcare services as 100* (1-IRR). For example, IRR of 0.75 converted to 25% reduction in healthcare services

5.3 Table of results of secondary outcomes of the included studies

Study	Secondary Outcome	Change in proportions of severe patients*	P-value, if provided
Andersson	Mortality	No change	0.45
Braiteh	STEMI/NSTEMI	No change	NR
Butt	% ACS from those presented with cardiac symptoms	Increase	NR
Cano-Valderrama	SOFA score >0	No change	0.16
Claeys	% Cardiac arrest	No change	0.7
Claeys	Killip class	No change	0.7
Claeys	Mortality	No change	0.6
Clerici	Voluntary/involuntary admission	Increase	NR
Collado-Mesa	Positive biopsy (diagnostic yield)	No change	NR
CVD-COVID	Procedures for cardiac, cerebrovascular, other vascular conditions	No change	NR
De Rosa	Mortality	Increase	<0.001
De Rosa	STEMI/NSTEMI	Increase	NR
De-Filippo	STEMI/NSTEMI	No change	0
Diegoli	Admissions for severe stroke (NIH stroke scale score)	Increase	NR
Egol	Mortality (In-patient and 30 day)	Increase	0.005-0.035
Egol	Non-operative cases	No change	0.793
Frankfurter	Hospitalisation	No change	0.22
Frankfurter	ICU admission	No change	0.86
Frankfurter	In-hospital mortality	No change	0.05
Frankfurter	NYHA class III-IV	No change	0.3
Giuntoli	Hospitalisation	Increase	NR
Hoyer	Stroke/TIA	Increase	NR
Kerleroux	% unwitnessed onset	Increase	0.004
Kerleroux	ASPECTs score	Increase	0.041

Kerleroux	Baseline NIHSS	No change	0.279
Kessler	STEMI/NSTEMI	No change	0
Lazaros	Emergency/nonemergency	Increase	<0.001
Lui	Positive rate for colon cancer	Increase	<0.001
Lui	Positive rate for gastric cancer	No change	0.14
Mafham	STEMI/NSTEMI	Increase	NR
Manzoni	Hospitalisation	Increase	<0.001
Mazzatenta	Urgent/Nonurgent	Increase	NR
Mitchell	Triage category	No change	NR
Novara	Hospitalisation	No change	0.8
Novara	Triage category	No change	0.06
Papafakis	STEMI/NSTEMI	Increase	NR
Pignon	Hospitalisation	No change	0.872
Pop	admission	Increase	NR
Pop	Initial NIHSS score	No change	0.886
Qasim	Changes in % of all trauma volume that was at the highest level of acuity (described as 'alert')	Increase	0.006
Romaguera	% of patients with sudden cardiac death	No change	0
Romaguera	10-day mortality	No change	0.459
Romaguera	Killip class II-IV	No change	0.8
Salerno	Diagnostic yield for urgent EGDs	Increase	<0.001
Salerno	Diagnostic yield for urgent lower endoscopy	No change	0.3
Santana	Triage category	No change	0
Scaramuzza	Triage category	Increase	0
Scholz	In-hospital mortality	No change	0.68
Scholz	TIMI score	No change	0.464
Secco	GRACE score	Increase	<0.01
Secco	Peak troponin	Increase	<0.01
Secco	STEMI/NSTEMI	Increase	<0.01
Secco	Mortality	No change	NS

Seiffert	Acute stroke/TIA	Increase	0
Seiffert	STEMI/NSTEMI	Increase	0
Seiffert	In-hospital mortality	No change	0
Seiffert	Intervention/surgeries	No change	0
Tinay	ASA scores	Increase	0.005
Toyoda	Visits in advanced disease patients	No change	0.11
Wong	Emergency/elective	Increase	NR

Note: *This secondary outcome domain is exploring, if there is a reduction in services, whether or not there is a greater or lesser reduction in the proportion of patients/people using the service who have milder or more severe forms of illness. If there is an increase in the proportions with more severe illness - which means a greater reduction among those with milder illness – then an “increase” is recorded in this column.

5.4 Figures Change in healthcare utilisation for each category of healthcare services:

Each dot represents a study estimate for each calendar week. For studies that only provided averages of changes for the whole study period, we plotted the average estimates for each calendar week of the corresponding study period.

Figure 5.4a visits

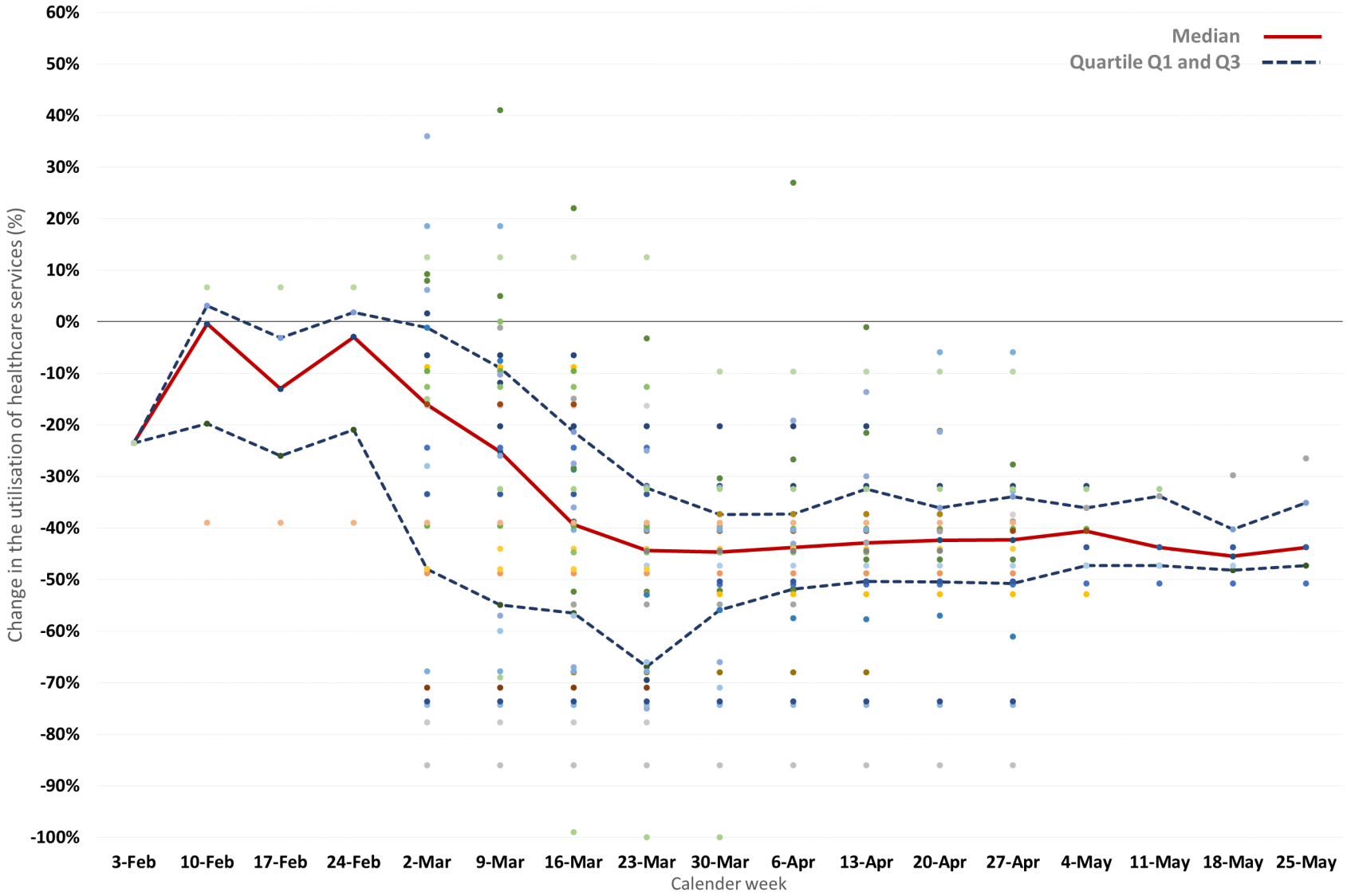


Figure 5.4b admissions

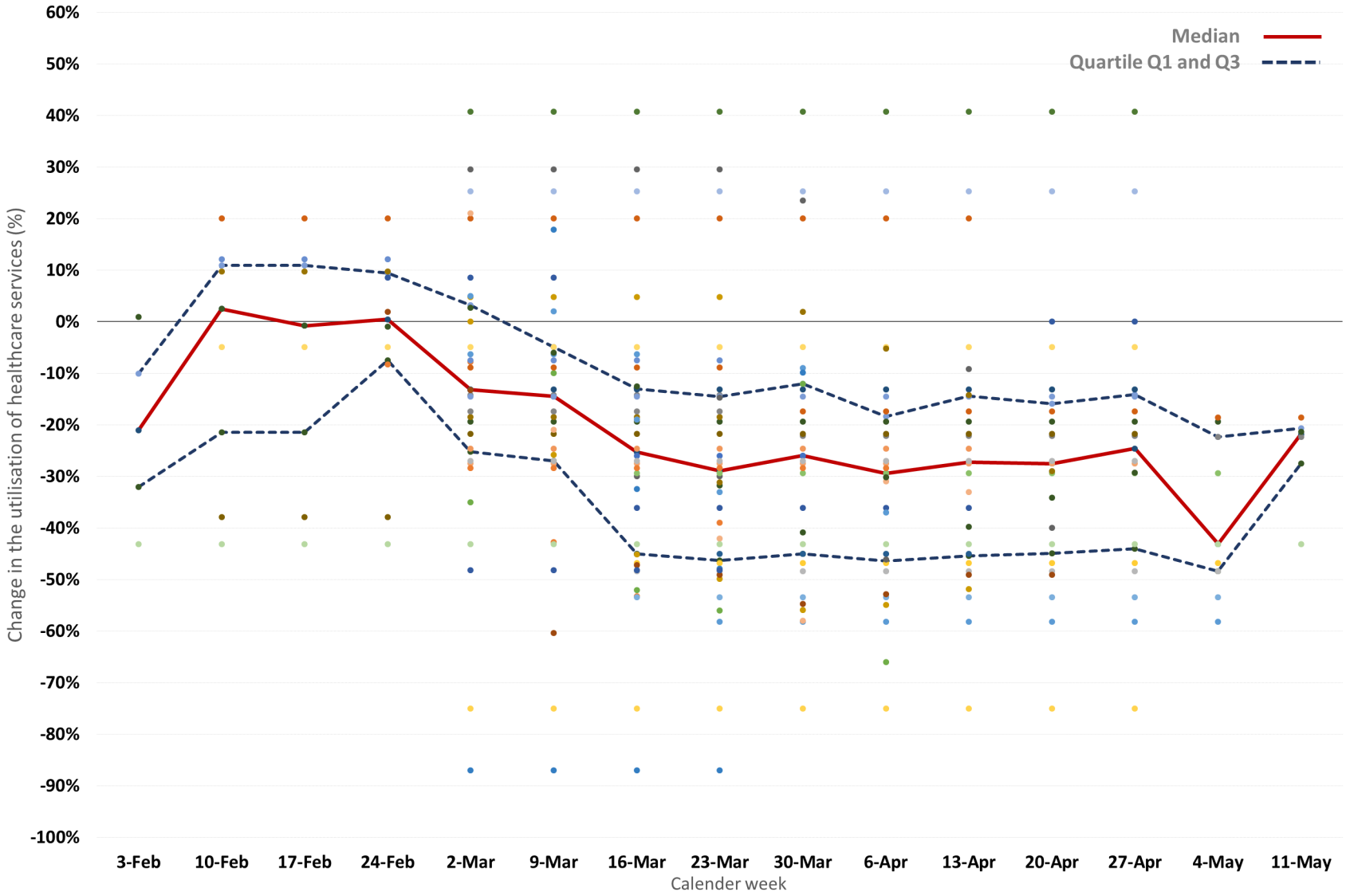


Figure 5.4c diagnostics

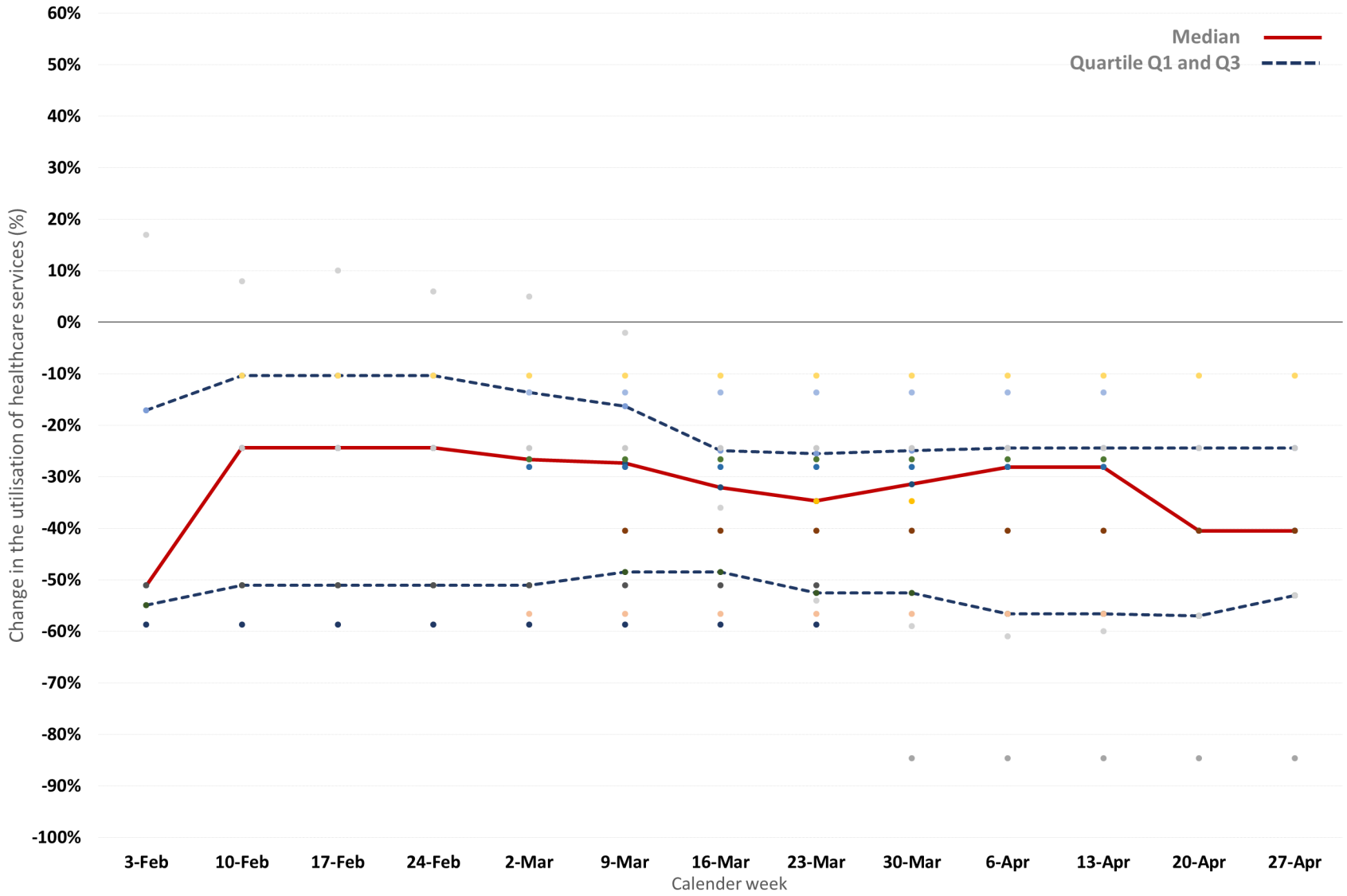
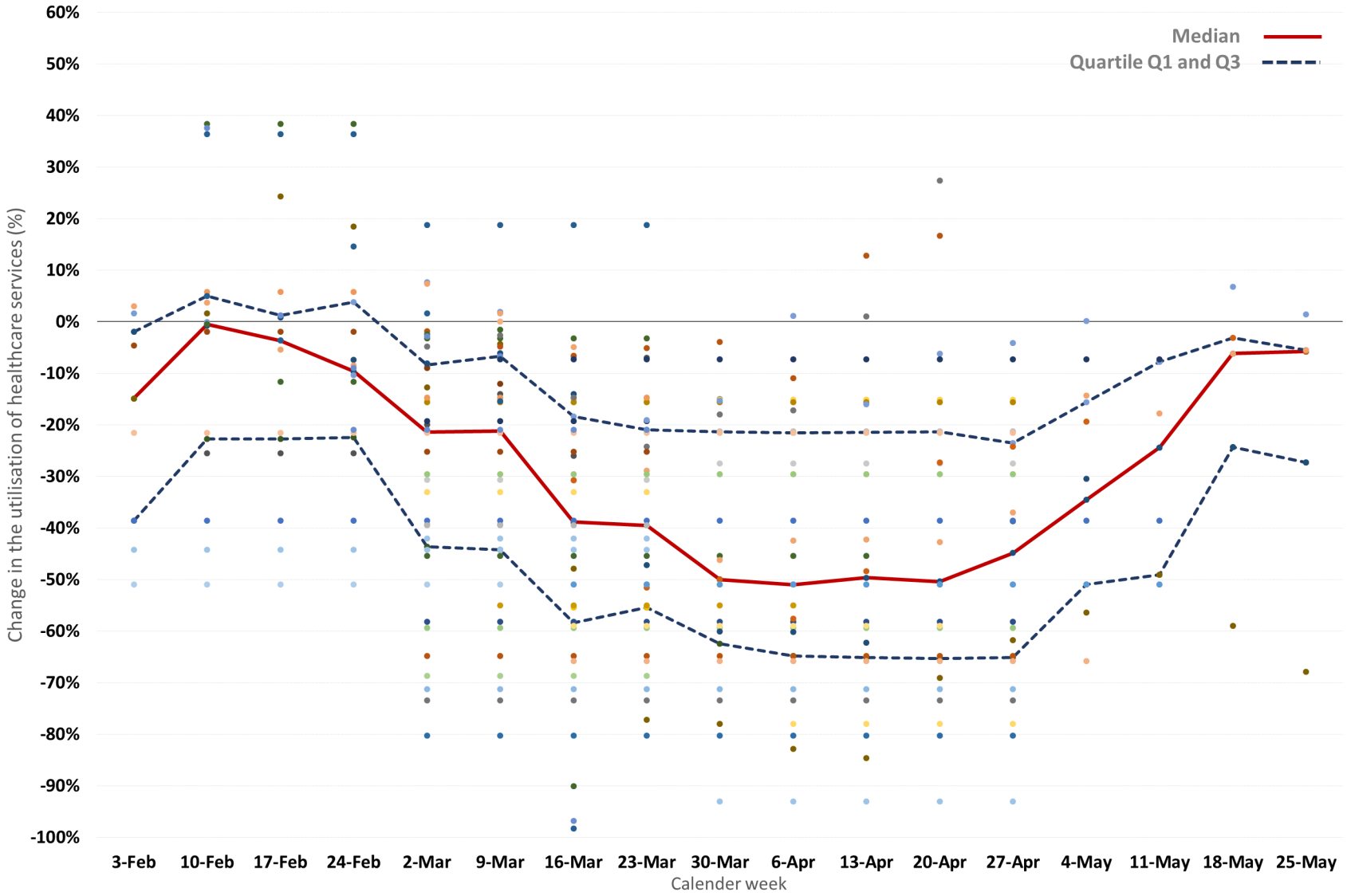


Figure 5.4d therapeutics



BMJ Open

Impact of the COVID-19 pandemic on utilisation of healthcare services: a systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-045343.R1
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Title "Impact of the COVID-19 pandemic on utilisation of healthcare services: a systematic review"

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Abstract

Objectives: To determine the extent and nature of changes in utilisation of healthcare services during COVID-19 pandemic.

Design: Systematic review

Eligibility: Eligible studies compared utilisation of services during COVID-19 pandemic to at least one comparable period in prior years. Services included visits, admissions, diagnostics, and therapeutics. Studies were excluded if from single-centres or studied only COVID-19 patients.

Data sources: PubMed, Embase, Cochrane COVID-19 Study Register, and pre-prints were searched, without language restrictions, until August 10, using detailed searches with key concepts including COVID-19, health services and impact.

Data analysis: Risk of bias was assessed by adapting ROBINS-I and Cochrane Effective Practice and Organization of Care tool. Results were analysed using descriptive statistics, graphical figures, and narrative synthesis.

Outcome measures: Primary outcome was change in service utilisation between pre-pandemic and pandemic periods. Secondary outcome was the change in proportions of users of healthcare services with milder or more severe illness (e.g. triage scores).

Results: 3097 unique references were identified, and 81 studies across 20 countries included, reporting on >11 million services pre-pandemic and 6.9 million during pandemic. For the primary outcome, there were 143 estimates of changes, with a median 37% reduction in services overall (interquartile range -51% to -20%), comprising median reductions for visits of 42%(-53% to -32%), admissions, 28%(-40% to -17%), diagnostics, 31%(-53% to -24%), and for therapeutics, 30%(-57% to -19%). Among 35 studies reporting secondary outcomes, there were 60 estimates, with 27(45%) reporting larger reductions in utilisation among people with a milder spectrum of illness, and 33 (55%) reporting no difference.

Conclusions: Healthcare utilisation decreased by about a third during the pandemic, with considerable variation, and with greater reductions among people with less severe illness. While addressing unmet need remains a priority, studies of health impacts of reductions may help health-systems reduce unnecessary care in the post-pandemic recovery.

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Strengths and limitations of this study

- The review is the first broad synthesis of global studies of pandemic related changes in utilisation across all categories of healthcare services.
- The review provides novel findings informing design of future studies of pandemic-related changes in utilisation and its impacts.
- Limitations include the possibility of publication bias and the potential of our eligibility criteria to exclude important data sources such as studies in single-centres and unpublished datasets from health systems.
- Heterogenous designs and settings precluding meta-analysis.

Introduction

As the COVID-19 pandemic continues, many studies have reported major changes in utilisation of healthcare services because of such measures as lockdowns and stay-at-home orders. [1-3] These changes include large reductions in services, particularly in places hit hard by the pandemic, but also some selective increases, such as for telemedicine. [4] Many people have missed out on much needed care, such as vaccination or life-extending interventions for cancer. [2,5,6] A World Health Organization survey found disruption to healthcare services greatest among lower income countries, [7] and there are estimates that reduction of essential maternal and child health interventions may cause more than a million additional child deaths. [8] Concurrently the pandemic may also have resulted in some people being spared unnecessary or inappropriate care with has the potential to cause harm. [9,10] The problem of too much medicine is well documented, [11-17] and multiple global campaigns are addressing this challenge, such as Choosing Wisely, which is active in more than 20 countries. [18] As some nations are forced to do more with less in the post-pandemic period, learning from this "natural experiment" in reduced care may help health systems identify and address unnecessary care, and move towards greater sustainability. [9,10]

Investigating the impact of changes in healthcare utilisation on health outcomes and costs presents major methodological challenges. First, there are many reasons why people have missed care, including fear of becoming infected while visiting a care facility, inability to access care due to lockdown policies, and suspension and cancellation of services such as elective surgery. Second, disentangling populations who have missed necessary care from those who have avoided unnecessary care requires sensitive and nuanced analysis, with adjustment for multiple potentially confounding variables. For instance, simply showing no adverse outcomes in the short term from missing an episode of care does not prove it was unnecessary. Notwithstanding these challenges, quantifying and characterising the unprecedented recent changes in utilisation, and their impact on health outcomes and costs, may help health systems optimise post-pandemic use of resources.

To this end, we conducted what is, to our knowledge, the first systematic review of studies reporting on pandemic-related changes in overall healthcare utilisation. In undertaking this review, we also sought to inform and optimise the design of future investigations of both the on-going changes in utilisation, and the impacts of this natural experiment with less care on health outcomes and costs.

Methods

As per a detailed protocol registered on PROSPERO [19] and uploaded to the Open Science Framework [20] (Supplementary File 1) we found, appraised, and synthesised studies that compared healthcare utilisation during the COVID-19 pandemic with a corresponding pre-pandemic period. Our abstract and full review follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statements. [21,22] (Supplementary File 2)

Eligibility Criteria and Search Strategy

Inclusion and exclusion criteria

We included studies which compared utilisation of healthcare services over a period of time during the pandemic, as defined by their authors, (the intervention) with a corresponding period in the year/s before the pandemic, (the comparator). Healthcare service utilisation included but was not limited to visits or presentations, admissions or hospitalisations, diagnostic services, and therapeutic or preventive interventions. Letters or pre-prints were included if providing enough data for extraction. We excluded surveys of practitioners, studies reporting only on utilisation by patients diagnosed with COVID-19, studies reporting utilisation data for less than one week, from a single centre only, or for non-medical allied health services, and modelling studies that predicted impacts on utilisation.

Outcome measures

The primary outcome was the change in utilisation of a healthcare service – such as a visit to a hospital or receipt of diagnostic imaging – between the pre-pandemic and pandemic periods, expressed as a change in absolute numbers and/or percentage change. The secondary outcome was change in the proportions of people using the service, across different levels of disease severity, as reported by authors of the primary study, using for example a triage score.

Data sources, searches, screening

We searched PubMed, Embase, the Cochrane COVID-19 Study Register, and pre-print servers via Europe PMC, from inception until 10th August, 2020, with search strings that included the following broad concepts: COVID-19, health services, admissions, and impact. (Supplementary File 3) No restrictions by language were

imposed. Following screening of articles for inclusion, we conducted a backwards (cited) and forwards (citing) citation analysis in Scopus/Web of Science on all included studies, and additional articles were screened for inclusion. We also consulted experts for other public reports.

Pairs of review authors (RM, SS, ZM, AS, JC, EK, ET, LA) independently screened the titles and abstracts against the inclusion criteria, and repeated the process following full-text retrieval. Any screening disagreements were resolved by discussion, or reference to a third author (RM or LA). A list of studies in single centres, excluded at screening stage, was recorded and is available on request from authors.

Data Collection and Analysis

Data extraction

Pairs of authors (RM, SS, ZM, AS, ET, LA) independently extracted data from included studies and resolved discrepancies, with referral, as necessary, to a third author (LA, RM). We developed, piloted, and used a data extraction form in Microsoft Excel for study characteristics and outcome data. We extracted data on study location, design, setting, (e.g. hospital) pandemic period and comparator, and primary and secondary outcomes.

Pairs of review authors (RM, SS, ZM, AS, LA, ET) independently assessed the risk of bias for each included study using a risk of bias tool adapted from the ROBINS-I tool [23,24] as per guidance provided by Cochrane for assessing risk of bias in uncontrolled before-after studies including interrupted time series, [23] and a tool developed by the Cochrane Effective Practice and Organization of Care group. [25] All disagreements were resolved by discussion or referral to a third author (RM, LA, SS). The domains assessed included bias related to: confounding (a. the possibility that extraneous events occurring around the time of the pandemic may have influenced the outcome, b. how well the study accounted for pre-intervention trends in utilisation); selection of participants; outcome measurement; and selective reporting of results. (Supplementary file 4) Each potential source of bias was graded as low, high or unclear, with the exception of grading for the pre-intervention trends, which was graded as low, moderate or high.

Data synthesis and analysis

As anticipated in the protocol, the considerable clinical and statistical heterogeneity in settings, outcome measures, and methods precluded a formal quantitative meta-analysis. Hence, we summarised the results using descriptive statistics (percentage change expressed as median and interquartile range), graphical figures and a narrative synthesis. In line with the "Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline" [26] we summarised findings for the primary outcome grouped by four service types: visits or presentations; admissions or hospitalisations; diagnostic or imaging investigations; and therapeutic or preventive interventions.

For the secondary outcome, given the wide variation in how severity was reported in the primary studies, we developed and report three categories which relied on the indicators of disease severity employed by primary study authors: a larger or smaller reduction among those with milder forms of illness, compared to people with more severe forms of illness; and no difference. An example of a secondary outcome for a study of emergency department, ED, visits would be the triage scores, used to assess severity of those attending. Two authors (RM, LA) independently assigned a category for each secondary outcome, informed where possible by statistics provided in primary studies, with oversight and resolution of any discrepancies from within the clinical authorship team, (IS, EL, MJ).

As per details in the protocol, we planned to conduct a limited meta-analysis and sensitivity analysis in situations where there was a sufficient number of clinically and statistically homogeneous studies. Also, as per protocol, we restricted our analysis to data in the primary studies, rather than correlating findings with external information, such as stages of lockdown.

Patient and public involvement

The most senior officer from a state peak consumer health organisation is a co-author on this review and was involved in the study before the protocol was finalised. The consumer representative provided feedback on the protocol and draft manuscripts, was consulted during the process of the review, was involved with interpretation of results, and will advise on methods for dissemination of study results to the public.

Ethics

No ethics approval was required.

Changes from protocol

Several minor changes comprised: during data extraction we could not confidently assess whether each utilised service was not provided or just deferred; finalisation of the adapted tool for risk of bias resulted in five domains, not six (two domains related to outcome measurement were combined), with one domain assessed as low, moderate, high, rather than unclear, low and high, with each grade supported by a comment; and given the very large number of included studies, we included data from studies reporting only a percentage change in service utilisation, without contacting authors requesting the absolute numbers.

Results

Study selection

We identified 4817 records through electronic database searching, 323 more through forward-backward citation analysis, and one from other sources, for a total of 3097 unique records. After screening titles and abstracts, we excluded 2929 records, and selected 179 records for full-text screening, of which 98 were excluded with reasons recorded. This left 81 studies which were included in the review. (Figure 1)

Characteristics of included studies

The 81 included studies collectively report on more than 6.9 million services in the pandemic and over 11 million in the comparator pre-pandemic period. Studies reported across multiple locations: 3 were multi-national; 20 originated from the United States (US); 15 from Italy; 8 from France; 6 from Germany; 5 from the United Kingdom; 3 from Spain; 2 from each of Taiwan, Hong Kong, Greece, Denmark, Qatar, Australia; and 1 from each of Argentina, China, Canada, Brazil, Belgium, Chile, Monaco, Turkey, and Portugal. Four studies were from low- or middle-income countries. The healthcare setting were: hospitals only (41; 51%); both ED and hospitals (12; 15%); ED only (15;19%); and primary care and/or community (9;11%). More than one third of studies reported on healthcare services related to cardiovascular diseases (n=33; 41%); 14 (17%) to emergency services; 12 (15%) to general services such as immunization and primary care; and 22 (27%) on services related to different conditions including orthopaedic and trauma services,

gastroenterology, and mental health. Of the included studies, 14 (17%) were national studies and 9 (11%) used time-trend data (Table 1; Supplementary file 5).

Risk of bias assessment

For the majority of studies there was insufficient information on which to judge the possibility that extraneous events occurring between pre-pandemic and pandemic periods may have influenced healthcare utilisation, or to assess the risk of bias arising from differences between those eligible to utilise healthcare services in the pre-pandemic and pandemic periods (76/81; 94%). 69% (56/81) of studies were considered to be at high risk of bias due to insufficient data for characterising pre-pandemic utilisation. In contrast, three studies (4%) were judged to be at low risk of bias on this domain due to adequate data and analysis to permit characterisation of pre-pandemic trends in utilisation. 63% (51/81) of studies were judged to be at high or unclear risk of bias from using different methods used to assess utilisation in the pre-pandemic and pandemic period, or lacking information on which to judge this domain. Most studies (n= 74; 91%) were judged to be at low risk of bias in selective reporting of results. (Figure 2)

Main findings

The 81 studies reported 143 estimates of changes in healthcare utilisation between pandemic and pre-pandemic periods, of which 136 (95.1%) were a reduction. The percentage change ranged between a 49% increase and an 87% decrease with a median 37.2% reduction (interquartile range -50.5% to -19.8%). For the 64 estimates about changes in cardiovascular service utilisation, from 33 studies, the median reduction was 29.3% (-41.3% to -17%). For the 13 estimates from the 9 studies using time-trend data, the median reduction was 37.3% (-45% to -25.2%). For all studies, the weekly median percentage changes starting from mid-February until late May 2020 are plotted graphically in Figure 3, showing greatest reductions through March and April. (Full data in Supplementary file 5)

We categorized the 143 estimates of change into 4 groups according to the type of healthcare service: 41 estimates for healthcare visits; 43 estimates for admissions; 12 estimates for diagnostics (e.g. imaging, pathology, screening investigations); and 47 estimates for therapeutics (e.g. surgery, vaccinations). All medians are reported in Table 2, with results of individual studies reported in Supplementary file 5.

Changes in visits

The percentage change for healthcare visits or presentations ranged between a 49% increase and an 86% decrease, with a median 42.3% reduction (-52.8% to -31.5%). Major reductions in visits to EDs were seen in multiple studies, such as a large national US study from the Centres for Disease Control and Prevention reporting a 42% reduction during April, rising to a 26% reduction at the end of May, compared to 2019. [1] That study found the largest absolute reduction involved people presenting with abdominal pain, with over 66,000 fewer ED visits per week for this complaint during April. In terms of age group, the largest reduction (-72%) was seen for children 10 years and under. [1] A metanalysis of a subgroup of six studies of ED visits that reported adequate data for meta-analysis (effect estimates and 95% CIs) was attempted, but demonstrated considerable heterogeneity (I^2 >95%).

Changes in admissions

The percentage change in the number of admissions ranged between a 20% increase and an 87% decrease, with a median 28.4% reduction (-40.4% to -17.4%). For example, a large study of the weekly admission rates for acute coronary syndrome in England showed a substantial reduction by the end of March (-40%) which partly rebounded by the last week of May 2020, (-16%). [27]

Changes in diagnostics

The percentage reduction ranged between 10% and 85%, with a median 31.4% reduction (-52.5% to -23.8%); no study reported any increase in the use of diagnostic and imaging procedures. The magnitude of reductions in diagnostic tests and imaging followed a trend over time similar to those observed in the previous categories, but with a far smaller number of estimates. (See Figures 5.4a-d, Supplementary file 5) For example, a study of imaging case volumes within the largest healthcare system in New York State found a 28% reduction in imaging volumes for March to mid-April 2020 across all locations and imaging modalities, [28] while a separate US study found volumes recovering through late April, but still 36% lower in the third week of May, compared to 2019. [29]

Changes in therapeutics

The percentage change in therapeutic and preventive care ranged between a 27% increase and an 80% decrease, with a median 29.6% reduction (-56.8% to -19.2%). For example a large study of routine childhood vaccination in England found fewer children receiving the first MMR dose, with a reduction of 24% in the final week of March, which rose to a 27% increase in the third week of April, compared to the same period in 2019. [5]

Secondary Outcome

Thirty-eight of the included studies reported a total of 60 secondary outcomes relating to potential changes in healthcare utilisation according to the disease severity of the service user. Despite the considerable heterogeneity in settings and services, for almost half of these outcomes, (27 of 60; 45%) we observed a pattern of larger reductions in utilisation among those with milder or less severe illness compared to those with more severe disease. For 33 of 60 outcomes (55%) there was no difference. (Figure 4) No studies reported a smaller reduction among those with milder forms of illness.

A national Italian study of urgent endoscopy reported a 40% reduction in utilisation overall, with bigger reductions in the proportion of patients with a negative finding on upper endoscopy between pre-pandemic and pandemic periods. [3] A study of three psychiatric emergency services in Paris found a 55% overall reduction in presentations in the first 4 weeks of lockdown, with greater reductions for consultations for anxiety and stress, and smaller reductions for consultations for psychotic disorders. [30] Authors speculated that "some people may find new strengths and coping strategies during disasters" and "the current results may arise from an elevation in resilience." Most strikingly, multiple studies reporting reduced acute coronary syndrome presentations found these reductions were much greater for the less severe non-ST-segment elevation myocardial infarction (NSTEMI) events compared to ST-segment elevation myocardial infarctions, (STEMIs). [27, 31] An example is a large English study reporting reductions in admissions of 42% for NSTEMI events versus 23% for STEMI. [27] In contrast, other studies found no change in presentations according to severity, including a national Portuguese study reporting a 48% reduction in ED episodes – from an expected 570 000 to an observed 295 000 in March 2020 – but no significant change in proportions of different triage categories. [32]

Discussion

This review of 81 studies involving over 17.9 million services provided across 20 countries found consistent evidence of major reductions in the utilisation of healthcare services during the pandemic period up to May 2020, compared to previous years, despite some studies reporting increases. Although a meta-analysis was not possible, we found a median reduction of 37% of services overall, which was highest for visits (42%) and slightly lower for admissions (28%), diagnostics (31%) and therapeutics (30%). Many studies also found larger reductions in utilisation among populations with milder or less severe illness. Few studies were assessed as having a low risk of bias, with lowest risk of bias for studies using time-trend data to

establish trends in the years leading up to 2020. For the 9 studies using time-trends, the median reduction in utilisation was 37%.

Our review has several strengths. First, we synthesized the most recent data reported in primary studies up to the end of May 2020, which corresponds to the peak of the pandemic in many countries, and provides a baseline for longer-term data on on-going changes in utilisation and the cumulative deficit of care. Second, the review constitutes the first broad synthesis of global studies of pandemic related changes in utilisation across all categories of healthcare services. Third, the review adhered to rigorous Cochrane, [24] PRISMA [21, 22] and SWiM [26] standards. Study limitations include the inability to undertake a meta-analysis because of considerable heterogeneity, the possibility of publication bias, the potential of our eligibility criteria to exclude important data sources such as studies in single-centres and unpublished datasets from health systems, subjectivity in our assessments of the secondary outcomes, and the use of an adapted but unvalidated risk of bias tool.

The massive global reduction in healthcare utilisation summarised in this review makes a compelling case for prioritising efforts that address the unmet needs of those with non-COVID 19 illness. Consistent messages from the primary studies include calls for monitoring the long-term impacts of this missed care, public campaigns to urge people to seek medical care when they need it, and better preparedness for reducing the extent of missed care in future waves of the pandemic. Evidence of excess population mortality, in addition to deaths from COVID-19, and related phenomena such as increases in out-of-hospital cardiac arrests and contacts with emergency phone-lines [33,34] make these calls to action even more urgent. Conversely, the review's finding that reductions often tended to be greater for milder or less severe forms of illness, combined with existing evidence about too much medicine, [11-17] suggest that for some people, missing care may not have caused harm.

This unprecedented pandemic-induced natural experiment in reduced healthcare utilisation provides a genuine opportunity to learn more about what services populations and healthcare systems came to regard as lesser priorities, when redistribution of resources towards more essential services was needed to minimize mortality in a crisis. As others have suggested, [35,36] greatly reduced ED attendances around the world for non-urgent complaints indicate an opportunity to inform and implement new strategies and models of care that maximise the appropriateness of visits in the future. Even at the heart and height of the epidemic in Northern Italy, in

paediatric EDs doctors found reductions in the mildest presentations accounted for more of the decrease in overall presentations, suggesting that "most of the non-relevant pathologies usually seen at our EDs have been avoided" thus freeing resources to "provide critical services to patients suffering from medical emergencies in a timely manner." [36] Our review adds weight to the view that the post-pandemic recovery provides a rare window of opportunity for systematic changes in healthcare systems aimed at reducing low-value care, including overtreatment and overdiagnosis. [9,10,37]

Many questions about the causes and impacts of the changes in healthcare utilisation documented in our review call for careful analysis and further research. (See Box 1) High quality time trend analyses are needed to better understand the extent and nature of on-going changes in utilisation, as are long-term cohort studies for collecting patient-centred outcomes to assess impacts on health, costs, and equity. Consultations with consumers during the pandemic highlight the need to understand how the pandemic may differentially impact the most vulnerable, and the need to prioritise those at most need. [38,39] Rigorous qualitative research investigating people's experience of avoiding or missing care, and professional responses to changes in process and practice, will also be important. We found no study which explicitly examined changes in utilisation of low-value healthcare services, which warrants further research. The extent and effects of substitution, such as with telehealth or self-care also requires investigation. Experience with SARS almost 20 years ago revealed significant drops in healthcare service utilisation in the most affected regions [40] and long periods before some rates returned to baseline. [41] Given the growing evidence about unnecessary care since then, it may be more beneficial for populations and their health systems if utilisation rates of some services do not return to pre-pandemic levels. Addressing genuine unmet need and winding back the harm and waste of unnecessary care are not conflicting interests, but rather two sides of a coherent strategy to efficiently improve human health.

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Tables, Figures, Box

Table 1: Summary characteristics of included studies
Table 2: Median changes in utilisation across categories of healthcare services
Figure 1. PRISMA Flow Diagram
Figure 2. Summary of Risk of Bias Assessments
Figure 3. Pandemic related changes in healthcare utilisation
Figure 4. Differential reductions in utilisation relating to severity
Box 1: Future Research

Supplementary Files

Supplementary File 1 – Protocol
Supplementary File 2 – PRIMSA checklist
Supplementary File 3 – Search Strings
Supplementary File 4 – ROB assessments for all studies
Supplementary File 5 – Full table of study characteristics, full report of results, primary outcomes and secondary outcomes, and extra Figures

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Competing Interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work. RM has helped organise Preventing Overdiagnosis international scientific conferences.

Data sharing

We have provided all data about all included studies, and a list of those studies, in the Supplementary files.

Transparency Statement

The lead and senior authors RM and LA affirm 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 protocol as originally planned and registered have been explained in a special section in the Methods.

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take responsibility for the integrity of the data and the accuracy of the data analysis. Authors write as individuals, not as representatives of organisations with which they work.

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Tables

Table 1. Summary characteristics of included studies (n=81)

Characteristics of included studies	No (%)
Scope	
National	14 (17%)
Multi-centre	67 (83%)
Disease categories	
Cardiovascular	33 (41%)
Emergency Services (adult and paediatric)	14 (17%)
General (including vaccination and hospice)	12 (15%)
Digestive	5 (6%)
Orthopaedic and Trauma	5 (6%)
Others (e.g. mental health, urology, neurology)	12 (15%)
Setting	
Hospitals (or inpatient care)	41 (51%)
Emergency	15 (19%)
Emergency and Hospital	12 (15%)
Community and/or outpatient	9 (11%)
Hospital and outpatient	4 (5%)
Study design*	
Time trend	
Time trend – multiple prior year	5 (6%)
Time trend – single prior year	4 (5%)
Same period (before – after)	
Same period – multiple prior year	16 (20%)
Same period – single prior year	56 (69%)
Country	
Multi-national	3 (4%)
Americas	24 (30%)
Europe	45 (56%)
Asia & Australia	9 (11%)

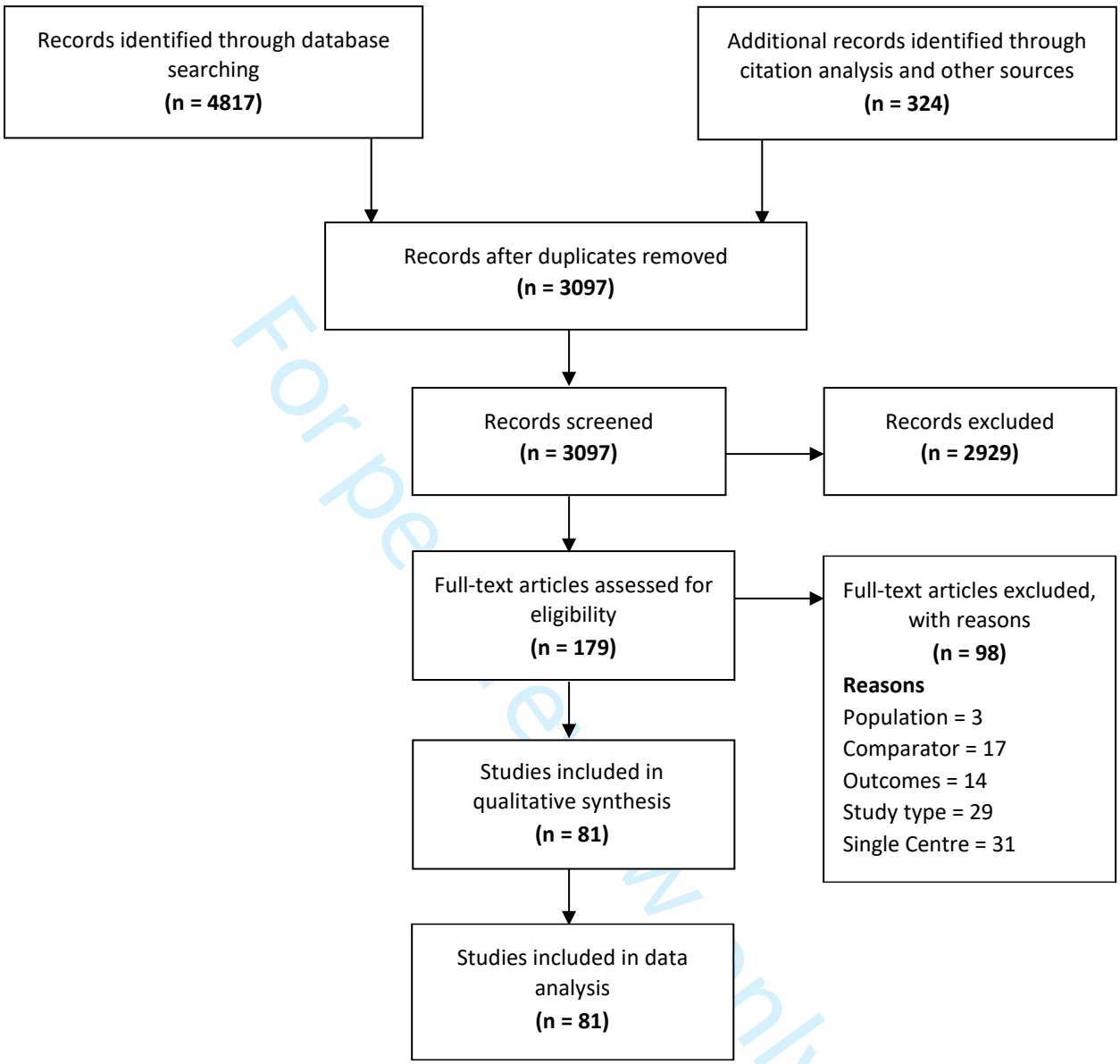
*This refer to the type of data used in included studies rather than the type of analysis

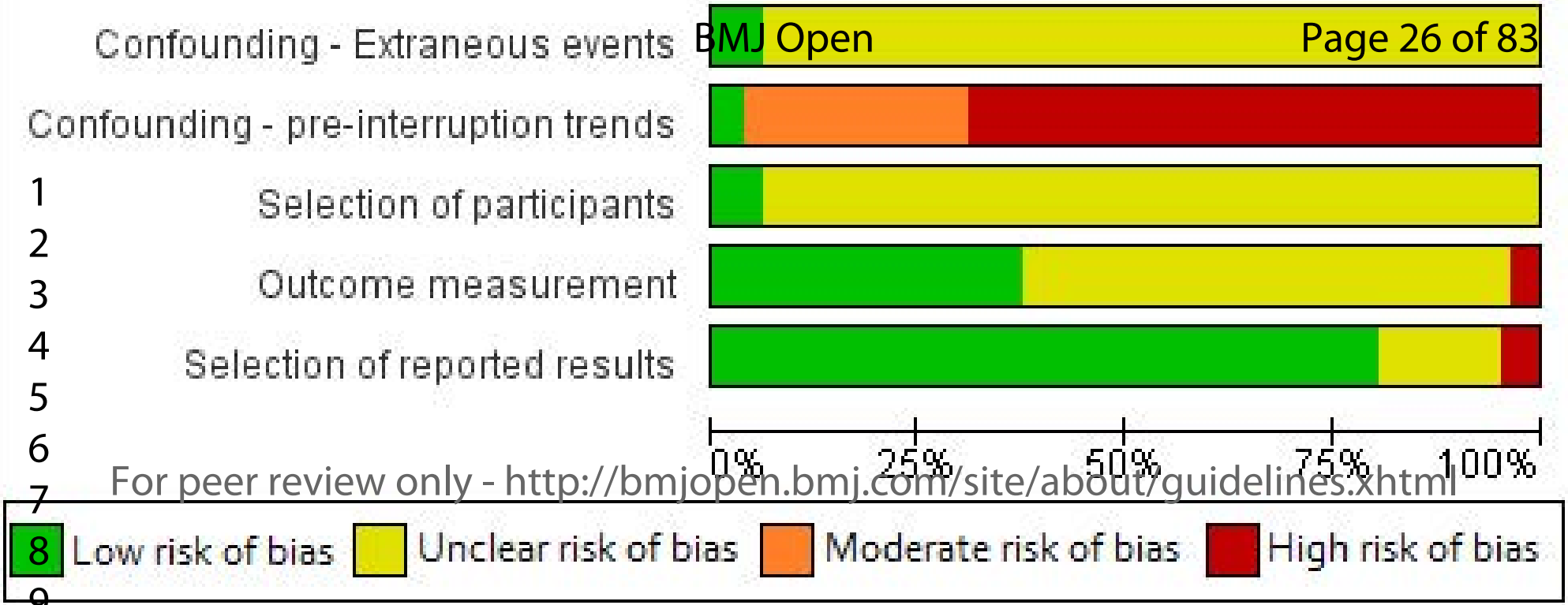
Table 2. Median changes in utilisation across categories of healthcare services

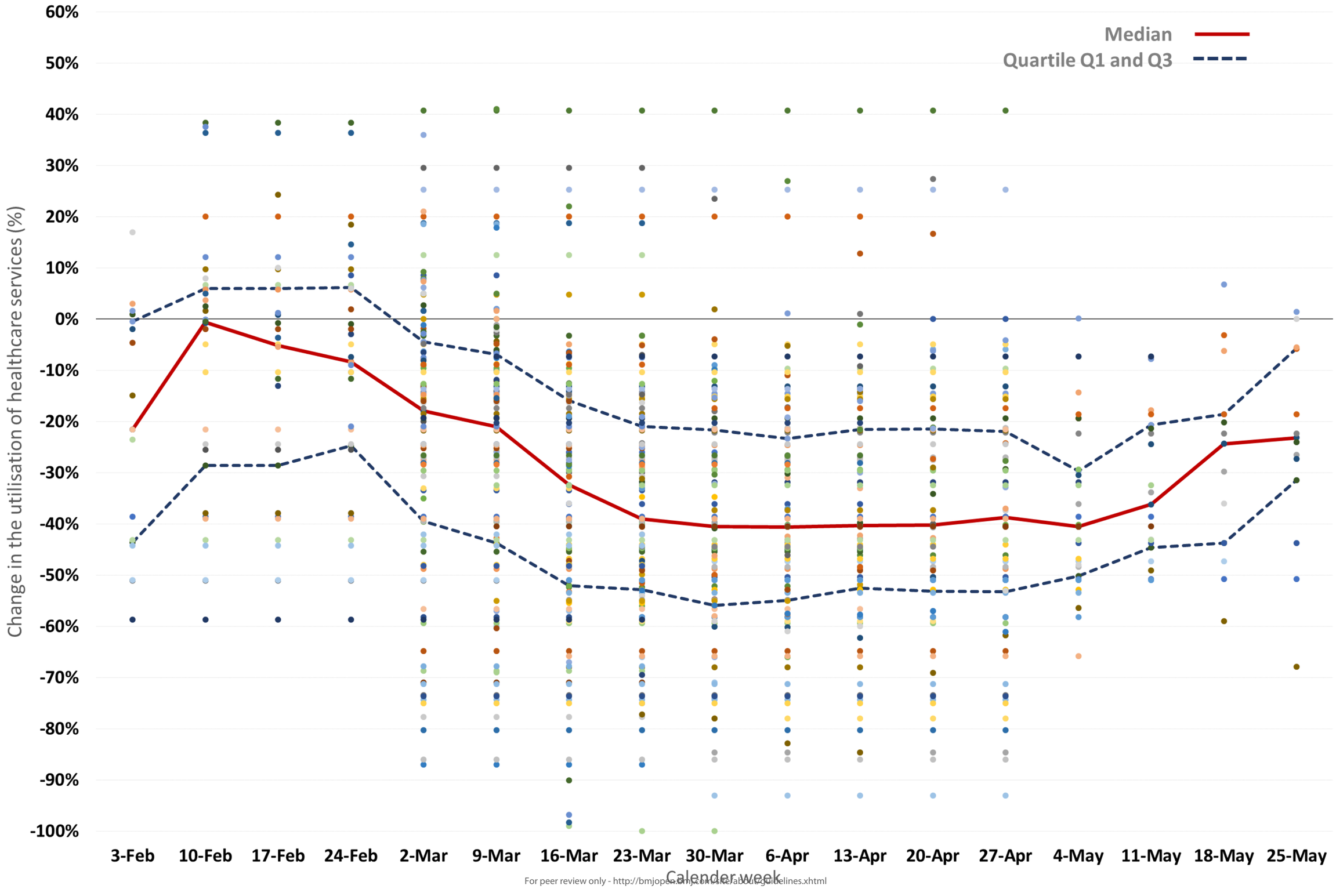
Healthcare Service	No. estimates (No. studies)	Total volume of services (Pandemic and Comparator)	Median change	Interquartile range
Total	**143 estimates (81 studies)**	**19,808,921 P: 6,948,834; C: 11,102,936**	**-37.2%**	**-50.5% to -19.8%**
Healthcare services categories*				
Visits	41 estimates (33 studies)	14,090,495 P: 4,631,899; C: 7,723,639	-42.3%	-52.8% to -31.5%
Admissions	43 estimates (32 studies)	1,690,021 P: 749,942; C: 939,737	-28.4%	-40.4% to -17.4%
Diagnostics	12 estimates (7 studies)	1,692,388 P: 640,885; C: 1,051,503	-31.4%	-52.5% to -23.8%
Therapeutics	47 estimates (28 studies)	2,336,017 P: 926,108; C: 1,388,057	-29.6%	-56.8% to -19.2%
Disease categories				
CVD	64 estimates (33 studies)	2,586,270 P: 1,166,610; C: 1,400,041	-29.3%	-41.3% to -17.0%
Emergency services	17 estimates (14 studies)	10,572,517 P: 3,252,399; C: 5,585,161	-44.0%	-48.0% to -31.5%
Study design and data				
Studies using time-trend data	13 estimates (9 studies)	6,263,331 P: 1,974,605; C: 3,425,412	-37.3%	-45.0% to -25.2%

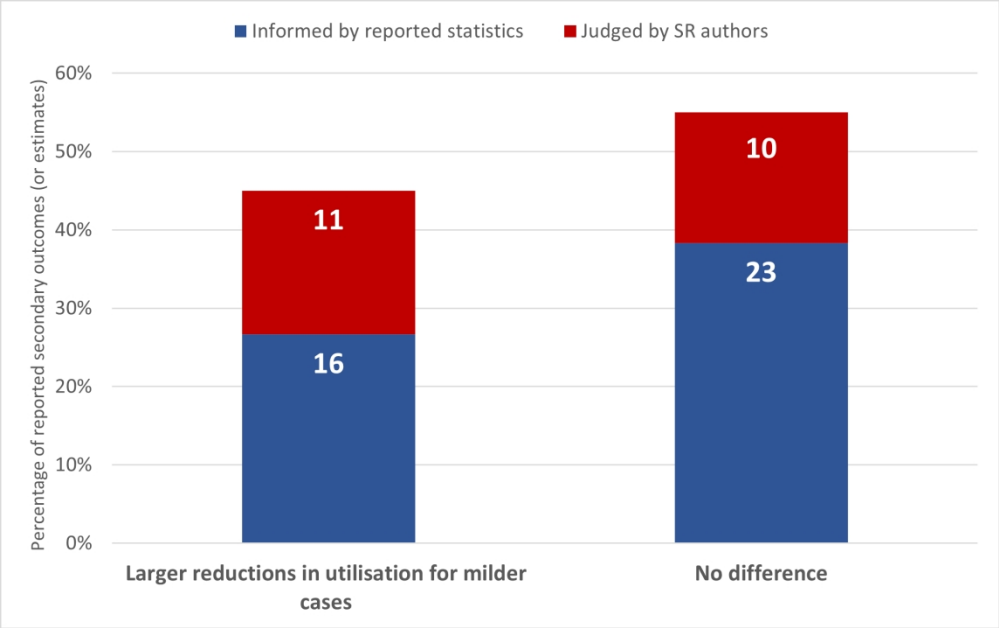
Abbreviations: C: comparator pre-pandemic period; P: pandemic period. *Each study could have included services across multiple categories. Note: In order to calculate the total volume of healthcare services, we used numbers as reported in the primary studies, whenever available. If not explicitly reported, we estimated these numbers using data plotted in the figures reported in the primary studies, when available. For studies that have not reported these absolute numbers anywhere – but only reported a percentage change – their services have not been included in these totals. In addition, there will be some discrepancy between the total numbers, and the sum of pandemic and pre-pandemic periods, because in some cases, a study may have included a total number of services, but without breaking it down into any absolute numbers for the pandemic or pre-pandemic periods.

Box 1: Future research
For future studies of changes in healthcare utilisation during the pandemic
Aim for time-series analyses; multiple years pre-pandemic as comparator
Aim to detect impacts on equity, such as different groups differentially affected
Need to cautiously interpret drivers and impacts of changes
Aim to analyse local, provincial, and national datasets
Consider potential for multi-national research collaborations with health systems
For future studies of impacts of the "natural experiment" in reduced care
Aim for long term cohort studies, with focus on specific conditions, or interventions
Seek strong clinical, patient, and public input, independence of commercial interests
Qualitative analyses with patients and public on reasons for and impacts of missing care
For those interested in opportunity to address problem of too much medicine
Studies of pandemic related changes in rates of overtreatment and overdiagnosis
Urgent need to learn from "natural experiment" before rates return to prior levels
Correlate condition-specific granular analyses, with existing data on medical overuse
Consider using pandemic learnings to guide trials of de-implementation strategies
Consider potential researcher-clinician-consumer-health system collaborations








Informed by reported statistics
Judged by SR authors
Percentage of reported secondary outcomes (or estimates)
60%
50%
40%
30%
20%
10%
0%
11
16
10
23
Larger reductions in utilisation for milder cases
No difference

Pandemic changes in healthcare utilisation: a protocol for a systematic review

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BACKGROUND

As the covid-19 pandemic continues, increasing numbers of studies are reporting major changes in utilisation of healthcare services, including large drops in services during certain periods,[1-3] as well as some increases, such as the use of telemedicine.[4] While many people have missed much needed care, such as vaccination or life-saving interventions,[2] others may be avoiding unnecessary or inappropriate care which would have caused them more harm than good.[3] A large and growing evidence base suggests the problem of too much medicine is widespread, including low value care which may carry no benefit, and overdiagnosis, which can cause more harm than good. [5-11] Multiple global campaigns are attempting to address this challenge, such as Choosing Wisely, which is active in more than 20 nations.[12] As nations are forced to do more with less, post-pandemic, learning from this "natural experiment" in less care may help health systems address the challenges of unnecessary care, and move towards more sustainability.[13,14]

Understanding the impact of these large changes in healthcare utilisation, on health outcomes and costs, will present a great methodological challenge. First, there are many

[1] non-first/last authors are indicative order only

reasons why people have missed care, including fear of visiting hospitals during the pandemic, inability to visit due to lockdown circumstances, or the unavailability of a service such as suspended elective surgery. Second, disentangling those groups who have missed needed care, from those who have avoided unnecessary care, will require sensitive and sophisticated analysis, considering multiple potentially confounding variables. Moreover, simply showing no adverse outcomes from missed care – such as a missed visit to a general practitioner – does not automatically mean that episode of missed care was unnecessary. Notwithstanding these challenges, understanding the unprecedented recent changes in utilisation and their impact, may help health systems, and the societies which fund them, optimise resource-use post-pandemic.

As a first step to that understanding, we aim to conduct a systematic review of studies which have reported on pandemic-induced changes in healthcare utilisation. We aim to examine the extent and nature of changes, particularly any reported changes in the severity of symptoms of people seeking or receiving care.[3] The broader purpose is to inform any future investigations of the impact of this natural experiment in less care on health outcomes and costs.

METHODS

We aim to find, appraise, and synthesise studies that assessed the impact of the covid-19 pandemic on the utilisation of healthcare services, compared to a corresponding period of time prior to the pandemic. This systematic review will be reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[15] The review protocol was developed prospectively and was registered on the Open Science Framework (https://osf.io/) and on Prospero (https://www.crd.york.ac.uk/prospero/). We will also follow the "2 week systematic review" (2weekSR) processes for this review.[16] In relation to the PICO for this systematic review, the P will be a population of people seeking or using a service within the healthcare system, the I will be the pandemic period as defined by primary study authors, the C will be a comparable period at least one year prior to the study period, and the O will be change in utilisation (primary outcome) and change in disease severity of the people using the service, (secondary outcome).

Studies to be included

Population

We will include studies that report changes in the utilisation of healthcare services by patients and public, irrespective of age. We will exclude studies that reported on the utilisation of healthcare services by patients diagnosed with covid-19.

Interventions and Comparators

We will include studies which compare utilisation during any period within the pandemic, with a similar period in at least one year before the pandemic. We will therefore include studies which compare – for example – April 2019 utilisation with April 2020 utilisation, but due to concerns about reliable comparisons, we will exclude studies which use the immediate pre-pandemic period as a comparator, (e.g. November 2019). We will include studies which report data from national or regional sources, of more than one centre, so we will exclude studies within a single unit or single hospital, due to limitations on

generalisability.

Outcomes

The primary outcome is the extent of changes in utilisation of a healthcare service between the pre-pandemic comparison period and the pandemic period. Healthcare service will include but not be limited to *consultation healthcare services* such as presentations or admissions to hospitals or visits to primary care; *diagnostic healthcare services* such as diagnostic imaging/investigations, laboratory testing; and *therapeutic or preventive healthcare services* such as prescriptions, or surgeries or utilisation of vaccinations. These healthcare services can be broad and may include packages of, rather than single isolated, healthcare services. Therefore, in the case of a broad package, the primary outcome for the purposes of our review will be the initial indication for the healthcare services utilisation, if that data is available in the primary study, (e.g. admission due to a stroke is an initial indication for a subsequent series of healthcare services including diagnostic investigations and therapeutic services).

The secondary outcome is the nature of the changes in relation to the people using the service, specifically changes in disease severity or diagnostic spectrum, (e.g. any changes in proportions of patients with mild or severe illness).

We will exclude studies which report utilisation for a time period less than one week in duration, because of the brevity of the time period, and the possibility of differences on different days of the week. We will exclude studies which do not include data on changes in routine healthcare utilisation, but rather only describe changes in healthcare processes, incidence/prevalence of conditions/diseases only, the nature of new practices, or the impacts of covid-19 on individual patients. We will exclude non-medical allied health services.

Study design

We will include any observational studies using clinical, hospital or health system administrative data and/or medical records reporting utilisation in a period after the pandemic was declared, and at least one corresponding period in the years prior to the pandemic. This will include before-after studies and interrupted time series studies. We will exclude surveys of healthcare practitioners, cross-sectional studies, any trials, or studies using modelling to predict impacts on utilisation.

Rational for selection and prioritisation of outcomes

We selected and prioritised the outcomes based on (i) a review of the outcomes reported in a sample of potentially included studies collected before the Systematic Review by 2 review authors (RM, LA); (ii) a discussion among the whole review team, which includes clinical advisors, methodological experts, and a patient and public (consumer) representative. Primary and secondary outcomes directly address the Systematic Review question, which is investigating the extent and nature of changes in healthcare utilisation due to the pandemic.

Search strategies to identify studies

Database search strings

We will search PubMed, Embase and the Cochrane COVID-19 Study Register and pre-print servers via Europe PMC, from inception until Monday 10th August, 2020, with an update close to date of submission. We designed a search string in pubmed that included the following concepts: Covid-19 AND Health services AND Admissions AND Impact. This search string was translated for use in other databases using the Polyglot Search Translator.[17] The complete search strings for all databases are provided in Appendix 1.

Restriction on publication type

No restrictions by language or publication date will be imposed. We will include publications that were published in full, as well as letters, or pre-prints, where data on the primary outcome is sufficient for data extraction. We will seek expert advice on the existence of other public reports unavailable in peer-reviewed journals and they will be included if all inclusion criteria are met.

Other searches

We will conduct a backwards (cited) and forwards (citing) citation analysis in Scopus/Web of Science on the included studies identified by the database searches, and these will be screened against the inclusion criteria.

Study selection and screening

Pairs of review authors [RM, SS, ZM, AS, JC, EK, ET, LA] will independently screen the titles and abstracts in Endnote for inclusion against the inclusion criteria. One review author [JC] will retrieve full-text, and pairs of authors [RM, SS, ZM, AS, JC, EK, ET, LA] will screen the full-texts for inclusion. Any screening disagreements will be resolved by discussion, or reference to a third author [RM or LA]. The selection process will be recorded in sufficient detail to complete a PRISMA flow diagram and a list of excluded (full-text) studies with reasons for exclusions. A list of studies in single-centres, excluded at title and abstract screening stage, but which otherwise meet inclusion criteria, will be recorded and made available on request from authors.

Data extraction

We will develop and use a data extraction form for study characteristics and outcome data, which will be piloted on 2-3 studies in the review. Pairs of authors [RM, SS, ZM, AS, LA, EK, ET] will independently extract the following data from included studies, resolve discrepancies and refer any unresolved to a third author [LA, RM]:

1. Methods: study authors, location, nature of service, period and length of study, period of comparator/s, disease (if applicable), and whether the changes in utilised services were likely due to them being omitted, delayed (or unclear).
2. Primary Outcome(s): percentage change in utilisation of health services and 95% CI, in pre and pandemic periods, and changes in absolute numbers of utilization, where data allow for calculation of percentage of change and 95% CI. In relation to the earlier point about packages of care, including care which flows from an initial indication or admission, when the data permits, we will consider the initial indication for the healthcare services utilisation as our primary outcome.

3. Secondary Outcome(s): change in the nature/characteristics of the users of health services (e.g. disease severity; disease spectrum/mix, or diagnostic yield; admissions to acute care)

Assessment of risk of bias in included studies

Pairs of review authors [RM, SS, ZM, AS, LA, EK, ET] will independently assess the risk of bias for each included study. We will use a modification of two risk of bias tools designed to assess before-after studies and interrupted time series analyses, the ROBINS-I tool [18-19] and a tool developed by the Cochrane EPOC group. [20] All disagreements will be resolved by discussion or by referring to a third author [RM, LA, AS, SS]. The following domains will be assessed:

1. Bias due to confounding (extraneous events)
2. Bias due to confounding (pre-intervention trends)
3. Bias in selection of participants
4. Bias due to missing data
5. Bias in measurement of the outcome
6. Bias in selection of reported result

Each potential source of bias will be graded as low, high or unclear, and each judgement was supported by a quote from the relevant trial. If secondary review outcomes require specific assessment on risk of bias domains this will be identified during further testing of the tool. Assessments of risk of bias will be presented for individual studies and across studies and will be incorporated into the results of the systematic review.

Data synthesis

We anticipate a wide heterogeneity in the population, settings, outcome measures, and methods used in the included studies, such that we do not expect to be able to perform a formal quantitative synthesis, i.e. a meta-analysis. Therefore, we plan to summarise the results narratively by using descriptive statistics, graphical figures, and a narrative synthesis. We will summarise the findings of included studies for the primary outcome grouped by service types: e.g. visits/admissions/consultations; diagnostic investigations; therapeutic/preventive interventions. If further sub-categorisation is needed, it will be by service locations: e.g. emergency department; primary care; and/or service specialty e.g. cardiology. We will calculate the mean difference and 95% confidence intervals for the change in the primary outcomes for each included study as appropriate.

If there is a sufficient number of sufficiently similar studies with acceptable levels of heterogeneity, and the data enable it, we would then aim to conduct a meta-analysis. In that case, we will use a random-effects model as the default to incorporate the assumption of heterogeneity between studies. We will evaluate statistical heterogeneity using both Chi^2 test (i.e. P value less than 0.10 was considered to be statistically significant heterogeneity) and the I^2 statistic (i.e. I^2 value of 0-40% was considered to be low heterogeneity, 40-60% moderate heterogeneity, 60-90% substantial heterogeneity, over 90% to be considerable heterogeneity).[19]

We anticipate that reporting of the secondary outcomes in each of the included studies will likely be expressed in a multitude of ways, specific to each study setting, disease category, patient population and category of utilisation. However, we will aim, if possible, to develop different categories for reporting of secondary outcomes.

Data Management

We will manage data using Endnote files, word documents and excel spreadsheets.

Dealing with missing data

If any primary studies only include changes as proportions, but do not include changes in absolute numbers of services, we will contact investigators or study sponsors to provide missing data.

Subgroup and sensitivity analyses

If there is a sufficient number of sufficiently similar studies with acceptable levels of heterogeneity to quantitatively synthesise the results, and the data enable it, we aim to conduct a sensitivity analysis (i) including only studies at an overall low risk of bias (eg low risk of bias in at least four of the six domains or interrupted time series studies vs pre-post pandemic studies); and (ii) including studies of longer duration (eg >6 weeks).

Assessment of reporting or publication biases

We plan to consider the possibility of the presence of reporting and/or publication bias and will take into account its likely influence when interpreting the review findings. If ten or more studies are included in a meta-analysis, we plan to examine the possibility of publication or small study bias using funnel plots. [19]

Additional analyses

We considered a range of analyses to explore correlations between study outcomes and other potentially relevant variables available outside the study data, such as nation-specific data about the stage of lockdown in the host nation at the time of the primary study. However, due to complexities in the large number of variables and potential discrepancies between official policy on restrictions and actual behaviour of people, as well as complex variation in the behaviours of different entities within the healthcare systems across the world, we decided, at protocol stage, to restrict our analysis to data within the publications.

Registration

We will register this protocol in the Open Science Framework, and in Prospero.

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August 11, 2020

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APPENDIX 1 – DATABASE SEARCH STRINGS

PubMed

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Embase (via Elsevier)

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Cochrane COVID-19 Study Register
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Europe PMC preprints
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Checklist of items to include when reporting a systematic review or meta-analysis

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3-4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6,7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supp. file 3

Section/topic	#	Checklist item	Reported on page #
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6,7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7,8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	9,10
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and	10-12

Section/topic	#	Checklist item	Reported on page #
		confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Figure 2, and Supp. File 4
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression) (see Item 16).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	12
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	12,13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	13, 14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Abstract

Supplementary File 3 – DATABASE SEARCH STRINGS

PubMed

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	Confounding - Extraneous events	Confounding - pre-interruption trends	Selection of participants	Outcome measurement	Selection of reported results
Abdulmalik	?	?	?	+	+
Andersson	+	-	+	+	+
ANGOULVANT	+	+	?	+	+
Antonucci	?	-	?	+	+
Athiel	?	-	?	+	+
Baum	?	?	?	+	+
Bayles	?	?	+	+	+
Benazzo	?	-	?	?	+
Bollmann	?	-	?	?	+
Bozovich	?	-	?	?	+
Braiteh	?	-	?	?	+
Bramer	?	?	?	?	+
Butt	?	-	?	+	+
Cano-Valderrama	?	-	?	+	+
Cheek	?	-	?	?	+
Chou	?	-	?	?	+
Claeys	?	?	+	+	+
Clerici	?	-	?	?	?
Collado-Mesa	?	?	?	?	+
CVD-COVID	?	-	?	?	?
De-Filippo	?	-	?	?	+
de Havenon	?	?	?	?	+
De Rosa	?	-	?	?	+
Diegoli	+	-	+	?	+
Egol	?	-	?	-	+
Enache	?	-	?	+	+
Franco	?	-	?	?	?
Frankfurter	?	-	?	?	+
Garcia	?	?	?	?	+
Gawron	?	?	?	+	+
Giuntoli	?	-	?	+	+
Gruttadauria	?	?	?	-	?
Hartnett	?	-	?	+	+
Houshyar	?	-	?	?	+
Hoyer	?	-	?	?	+
Isba	?	-	?	?	+
Jasne	?	-	?	?	+
Kadavath	?	-	?	-	-
Kerleroux	?	-	?	+	+
Kessler	?	-	?	+	+
Kim	?	-	?	+	-
Kolbaek	?	-	?	?	?
Krenzlin	?	?	?	+	+
Langdon-Embry	?	-	?	?	?
Lantelme	?	?	?	?	+
Lazaros	?	-	?	+	+
Lazzerini	?	?	?	+	?
Li	?	-	?	?	?
Lui	?	?	?	+	+
Mafham	+	-	?	+	+
Manzoni	?	-	?	?	+
Mazzatenta	?	?	?	?	-
McDonald	?	-	?	+	+
Mitchell	?	+	?	+	+
Naidich	+	-	?	+	+
Norbash	?	-	?	?	-
Novara	?	-	?	?	+
Onteddu	?	-	?	?	+
Papafaklis	?	-	?	?	+
Pignon	?	-	?	?	+
Pinar	?	-	?	+	+
Polo Lopez	?	-	?	?	+
Pop	?	-	?	?	+
Qasim	?	-	?	+	+
Range	?	?	?	?	?
Reeves	?	?	?	?	+
Requena	?	-	?	?	?
Romaguera	?	-	?	+	+
Salerno	?	-	?	?	+
Santana	?	+	?	+	+
Scaramuzza	?	-	?	?	?
Scholz	?	?	?	+	+
Secco	?	-	?	?	+
Seiffert	?	-	+	?	+
Smalley	?	-	?	?	+
Tinay	?	-	?	?	+
Toro	?	?	?	?	?
Toyoda	?	?	?	?	+
Wong	?	?	?	?	+
Xu	?	?	?	?	+
Zhao	?	-	?	?	+

Title: Pandemic impacts on healthcare utilisation: a systematic review

Authors names: R Moynihan, S Sanders, ZA Michaleff, AM Scott, J Clark, EJ To, M Jones, E Kitchener, M Fox, M Johansson, E Lang, A Duggan, IA Scott, L Albarqouni.

Supplementary File 5 –

5.1 Table of Study Characteristics and reference list of all included studies.

5.2 Table of Results of the primary outcome of the included studies

5.3 Table of Results of secondary outcomes of the included studies

5.4 Figures of changes in healthcare utilisations reported in included studies

Supplementary Table. Characteristics of Included Studies of pandemic related changes in healthcare utilization

Author; Country; Scope; Design	Setting; Population	Pandemic and comparator periods*	Primary Outcomes	Secondary Outcomes
Abdulmalik; Qatar; National; Same period single year	Outpatient/Primary care; 27 primary health care centres	March - May; 2020 vs. 2018-19	Overall utilization of all primary healthcare services across all health centres	N/A
Andersson; Denmark; National; Same period single year	Hospital; Danish Nationwide Patient Registry	March 12 - March 31; 2020 vs. 2019	Incidence rates of new-onset HF and hospitalization for worsening HF	Mortality
Angoulvant; France; Multi-centre; Time trend multiple years	ED & Hospital; 6 Paediatric EDs from academic hospitals being part of Assistance Publique – Hôpitaux de Paris	March 18 - April 19; 2020 vs. 2017-19	Number of hospital visits and admissions	N/A
Antonucci; Italy; Multi-centre; Same period single year	ED & Hospital; 3 high volume urology departments in Rome, Italy	March - April; 2020 vs. 2019	Number of ED admissions for urolithiasis; Number of hospitalisations	N/A
Athiel; France; Multi-centre; Same period single year	ED & Hospital; 12 gynaecological emergency units of the Greater Paris University Hospitals	March - May; 2020 vs. 2019	Number of emergency gynaecological hospitalisations	N/A

Baum; USA; National; Time trend single year	Hospital; Veterans Affairs Hospitals' Corporate Data Warehouse, a national repository of electronic health records from visits to any VA facility	March 11 – April 21; 2020 vs 2019	All admissions for any condition	N/A
Bayles; USA; Multi-centre; Same period single year	ED; 3 acute care facilities from the Marin County Department of Health and Human Services	March 17 - May 4; 2020 vs. 2018-19	Average number of daily ED visits	N/A
Benazzo; Italy; Multi-centre; Same period single year	ED & Hospital; 15 orthopaedic and trauma units	February 23 - April 4; 2020 vs. 2019	Outpatient consultations; Trauma ED visits; Surgeries	N/A
Bollman; Germany; Multi-centre; Same period single year	Hospital; 66 Helios hospitals	March 1 - April 30; 2020 vs. 2019	Admissions for heart failures and arrythmias	N/A
Bozovich; Argentina; Multi-centre; Same period single year	ED & Hospital; 31 private hospitals	April 1 - April 30; 2020 vs. 2019	ED consultations and procedures	N/A
Braiteh; USA; Multi-centre; Same period single year	Hospital; 4 hospitals	March - April; 2020 vs. 2019	Admissions for any cause; Presentations for Acute Coronary Syndrome (also describes as admissions)	Rates of STEMI versus NSTEMI

Bramer; USA; Multi-centre; Same period single year	Community; vaccinations from one state immunization system	May; 2020 vs. 2017-19	Proportion of children with up-to-date status for all recommended vaccines	N/A
Butt; Qatar; Multi-centre; Same period single year	ED; 2 hospitals in Qatar that see over 80% of patients in Qatar with suspected Acute Coronary Syndrome	March - April; 2020 vs. 2019	Total ED visits; ED presentations with cardiac symptoms	Rates presenting with Acute Coronary Syndrome (ACS)
Cano-Valderrama; Spain; Multi-centre; Same period single year	Hospital; 3 tertiary care centres	March 16 - April 26; 2020 vs. 2019	Acute care surgeries	SOFA scores
Cheek; Australia; Multi-centre; Same period single year	ED; 2 tertiary hospitals and 2 urban district hospitals	March 22 - May 23; 2020 vs. 2019	Number of attendances at paediatric ED; Number of attendances at paediatric ED for mental health diagnoses; Number of neonatal presentations	N/A
Chou; Taiwan; Multi-centre; Same period single year	Community/Primary care; Hospice homecare services, hospice inpatient services and non-hospice services provided by 2 branches of health care organisation in Northern Taiwan	January - April; 2020 vs. 2019	Number of hospice home care visits; Number of new enrolments in hospice home care; Bed occupancy rates in hospice and non-hospice units; Monthly patient days in hospice and non-hospice units	N/A
Claeys; Belgium; National; Same period single year	Hospital; 36 of the 49 PCI-capable hospitals in the Belgian STEMI database and Belgian Coronary Stent Registry	March 13 - April 3; 2020 vs. 2017-19	Number of STEMI admission	Mortality; % cardiac arrest; Killip class

Clerici; Italy; Multi-centre; Same period single year	Hospital; 7 general hospital psychiatric wards in the Lombardy region of Italy	February 21 - March 31; 2020 vs. 2019	Average daily number of admissions by week, total number of weekly admissions; Annual rates of admissions/1000 adults	Number of voluntary and involuntary admissions
Collado-Mesa; USA; Multi-centre; Same period single year	Community/Outpatient; five breast imaging centres	April; 2020 vs. 2018-19	Number of breast imaging examinations; Number of image-guided procedures	Proportion of positive biopsy of image guided biopsy
CVD-Covid-UK Consortium; UK; Multi-centre; Same period single year	Hospital; 9 hospitals in England and Scotland	March 23 - May 10; 2020 vs. 2018-19	Number of ED attendances and hospital admissions	procedures for cardiac, cerebrovascular, other vascular conditions
De Filippo; Italy; Multi-centre; Same period single year	Hospital; 15 hospitals in Northern Italy	February 20 - March 31; 2020 vs. 2019	Incidence rate ratio for hospital admissions for ACS	Incidence rate ratio for STEMI/NSTEMI
de Havenon; USA; Multi-centre; Same period single year	Hospital; 65 academic and community hospitals	February - March; 2020 vs. 2018-19	Number of hospitalisations for stroke and ACS; Number of procedures for stroke and ACS	N/A
De Rosa; Italy; Multi-centre; Same period single year	Hospital; cardiac care units at 54 Italian hospitals affiliated with Italian Society of Cardiology	March 12 - March 19; 2020 vs. 2019	Number of admissions for acute myocardial infarction	Case fatality rates; Number of admissions per diagnosis (STEMI/NSTEMI)

Diegoli; Brazil; Multi-centre; Same period single year	Hospital; 6 hospitals in Joinville, Brazil	March 17 - April 15; 2020 vs. 2019	Admissions for stroke/100000 inhabitants	Admissions for severe stroke (NIH stroke scale score)
Egol; USA; Multi-centre; Same period single year	ED & Hospital; The NYU Langone Orthopaedic Department is responsible for the musculoskeletal care at 7 different hospitals within the New York City area.	February 1 - April 15; 2020 vs. 2019	Number of ED presentations with hip fracture	Mortality; Non/operative case
Enache; Monaco; National; Same period single year	ED & Hospital; Monaco public health care system	March; 2020 vs. 2019	Number cardiovascular and emergency admissions	N/A
Franco; Italy; Multi-centre; Same period single year	Hospital; 10 cardiology centres in Northern Italy	February 23 - March 28; 2020 vs. 2019	Number of hospitalisations for NSTEMI	N/A
Frankfurter; Canada; Multi-centre; Same period single year	ED & Hospital; University Health Network (Toronto General Hospital and Toronto Western Hospital), in Toronto, Canada	March 1 - April 19; 2020 vs. 2019	Number ED visits and hospitalised with heart failure	ICU admission; Mortality; Hospitalisation; NYHA class III-IV
Garcia; USA; Multi-centre; Time trend single year	Hospital; 18 sites representing primary percutaneous coronary intervention (PPCI) hospitals and healthcare systems across the US	March - April; 2020 vs. 2019	Monthly volume of cardiac catheterisation leading to intervention (angiography)	N/A

Gawron; USA; National; Time trend single year	Hospital & Outpatient; 170 medical centres and 1074 outpatient sites	March - April; 2020 vs. 2019	Average number of upper gastrointestinal endoscopies per month	N/A
Giuntoli; Italy; Multi-centre; Same period single year	Hospital; three of the major trauma and elective orthopaedic surgery centres of north-west Tuscany	March; 2020 vs. 2019	Number of patients treated	Hospitalisation
Gruttadauria; Italy; Multi-centre; Same period single year	Hospital; 22 Italian Liver Transplant Programs.	March 1 - March 15; 2020 vs. 2018-19	Number of liver transplants	N/A
Hartnett; USA; Multi-centre; Same period single year	ED; subset of hospitals in 47 states capturing approximately 73% of ED visits in the USA	March 29 - April 25; 2020 vs. 2019	Mean weekly ED presentations	N/A
Houshyar; USA; Multi-centre; Same period single year	ED & Hospital; 5 University of California Health Centres with academic radiology programs.	March 19 - April 2; 2020 vs. 2019	Daily number of ED radiologic examinations	N/A
Hoyer; Germany; Multi-centre; Same period single year	ED & Hospital; 4 German comprehensive stroke centres.	March 16 - April 12; 2020 vs. 2019	Numbers of patients admitted with final diagnoses of ischemic stroke or TIA	TIA/ Stroke

Isba; UK; Multi-centre; Same period single year	ED; 2 hospitals in greater Manchester	February - March; 2020 vs. 2019	Weekly PED attendances	N/A
Jasne; USA; Multi-centre; Same period single year	ED & Hospital; 3 hospitals in New Haven, Connecticut	March 1 - April 28; 2020 vs. 2019	Weekly stoke code calls	N/A
Kadavath; USA; Multi-centre; Same period single year	Hospital; 12 fellowship training sties	March 1 - April 15; 2020 vs. 2019	Number of invasive cardiac procedures	N/A
Kerleroux; France; Multi-centre; Same period single year	Hospital; 32 centres in all French administrative regions.	February 15 - March 30; 2020 vs. 2019	Number of patients receiving MT between study periods	% unwitnessed onset; Baseline NIHSS; ASPECTs
Kessler; Germany; Multi-centre; Same period single year	Hospital; 15 cardiac care centres distributed across Germany providing 24/7 interventional cardiac care.	March 1 - April 30; 2020 vs. 2019	Number of patients presenting with Acute Coronary Syndrome	STEMI/NSTEMI
Kim; USA; Multi-centre; Same period single year	ED; seven EDs include one urban academic hospital, five suburban community hospitals, and one free-standing ED.	March 8 - May 2; 2020 vs. 2019	Weekly Emergency Department visits	N/A

Kolbaek; Denmark; Multi-centre; Same period single year	Community/Outpatient; Psychiatric services	February 23 - May 2; 2020 vs. 2019	Number of referrals to psychiatric service	N/A
Krenzlin; Germany; Multi-centre; Same period single year	Hospital; Two major neurosurgical departments in Germany	March 16 - April 19; 2020 vs. 2018-19	Number of emergency admissions	N/A
Langdon-Embry; USA; Multi-centre; Same period single year	Community; childhood immunisation facilities in New York City	March 16 – May 31; 2020 vs. 2019	Number of childhood vaccine doses administered; Number of unique facilities reporting administration of at least one childhood vaccine	N/A
Lantelme; France; Multi-centre; Same period single year	Hospital; 3 public centres in Lyon.	March 9 - April 5; 2020 vs. 2019	Weekly rate of hospital admissions for myocardial infarction	N/A
Lazaros; Greece; Multi-centre; Same period single year	Hospital; 2 large hospitals of the National Health System belonging to the larger Metropolitan area of Athens	March 12 - May 7; 2020 vs. 2019	Number of cardiac surgery procedures	Emergency vs non-emergency
Lazzerini; Italy; Multi-centre; Same period single year	ED; 5 Pediatric ED (three third-level referral hospitals and two second-level hospitals)	March 1 - March 27; 2020 vs. 2019	Number of paediatric emergency department visits	N/A

Li; Taiwan; Multi-centre; Same period single year	Hospital; 40 major hospitals	February - April; 2020 vs. 2019	Number of patients admitted for STEMI	N/A
Lui; Hong Kong; National; Same period single year	Hospital; all public hospitals	January 21 - March 31; 2020 vs. 2017-19	Upper and lower endoscopies	Positive rate for colon cancer and gastric cancer
Mafham; UK; National; Same period single year	Hospital; 147 acute NHS hospital trusts	January 6 - May 30; 2020 vs. 2019	Admissions for Acute Coronary Syndromes	Proportions of STEMI vs NSTEMI
Manzoni; Italy; Multi-centre; Same period single year	ED; 2 emergency paediatric departments	March - April; 2020 vs. 2019	Volume of ED visits	Hospitalisation
Mazzatenta; Italy; Multi-centre; Same period single year	Hospital; 5 neurosurgery departments and 1 paediatric centre	March 13 - April 13; 2020 vs. 2018-19	Outpatient consultations; Surgical activities	Urgent/nonurgent surgery
McDonald; UK; National; Same period single year	Community; electronic patient records of vaccination	March 2 - April 25; 2020 vs. 2019	Hexavalent vaccines; MMR first vaccination	N/A

Mitchell; Australia; Multi-centre; Time trend multiple years	ED & Hospital; 2 Emergency Departments	March 26 - April 25; 2020 vs. 2017-19	Daily number of ED presentations	Triage category
Naidich; USA; Multi-centre; Same period single year	Hospital & Outpatient; 92 centres across NY state	March 2 - April 18; 2020 vs. 2019	Volume of imaging	N/A
Norbash; USA; Multi-centre; Same period single year	Hospital & Outpatient; 6 academic medical systems	January 6 - May 23; 2020 vs. 2019	Volume of imaging	N/A
Novara; Italy; Multi-centre; Same period single year	ED; EDs within 8 academic and non-academic urology centres	March 12 - March 16; 2020 vs. 2019	ED urological consults	Triage category/ hospitalisation
Onteddu; Multi-national; Multi-centre; Same period single year	Hospital; TriNetX, a global health collaborative clinical research platform collecting real-time electronic medical record data from a network of health care organizations	January 20 - May 16; 2020 vs. 2019	Number of ischemic stroke patients	N/A
Papafakis; Greece; Multi-centre; Same period single year	Hospital; Greek public hospitals with PCI capability, including a primary PCI service	March 2 - April 12; 2020 vs. 2019	Number of patients admitted for Acute coronary syndrome	ACS presentation

Pignon; France; Multi-centre; Same period single year	ED; 3 psychiatric emergency services	March 17 - April 13; 2020 vs. 2019	Emergency psychiatric consultations	Rates of hospitalisation
Pinar; France; Multi-centre; Same period single year	Hospital; 8 academic urology departments	March 12 - March 27; 2020 vs. 2019	Urological surgeries	N/A
Polo Lopez; Spain; Multi-centre; Same period single year	Hospital; 13 public hospitals where most congenital heart disease surgery in Spain is performed	March 13 - May 13; 2020 vs. 2019	Number of congenital heart disease surgeries	N/A
Pop; France; Multi-centre; Same period single year	Hospital; 3 hospitals with stroke units	March 1 -March 31; 2020 vs. 2019	Stroke alerts (following initial consult)	Proportion of alerts resulting in admissions for stroke; Initial NIHSS score
Qasim; USA; Multi-centre; Same period single year	ED; 4 adult and 2 paediatric Level 1 Trauma centres	March 9 - April 19; 2020 vs. 2019	Trauma contacts	Rates of highest acuity ("alerts")
Range; France; Multi-centre; Time trend single year	Hospital; 12 interventional cardiology centres	March 15 - April 4; 2020 vs. 2019	Patients enrolled in Percutaneous Coronary Intervention registry (follows all STEMI patients undergoing PCI)	N/A

Reeves; UK; Multi-centre; Time trend multiple years	Hospital; University hospitals in one NHS Foundation Trust	March 22 - April 25; 2020 vs. 2016-19	Admissions for STEMI and stroke	N/A
Requena; Multi-national; Multi-centre; Same period single year	Community; 2 fertility facilities in Spain and 1 in Italy	February 3 - March 23; 2020 vs. 2019	Fertility related procedures	N/A
Romaguera; Spain; Multi-centre; Same period single year	Hospital; 10 percutaneous coronary intervention hospitals	March 1 - April 19; 2020 vs. 2019	STEMI admissions	Proportion of more severe Killip classes; Proportion of sudden cardiac death; mortality
Scaramuzza; Italy; Multi-centre; Same period single year	ED; 2 paediatric emergency departments	February 20 - March 30; 2020 vs. 2019	Presentations to paediatric ED	Reductions across different triage categories
Salerno; Italy; National; Same period single year	Hospital; 35 endoscopy units in Italy	March; 2020 vs. 2019	Number of urgent endoscopic procedures	Proportion of positive procedures (i.e. diagnostic yield) for urgent EGDs and lower endoscopy
Santana; Portugal; National; Time trend multiple years	ED; emergency services in mainland Portugal	March; 2020 vs. 2019	Number of emergency episodes	Triage category

Scholz; Germany; Multi-centre; Same period single year	Hospital; 41 percutaneous coronary intervention centres participating in a trial	March; 2020 vs. 2017-19	Number of STEMI patients treated	Mortality; TIMI score
Secco; Italy; Multi-centre; Same period single year	Hospital; 3 high volume centres in North and Central Italy	March; 2020 vs. 2019	Number of admissions for ACS	Type of ACS; TIMI score; GRACE score; Admission peak hs-troponin; Mortality
Seiffert; Germany; National; Same period single year	Hospital; Health insurance claims from second largest insurer in Germany	March 2 - May 31; 2020 vs. 2019	Rate of admissions/100000 insured for cardiovascular or cerebrovascular emergencies	Number per diagnosis (STEMI, NSTEMI, stroke, TIA); Number of invasive procedures; Mortality
Smalley; USA; Multi-centre; Same period single year	ED; 20 EDs across a large Midwest integrated healthcare system	March 25 - April 24; 2020 vs. 2019	Number of ED encounters; Number of behavioural health visits to the ED	N/A
Tinay; Turkey; Multi-centre; Same period single year	Hospital; Surgical urologic oncology practices	March 11-April 11; 2020 vs. 2019	Number of nondeferrable uro-oncological procedures	ASA score
Toro; Chile; National; Time trend multiple years	ED; public health hospitals, emergency care services in 16 regions of Chile	March 8 - April 18; 2020 vs. 2015-19	Number of emergency service consultations	N/A

Toyoda; Multi-national; Multi-centre; Same period single year	Hospital; 3 liver speciality clinics	February 1 - May 1; 2020 vs. 2018-19	Number of clinic visits; Number of ultrasounds performed; Number of CT/MRIs performed	Visits in advanced disease patients
Wong; Hong Kong; National; Same period single year	Hospital & Outpatient; 43 Hong Kong public hospitals and 122 outpatient clinics	January 25 - March 27; 2020 vs. 2016-19	Mean weekly orthopaedic operations; Mean weekly orthopaedic emergencies treated operatively	Elective and emergency operations
Xu; USA; Multi-centre; Same period single year	Outpatient; retinal care centres	March 8 - May 16; 2020 vs. 2018-19	Mean weekly office visits; Mean weekly intravitreal injections; Mean weekly optical coherence tomography, fluorescein angiography and indocyanine green testing	N/A
Zhao; China; Multi-centre; Same period single year	Hospital; 280 stroke centres across China participating in Big Data Observatory platform	January - February; 2020 vs. 2019	Number of stroke admissions; Number of thrombolysis treatments; Number of thrombectomy treatments	N/A

Abbreviations: CT: Computed Tomography Scan; ED: Emergency Department; MRI: Magnetic resonance imaging; N/A: Not applicable; NIHSS:NIH Stroke Scale Score; NSTEMI: Non-ST elevation myocardial infarction; PED: Paediatric Emergency Department; STEMI: ST-elevation myocardial infarction; TIA: Transient Ischaemic Attack.

Note: *This is the period of time analysed in this Systematic Review, not necessarily all of the time period reported in each study. For a few studies that did not clearly define the pandemic period, we defined that period using any indication/reference in the same article for a lockdown or a surge in the number of COVID-19 cases.

Study design label explanations: ‘Same period single year' - Preinterruption measurement at a comparable time period in 2019 only with basic pre-post analysis (unadjusted or adjusted comparison of mean utilisation across the two comparator periods). An example is a study comparing utilisation in the month of March 2020 with utilisation in the month of March 2019; 'Same period multiple years' - Preinterruption measurement at comparable time periods in prior years (2 or more) with basic pre-post analysis. An example is a study comparing utilisation for weeks 10-16 of 2020 with utilisation during weeks 10-16 in 2019 and 2018 (using the average utilisation from the comparator years) ; 'Time trend single year' – This category refers to studies considering data

from an entire year preinterruption time period rather than a single month or period of weeks. An example is a study documenting utilisation for the period January 2019 to some time point in 2020. In these studies preinterruption utilisation trends may be modelled using data from the prior year to estimate predicted utilisation. This category also includes studies that do not model prior data but average utilisation across the prior year for comparison to a postinterruption period. An example is a study comparing the monthly average utilisation for the period Jan 1 2019 to Feb 29 2020 with the monthly average utilisation for March in 2020. Both these types of studies would be rated as moderate risk of bias; 'Time trend multiple years' – This category refers to studies considering data from more than one entire year prior to the pandemic interruption. An example is a study documenting utilisation from the period January 2014 to some point in 2020. In these studies preinterruption utilisation trends may be modelled using observations from previous years to estimate utilisation that would have occurred in the absence of the pandemic.

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5.2 Table Percentage change in healthcare utilisation for each individual study grouped by category of healthcare utilisation.

Study	Outcome	Comparator time period*	Weeks being compared	Total volume of services	% Change (95% CI)
Admissions					
Andersson	Worsening HF	2019	12 to 13	568 (C: 353; P: 215)	-30
Angoulvant	Ped ED Hospitalisation	2017/18/19**	12 to 16	NR	-45 (-32.4 to -57.0)
Athiel	Gynaecological ED Hospitalisation	2019	10 to 22	1761 (C: 976; P: 785)	-20
Baum	Admissions for any cause	2019	11 to 16	130353 (C: 85326; P: 45027)	-43 (-36.0 to -49.0)
Bollmann	HF	2019	10 to 18	6424 (C: 3604; P: 2820)	-21.8 (-18.0 to - 26.0)
Bollmann	Bradycardia	2019	10 to 18	624 (C: 334; P: 290)	-13.2 (-26.0 to +1.0)
Bollmann	Atrial Fibrillation	2019	10 to 18	2962 (C: 1640; P: 1322)	-19.4 (-13.0 to -25.0)
Bollmann	Supraventricular tachycardia	2019	10 to 18	525 (C: 283; P: 242)	-14.5 (-28.0 to +1.0)
Bollmann	Ventricular tachyarrhythmia	2019	10 to 18	433 (C: 251; P: 182)	-27.5 (-13.0 to -40.0)
Braiteh	ACS	2019	10 to 18	180 (C: 113; P: 67)	-40.71
Braiteh	Admissions for any cause	2019	10 to 18	6108 (C: 3496; P: 2612)	-25.29
Claeys	STEMI	2017/18/19	12 to 14	NR	-26

Clerici	Psychiatric hospitalisation	2019	8 to 13	618 (C: 354; P: 264)	-25.42
CVD-Covid-UK Consortium	Total	2018/19	6 to 19	1113075 (C: 599372; P: 513703)	-58.2 (-57.5 to -58.9)
De Filippo	ACS	2019	9 to 13	1320 (C: 775; P: 545)	-29.6 (-22.0 to -37.0)
de Havenon	Stroke	2018/19	6 to 13	33867 (C: 17380; P: 16487)	-5.14
de Havenon	ACS	2018/19	6 to 13	24441 (C: 12111; P: 12330)	1.81
De Rosa	AMI	2019	12 to 19	937 (C: 618; P: 319)	-48.4 (-44.6 to-52.5)
De Rosa	HF	2019	12 to 19	236 (C: 154; P: 82)	-46.8 (-39.5 to -55.3)
De Rosa	Atrial Fibrillation	2019	12 to 19	129 (C: 88; P: 41)	-53.4 (-43.9 to -64.9)
De Rosa	Pulmonary Embolism	2019	12 to 19	29 (C: 17; P: 12)	-29.4 (-0.14 to -0.61)
Diegoli	Stroke	2019	8 to 16	1169 (C: 713; P: 456)	-36.15 (-7.7 to -64.6)
Egol	Hip fracture	2019	6 to 16	253 (C: 115; P: 138)	20
Enache	Cardiovascular disease	2019	10 to 13	765 (C: 419; P: 346)	-17.42
Franco	STEMI	2019	9 to 13	215 (C: 105; P: 110)	4.8
Franco	NSTEMI	2019	9 to 13	1249 (C: 1105; P: 144)	-87
Frankfurter	Worsening HF	2019	10 to 16	256 (C: 149; P: 107)	-39.3 (-8.6 to -78.5)
Hoyer	Strokes admissions	2019	10 to 15	NR	-15.2
Hoyer	TIA admissions	2019	10 to 15	NR	-38.5
Jasne	Strokes admissions	2019	8 to 17	863	-37.2

				(C: 530; P: 333)	
Kessler	ACS	2019	10 to 18	5920 (C: 3411; P: 2509)	-27 (-23.0 to -30.0)
Lantelme	AMI	2019	11 to 14	240 (C: 142; P: 98)	-30.99
Li	STEMI	2019	6 to 18	2130 (C: 1092; P: 1038)	-4.95
Mafham	ACS	2019	2 to 22	120076 (C: 65375; P: 54701)	-40 (-37 to -43)
Manzoni	Ped	2019	10 to 18	91 (C: 73; P: 18)	-75
Onteddu	Strokes	2019	4 to 20	104615 (C: 66674; P: 37941)	-43.09
Papafaklis	ACS	2019	10 to 15	1848 (C: 1077; P: 771)	-28.41 (-21.0 to -35.0)
Reeves	STEMI	2016/17/18/19	13 to 17	155 (C: 85; P: 70)	-17.3
Reeves	Stroke	2016/17/18/19	13 to 17	230 (C: 175; P: 155)	-15.6
Romaguera	STEMI	2019	10 to 16	919 (C: 524; P: 395)	-24.6 (-14.0 to -34.0)
Secco	ACS	2019	10 to 13	246 (C: 162; P: 84)	-48.15 (-33.0 to -61.0)
Seiffert	Cardiovascular or cerebrovascular emergencies	2019	10 to 22	67443 (C: 35841; P: 31602)	-14.97
Zhao	Stroke	2019	6 to 9	56306 (C: 34725; P: 21581)	-37.9
Diagnostics					
Collado-Mesa	Breast imaging	2018/19	14 to 18	8239 (C: 7142; P: 1097)	-84.64
Houshyar	ED volume of all imaging	2019	13 to 14	5871 (C: 3552; P: 2319)	-34.7 (-12.0 to -57.4)

	(MRI, CT, x-ray, US, fluoroscopy)				
Lui	Upper endoscopies	2017/18/19	4 to 13	2700 (C: 1813; P: 887)	-51.1
Lui	Lower endoscopies	2017/18/19	4 to 13	1681 (C: 1190; P: 491)	-58.7
Naidich	Total imaging volume	2019	10 to 16	408067 (C: 237388; P: 170679)	-28.1
Naidich	ED imaging volume	2019	10 to 16	195160 (C: 112579; P: 82581)	-26.6
Naidich	Inpatient imaging volume	2019	10 to 16	147070 (C: 78902; P: 68168)	-13.6
Naidich	Outpatient imaging volume	2019	10 to 16	65837 (C: 45907; P: 19930)	-56.6
Norbash	All radiological requests	2019	2 to 21	282749 (C: 203132; P: 79617)	-21.8
Toyoda	Abdominal US	2018/19	6 to 18	4506 (C: 2566; P: 1940)	-24.4
Toyoda	Abdominal CT/MRIs	2018/19	6 to 18	3553 (C: 1874; P: 1679)	-10.38
Xu	Optical coherence tomography, indocyanine green, fluorescent angiography	2018/19	11 to 20	566955 (C: 355458; P: 211497)	-40.5 (-26.4 to -54.7)
Therapeutics, Procedures, Surgeries					
Benazzo	Trauma surgeries	2019	9 to 14	1011 (C: 559; P: 452)	-19.2
Benazzo	Femoral neck fracture surgeries	2019	9 to 14	656 (C: 349; P: 307)	-12.2
Bollmann	Catheter ablations	2019	10 to 18	472 (C: 264; P: 208)	-21.2 (-6.0 to -44.0)
Bollmann	CRM device implantations	2019	10 to 18	675 (C: 365; P: 310)	-15.1 (-1.0 to -27.0)

Bozovich	Coronary angioplasties	2019	14 to 18	1330 (C: 946; P: 384)	-59.41 (-50.0 to -67.0)
Bozovich	Heart surgeries	2019	14 to 18	400 (C: 282; P: 118)	-58.16 (-46.0 to -100)
Bozovich	PCI	2019	14 to 18	2501 (C: 1850; P: 651)	-64.81 (-50.0 to -78.0)
Bozovich	General surgeries	2019	14 to 18	24805 (C: 19600; P: 5205)	-73.44 (-62.0 to -75.0)
Bozovich	Chemotherapy and radiotherapy	2019	14 to 18	9227 (C: 5005; P: 4222)	-15.64 (-3.0 to -52.0)
Bozovich	GI endoscopies	2019	14 to 18	8549 (C: 7137; P: 1412)	-80.22 (-77.0 to -93.0)
Bramer	Non-influenza immunisation for children	2017/18/19	1 to 18	NR	-21.5
Cano-Valderrama	Acute surgeries	2019	12 to 17	402 (C: 285; P: 117)	-58.95
de Havenon	MT	2018/19	6 to 13	725 (C: 319; P: 406)	27.3
de Havenon	tPA	2018/19	6 to 13	570 (C: 266; P: 304)	14.3
de Havenon	PCI	2018/19	6 to 13	2596 (C: 1330; P: 1266)	-4.81
Garcia	Cardiac catheterisation	2019	10 to 18	1332 (C: 779; P: 553)	-29.1
Gawron	Gastrointestinal endoscopies	2019	10 to 18	34053 (C: 23455; P: 10598)	-54.81
Gawron	Colonoscopies	2019	10 to 18	57183 (C: 43371; P: 13812)	-68.15
Giuntoli	Scheduled orthopaedic procedures	2019	10 to 13	583 (C: 444; P: 139)	-68.69

Giuntoli	Trauma orthopaedic procedures	2019	10 to 13	488 (C: 270; P: 218)	-19.26
Gruttadauria	Liver transplantation and related procedures	2018/19	10 to 11	98 (C: 61; P: 37)	-39.34
Kadavath	Invasive cardiac procedures	2019	10 to 16	7219 (C: 4671; P: 2548)	-45.45
Kerleroux	MT for stroke	2019	8 to 13	1512 (C: 844; P: 668)	-21 (-18.0 to -24.0)
Langdon-Embry	Routine childhood immunisation	2019	12 to 22	590000 (C: 344000; P: 246000)	-28.49
Lazaros	Cardiac surgery procedures	2019	12 to 19	330 (C: 246; P: 84)	-65.85
Mafham	PCI after the admission day	2019	2 to 22	17469 (C: 8055; P: 9414)	-47 (-37 to -52)
Mafham	PCI on the admission day	0	2 to 22	19277 (C: NR; P: NR)	-16 (-7 to -24)
Mafham	CABG	2019	2 to 22	3196 (C: 2663; P: 533)	-80 (-68 to -87)
Mafham	Angiography	2019	2 to 22	16079 (C: 11485; P: 4594)	-60 (-53 to -65)
Mazzatenta	Non-urgent surgical procedures	2018/19	12 to 15	918 (C: 713; P: 205)	-71.25
Mazzatenta	Urgent surgical procedures	2018/19	12 to 15	274 (C: 161; P: 113)	-29.6
McDonald	Hexavalent vaccine (first does)	2019	10 to 17	62692 (C: 31475; P: 31217)	-0.82
McDonald	MMR vaccine (first does)	2019	10 to 17	59809 (C: 30989; P: 28820)	-7
Onteddu	tPA	2019	4 to 20	1841	-50.93

				(C: 1235; P: 606)	
Onteddu	MV	2019	4 to 20	644 (C: 399; P: 245)	-38.6
Pinar	Urological surgeries	2019	12 to 13	1439 (C: 995; P: 444)	-55.4
Polo Lopez	Congenital heart diseases surgeries	2019	12 to 20	193 (C: 142; P: 51)	-51
Range	Coronary angiography for STEMI	2019	10 to 13	430 (C: 246; P: 184)	-25.2
Requena	Frozen embryo transfer	2019	6 to 12	4461 (C: 2500; P: 1961)	-21.5
Requena	IVF	2019	6 to 12	5441 (C: 3007; P: 2434)	-19.1
Requena	IUI	2019	6 to 12	1301 (C: 564; P: 467)	-17.3
Salerno	Urgent GI endoscopic procedures	2019	10 to 13	2305 (C: NR; P: NR)	-39.49
Tinay	Non-deferrable uro-oncological procedures	2019	11 to 15	290 (C: 200; P: 90)	-55
Wong	Orthopaedic operations	2016/17/18/19	5 to 13	928278 (C: 595814; P: 332464)	-44.2 (-54.7 to -33.7)
Xu	Intravitreal injections	2018/19	11 to 20	454765 (C: 235996; P: 218769)	-7.3 (2.2 to -16.8)
Zhao	Thrombolysis	2019	6 to 9	5930 (C: 3422; P: 2508)	-25.5
Zhao	Thrombectomy	2019	6 to 9	2268 (C: 1298; P: 970)	-22.7
Visits					
Abdulmalik	All primary care services	2018/19	10 to 22	1384037 (C: 872691; P: 511346)	-41.41

Angoulvant	Ped ED	2017/18/19**	12 to 16	871543 (C: NR; P: NR)	-68 (-55.8 to -81.2)
Antonucci	ED urological	2019	10 to 18	304 (C: 201; P: 103)	48.8
Athiel	Gynaecological ED	2019	10 to 22	39690 (C: 24982; P: 14708)	-41
Bayles, preprint	ED	2018/19	12 to 18	21527 (C: 17230; P: 4297)	-50.1 (-39.5 to -60.7)
Benazzo	Orthopaedic outpatient	2019	9 to 14	17041 (C: 6863; P: 10178)	-48.3
Benazzo	ED trauma	2019	9 to 14	14772 (C: 6050; P: 8722)	-44.17
Benazzo	Elective orthopaedic surgeries	2019	9 to 14	8113 (C: 3065; P: 5048)	-64.7
Bozovich	ED	2019	14 to 18	268899 (C: 213947; P: 54952)	-74.32 (-65.0 to -79.0)
Butt	ED	2019	10 to 18	102033 (C: 58858; P: 43175)	-26.7
Cheek	ED	2019	13 to 21	41041 (C: 26871; P: 14170)	-47.27 (-44.2 to -50.3)
Chou	Hospice home care visits	2019	1 to 18	1516 (C: 777; P: 739)	-4.89
CVD-Covid-UK Consortium	ED	2018/19	6 to 19	942169 (C: 506516; P: 435653)	-52.8 (-52.2 to -53.5)
CVD-Covid-UK Consortium	ED cardiac	2018/19	6 to 19	NR	-40.2 (-35.6 to -45.0)
CVD-Covid-UK Consortium	ED cerebrovascular	2018/19	6 to 19	NR	-31.8 (-26.2 to -38.0)

CVD-Covid-UK Consortium	ED vascular	2018/19	6 to 19	NR	-40.6 (-31.5 to -50.3)
Frankfurter	Symptoms suggestive of HF	2019	10 to 16	1906 (C: 800; P: 1106)	38.3 (26.3 to 51.6)
Frankfurter	HF	2019	10 to 16	314 (C: 186; P: 128)	-43.5 (-14.8 to -79.4)
Giuntoli	Orthopaedic first aid visits	2019	10 to 13	1679 (C: 1301; P: 378)	-70.95
Hartnett	ED	2019	11 to 22	3319945 (C: 2099734; P: 1220211)	-31.47
Isba	Ped ED	2019	6 to 13	NA (C: NA; P: NA)	-17.74
Kim	ED	2019	11 to 18	68384 (C: 38712; P: 29672)	-44 (-33.0 to -53.0)
Kolbaek	Referrals to psychiatric services	2019	9 to 18	7982 (C: 4419; P: 3563)	-19.4
Krenzlin	ED Neurosurgery	2018/19	12 to 16	2646 (C: 1824; P: 822)	-44.7 (-42.6 to -46.8)
Lazzerini	Ped ED	2019	10 to 13	10826 (C: 8818; P: 2008)	-77.72 (-73.0 to -88.0)
Manzoni	Ped ED	2019	10 to 18	1654 (C: 1428; P: 226)	-86 (-32.0 to -55.0)
Mazzatenta	Outpatient neuro-surgical	2018/19	12 to 15	2234 (C: 1768; P: 466)	-73.6
Mitchell	ED	2017/18/19	14 to 17	14059 (C: 8643; P: 5416)	-37.3 (-33.0 to -41.0)
Novara	ED urological	2019	12	399 (C: 275; P: 124)	-54.9
Pignon	ED psychiatric	2019	12 to 15	1777 (C: 1224; P: 553)	-54.8
Pop	Stroke	2019	10 to 13	462	-39.6

				(C: 288; P: 174)	
Qasim	Trauma	2019	11 to 16	2386 (C: 1328; P: 1058)	-20.3
Santana	ED	2019**	10 to 13	863414 (C: NR; P: NR)	-47.98
Scaramuzza	Ped ED	2019	9 to 13	3912 (C: 2958; P: 954)	-67.8
Scholz	STEMI	2017/18/19	10 to 13	1716 (C: 1329; P: 387)	-12.64
Smalley	ED	2019	13 to 17	87840 (C: 56453; P: 31387)	-44.4
Toro	ED	2015/16/17/18/19	10 to 18	5045647 (C: 3198508; P: 1847139)	-42.25
Toro	Circulatory system ED	2015/16/17/18/19	10 to 18	105471 (C: 58439; P: 47032)	-19.52
Toro	Stroke ED	2015/16/17/18/19	10 to 18	11004 (C: 6385; P: 4619)	-27.66
Toyoda	Liver clinics	2018/19	6 to 18	8568 (C: 5335; P: 3233)	-39.4
Xu	Retinal outpatient clinics	2018/19	11 to 20	813585 (C: 485433; P: 328152)	-32.4 (-20.4 to - 44.4)

*this is the comparator year that studies included in their comparison to the 2020 time period; **these studies compared the expected/forecasted utilisation for 2020 from data from these years

Abbreviations: ED: emergency department; HF: Heart Failure; IVF: In vitro fertilisation; IUI: Intrauterine insemination; MT: Mechanical thrombectomy; tPA: tissue Plasminogen Activator; CABG: Coronary artery bypass grafting; ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; STEMI: ST Elevation Myocardial Infarction; MRI: Magnetic Resonance Imagine; CT: computerized tomography; US: Ultrasonography; CRM: Cardiac rhythm management; PCI: Percutaneous Coronary Interventions; GI: Gastrointestinal

For studies that reported the changes in healthcare services as incidence rate ratios, IRR, we estimated the % change in healthcare services as 100* (1-IRR). For example, IRR of 0.75 converted to 25% reduction in healthcare services

5.3 Table of results of secondary outcomes of the included studies

Study	Secondary Outcome	Change in proportions of severe patients*	P-value, if provided
Andersson	Mortality	No change	0.45
Braiteh	STEMI/NSTEMI	No change	NR
Butt	% ACS from those presented with cardiac symptoms	Increase	NR
Cano-Valderrama	SOFA score >0	No change	0.16
Claeys	% Cardiac arrest	No change	0.7
Claeys	Killip class	No change	0.7
Claeys	Mortality	No change	0.6
Clerici	Voluntary/involuntary admission	Increase	NR
Collado-Mesa	Positive biopsy (diagnostic yield)	No change	NR
CVD-COVID	Procedures for cardiac, cerebrovascular, other vascular conditions	No change	NR
De Rosa	Mortality	Increase	<0.001
De Rosa	STEMI/NSTEMI	Increase	NR
De-Filippo	STEMI/NSTEMI	No change	0
Diegoli	Admissions for severe stroke (NIH stroke scale score)	Increase	NR
Egol	Mortality (In-patient and 30 day)	Increase	0.005-0.035
Egol	Non-operative cases	No change	0.793
Frankfurter	Hospitalisation	No change	0.22
Frankfurter	ICU admission	No change	0.86
Frankfurter	In-hospital mortality	No change	0.05
Frankfurter	NYHA class III-IV	No change	0.3
Giuntoli	Hospitalisation	Increase	NR
Hoyer	Stroke/TIA	Increase	NR
Kerleroux	% unwitnessed onset	Increase	0.004
Kerleroux	ASPECTs score	Increase	0.041

Kerleroux	Baseline NIHSS	No change	0.279
Kessler	STEMI/NSTEMI	No change	0
Lazaros	Emergency/nonemergency	Increase	<0.001
Lui	Positive rate for colon cancer	Increase	<0.001
Lui	Positive rate for gastric cancer	No change	0.14
Mafham	STEMI/NSTEMI	Increase	NR
Manzoni	Hospitalisation	Increase	<0.001
Mazzatenta	Urgent/Nonurgent	Increase	NR
Mitchell	Triage category	No change	NR
Novara	Hospitalisation	No change	0.8
Novara	Triage category	No change	0.06
Papafakis	STEMI/NSTEMI	Increase	NR
Pignon	Hospitalisation	No change	0.872
Pop	admission	Increase	NR
Pop	Initial NIHSS score	No change	0.886
Qasim	Changes in % of all trauma volume that was at the highest level of acuity (described as 'alert')	Increase	0.006
Romaguera	% of patients with sudden cardiac death	No change	0
Romaguera	10-day mortality	No change	0.459
Romaguera	Killip class II-IV	No change	0.8
Salerno	Diagnostic yield for urgent EGDs	Increase	<0.001
Salerno	Diagnostic yield for urgent lower endoscopy	No change	0.3
Santana	Triage category	No change	0
Scaramuzza	Triage category	Increase	0
Scholz	In-hospital mortality	No change	0.68
Scholz	TIMI score	No change	0.464
Secco	GRACE score	Increase	<0.01
Secco	Peak troponin	Increase	<0.01
Secco	STEMI/NSTEMI	Increase	<0.01
Secco	Mortality	No change	NS

Seiffert	Acute stroke/TIA	Increase	0
Seiffert	STEMI/NSTEMI	Increase	0
Seiffert	In-hospital mortality	No change	0
Seiffert	Intervention/surgeries	No change	0
Tinay	ASA scores	Increase	0.005
Toyoda	Visits in advanced disease patients	No change	0.11
Wong	Emergency/elective	Increase	NR

Note: *This secondary outcome domain is exploring, if there is a reduction in services, whether or not there is a greater or lesser reduction in the proportion of patients/people using the service who have milder or more severe forms of illness. If there is an increase in the proportions with more severe illness - which means a greater reduction among those with milder illness – then an “increase” is recorded in this column.

5.4 Figures Change in healthcare utilisation for each category of healthcare services:

Each dot represents a study estimate for each calendar week. For studies that only provided averages of changes for the whole study period, we plotted the average estimates for each calendar week of the corresponding study period.

Figure 5.4a visits

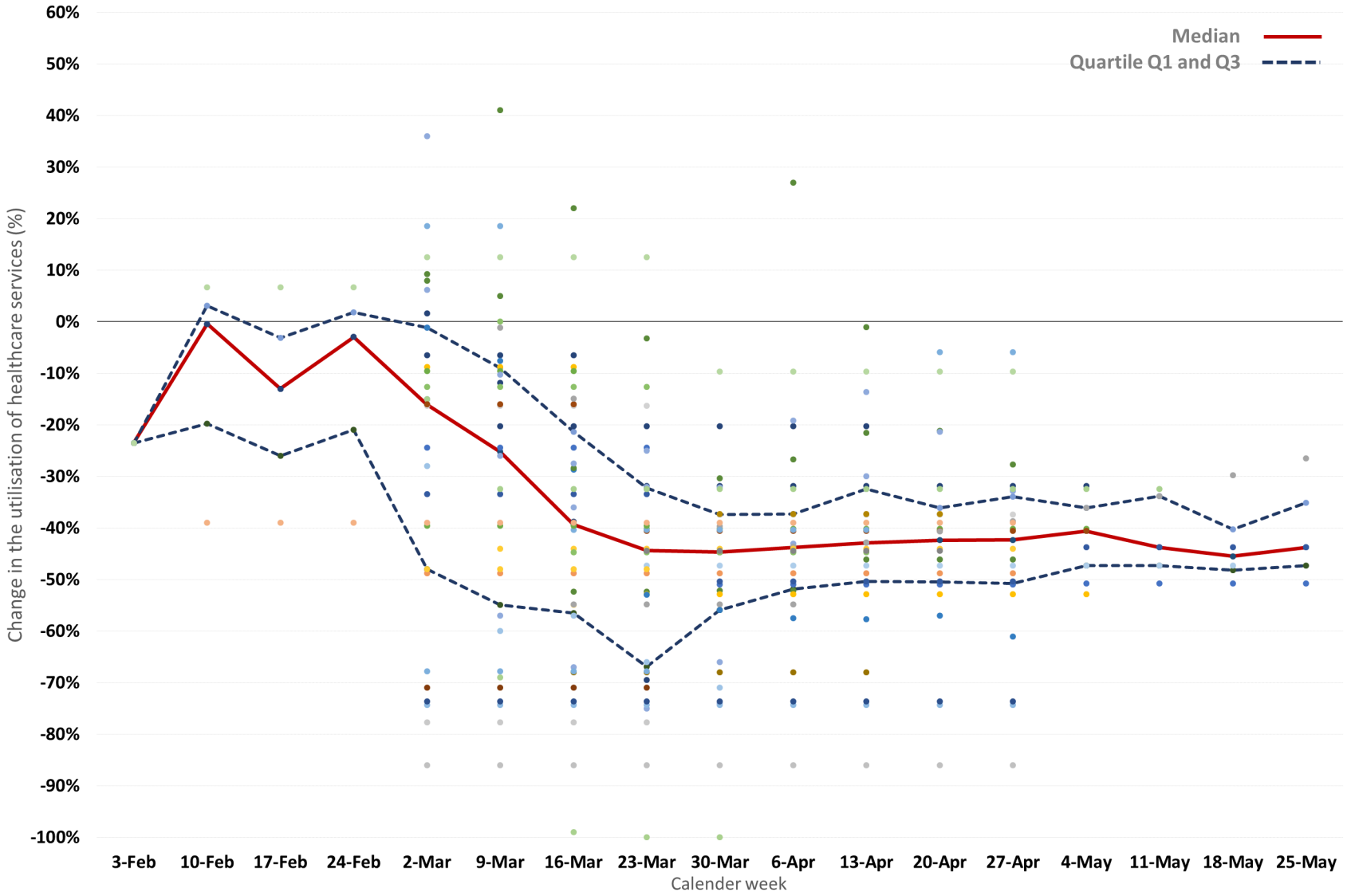

Figure 5.4b admissions

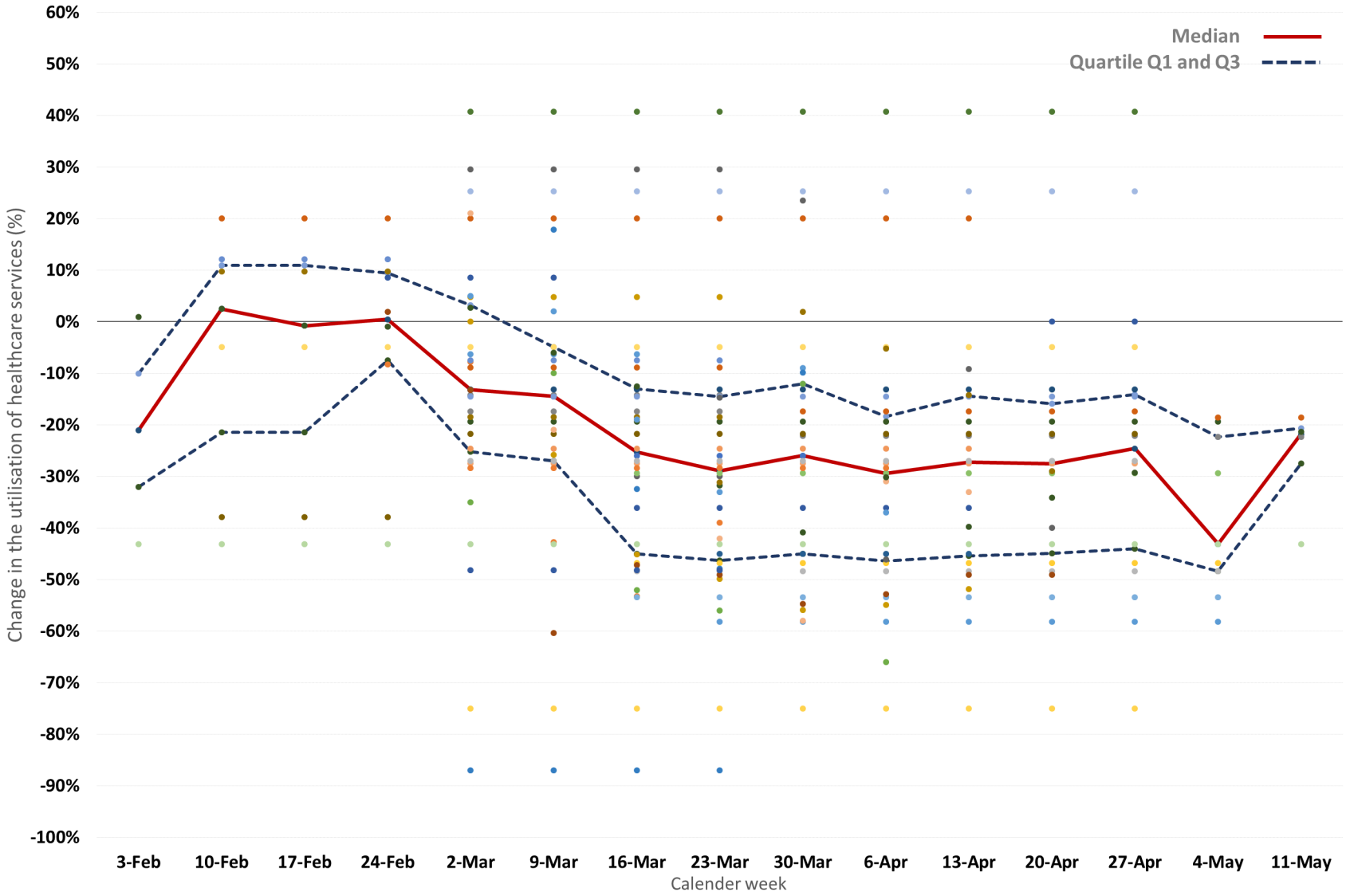

Figure 5.4c diagnostics

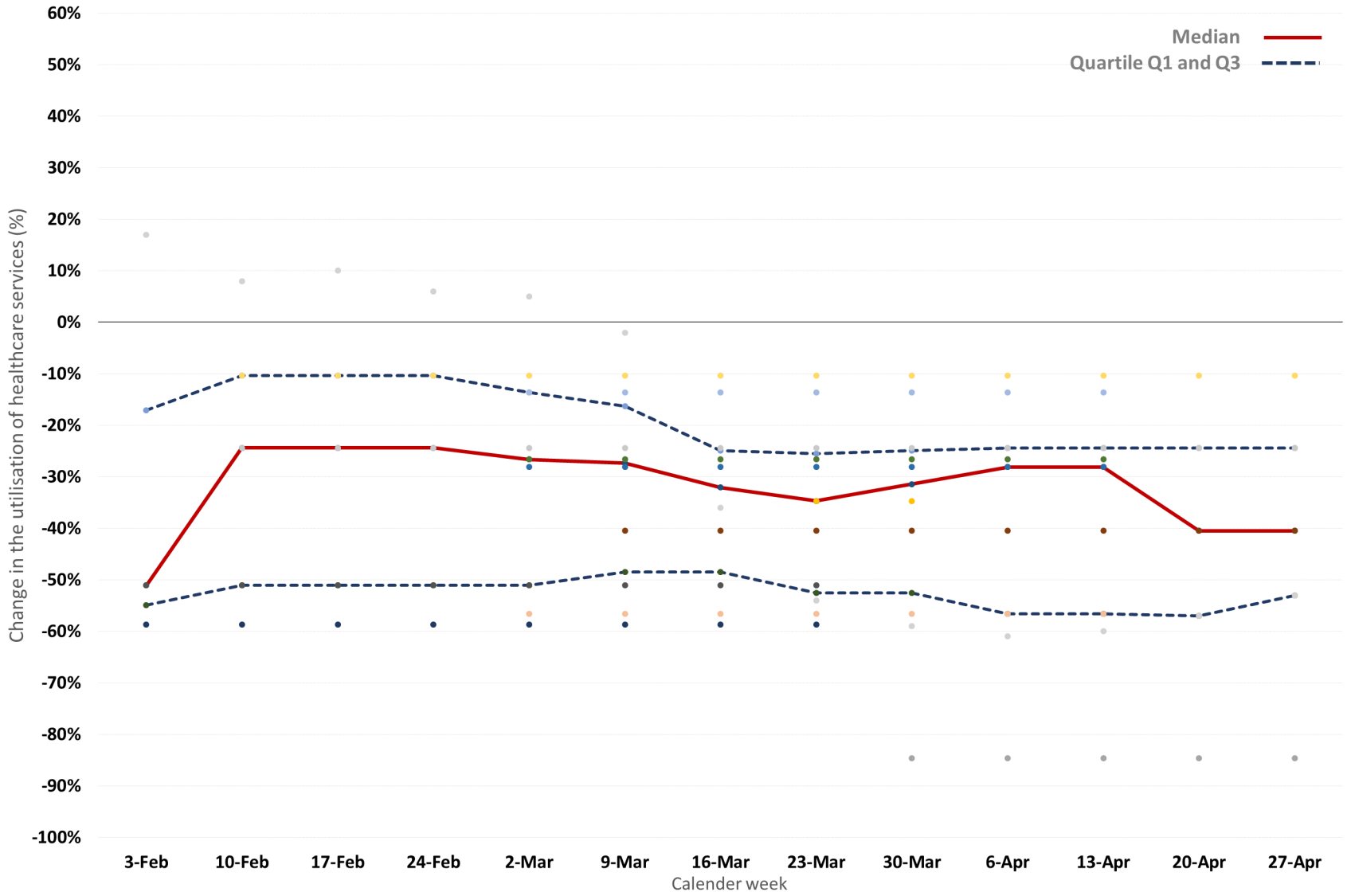

Figure 5.4d therapeutics