


EPIDEMIOLOGICAL SCIENCE

Influenza outcomes in patients with inflammatory joint diseases and DMARDs: how do they compare to those of COVID-19?

Hannah Bower , Thomas Frisell , Daniela Di Giuseppe, Bénédicte Delcoigne, Johan Askling 

Handling editor Josef S Smolen

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/annrheumdis-2021-221461>).

Clinical Epidemiology Division, Department of Medicine Solna, Karolinska Institutet, Stockholm, Sweden

Correspondence to

Dr Hannah Bower, Clinical Epidemiology Division, Department of Medicine Solna, Karolinska Institutet, Stockholm 171 76, Sweden; hannah.bower@ki.se

Received 6 September 2021
Accepted 22 October 2021

ABSTRACT

Objectives To estimate absolute and relative risks for seasonal influenza outcomes in patients with inflammatory joint diseases (IJDs) and disease-modifying antirheumatic drugs (DMARDs). To contextualise recent findings on corresponding COVID-19 risks.

Methods Using Swedish nationwide registers for this cohort study, we followed 116 989 patients with IJD and matched population comparators across four influenza seasons (2015–2019). We quantified absolute risks of hospitalisation and death due to influenza, and compared IJD to comparators via Cox regression. We identified 71 556 patients with IJD on active treatment with conventional synthetic DMARDs and biological disease-modifying antirheumatic drugs (bDMARDs)/targeted synthetic disease-modifying antirheumatic drug (tsDMARDs) at the start of each influenza season, estimated risks for the same outcomes and compared these risks across DMARDs via Cox regression.

Results Per season, average risks for hospitalisation listing influenza were 0.25% in IJD and 0.1% in the general population, corresponding to a crude HR of 2.38 (95% CI 2.21 to 2.56) that decreased to 1.44 (95% CI 1.33 to 1.56) following adjustments for comorbidities. For death listing influenza, the corresponding numbers were 0.015% and 0.006% (HR=2.63, 95% CI 1.93 to 3.58, and HR=1.46, 95% CI 1.07 to 2.01). Absolute risks for influenza outcomes were half (hospitalisation) and one-tenth (death) of those for COVID-19, but relative estimates comparing IJD to the general population were similar.

Conclusions In absolute terms, COVID-19 in IJD outnumbers that of average seasonal influenza, but IJD entails a 50%–100% increase in risk for hospitalisation and death for both types of infections, which is largely dependent on associated comorbidities. Overall, bDMARDs/tsDMARDs do not seem to confer additional risk for hospitalisation or death related to seasonal influenza.

INTRODUCTION

Rheumatoid arthritis (RA) and biological disease-modifying antirheumatic drugs (bDMARDs) or targeted synthetic disease-modifying antirheumatic drugs (tsDMARDs) have been linked with increased risks of infections, which in turn constitute one of the reasons behind the increased morbidity and preterm mortality in RA and other inflammatory joint diseases (IJDs).^{1 2} Some of these infection

Key messages

What is already known about this subject?

► Patients with rheumatoid arthritis (RA) or other inflammatory joint diseases (IJDs) are at increased risk of infections. Historical studies indicate that this applies also to seasonal influenza. Risks in contemporary patients with IJDs and with modern antirheumatic therapies remain unclear.

What does this study add?

► Patients with RA and other IJDs are at increased risk of hospitalisations and death related to seasonal influenza. Much though not all of these increases can be explained by contextual factors rather than the rheumatic disease diagnosis as such. Taken together, biological disease-modifying antirheumatic drugs (DMARDs)/targeted synthetic DMARDs do not confer additional risks beyond conventional synthetic DMARDs. These patterns of relative risks are largely similar to those recently observed for COVID-19, although the absolute risks with the latter are much higher.

How might this impact on clinical practice or future developments?

► Our results indicate the need and potential to further optimise risk mitigation measures against common and epidemic infections such as seasonal influenza in patients with IJDs, but also suggest that common antirheumatic therapies are not strong drivers of this increase.

risks are relatively specific to infectious agent and clinical context (eg, tuberculosis in patients treated with tumour necrosis factor inhibitors (TNFis). Others are less specific with respect to infectious agent and causative context, and rather arise against a background of suboptimally controlled rheumatic disease activity, comorbid conditions associated with RA and a certain level of perturbed immune competence, be it from oral glucocorticoids or from bDMARDs/tsDMARDs. It is clear, however, that ‘infection risk’ is a broad entity, that risks may not be directly translatable across infectious agents, and thus that a complete understanding of infection risks in IJD and with disease-modifying



© Author(s) (or their employer(s)) 2021. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Bower H, Frisell T, Di Giuseppe D, *et al*. *Ann Rheum Dis* Epub ahead of print: [please include Day Month Year]. doi:10.1136/annrheumdis-2021-221461

antirheumatic drugs (DMARDs) calls for studies of specific types of infections.

Seasonal influenza is known to lead to significant morbidity and mortality in the general population.³ Despite the notion that RA, IJD and DMARDs are associated with increased infection risks, that the absolute risk of contracting seasonal influenza in many countries is several times higher than the risks of less prevalent infections such as tuberculosis and other opportunistic infections that have received much (more) attention, and that risk mitigation measures for seasonal influenza, such as annual vaccination, are indeed available,^{4,5} surprisingly little is known on influenza outcomes in patients with RA or other IJDs, and in relation to DMARDs as currently used in clinical practice. Cross-sectional self-report studies have indicated an increased occurrence of influenza-like illnesses in patients with RA.^{6–8} A claims-data based study from the USA reported increased risks of influenza-related complications in patients with RA, but little impact of bDMARDs, but these studies were all based on data from more than 10 years ago.⁹

For many common infections such as seasonal influenza, clinical risks lie not so much with the infection per se as with its severity and outcome, suggesting that further studies of influenza outcomes are needed. In IJD, this is particularly important since common DMARDs may both reduce effectiveness of vaccines against seasonal influenza¹⁰ (the main intended effect of which is to prevent serious disease rather than infection per se) and impair host immune competence of relevance for the clinical severity of seasonal influenza infection.

Recently, we presented absolute and relative risks of hospitalisation and death following COVID-19 in patients with RA or other IJD and in relation to the general population, and could demonstrate that patients with RA and other IJD are at increased risks of hospitalisation and death following COVID-19, but also that most of these increased risks appear attributable to comorbid conditions associated with IJD rather than to the IJD disease or its DMARD treatment per se.¹¹ A full interpretation of these risks and the impact of COVID-19 on the IJD population call for contextualisation with risks of other prevalent infections, such as seasonal influenza during the past years.

In this study, we therefore aimed to estimate absolute and relative risks of hospitalisation and death following seasonal influenza in patients with RA, other IJD and with specific DMARDs in Sweden. The second aim was to put risks with seasonal influenza next to those we recently presented for COVID-19.

METHODS

Study population and period

We used an existing multiregister linkage of IJD (Anti-Rheumatic Treatments In Sweden ('ARTIS')), described elsewhere,^{11,12} to identify our study population, exposures, outcomes and covariates (see online supplemental tables S1–S3 for details). To enable comparison with our recent COVID-19 study, we used similar methodological approaches and definitions.¹¹

We first identified all adult individuals with IJD in Sweden alive at the beginning of at least one of four consecutive influenza seasons (15 September–15 May the following year, as defined by the Swedish National Board of Health and Welfare) 2015/2016, 2016/2017, 2017/2018 and 2018/2019. IJD was identified using the International Classification of Diseases 10th Revision, 10th Revision (ICD-10) codes for RA, psoriatic arthritis, ankylosing spondylitis, other spondyloarthropathies and juvenile idiopathic arthritis via the National Patient Register (NPR) using previously devised algorithms (online supplemental table S2).¹¹ Each

unique individual was matched on year of birth, sex and region of domicile to five randomly selected population comparator subjects from the Swedish Population Register.

Treatment exposures

DMARD treatment status of the patients with IJD at the start of each influenza season was identified using the closest ongoing treatment on or before 15 September per season recorded in the Swedish Rheumatology Quality Register and the Prescribed Drug Register. These were categorised into the following exposures: conventional synthetic disease-modifying antirheumatic drugs (csDMARDs) and bDMARDs/tsDMARDs. The latter was further divided into TNFi, abatacept, tocilizumab, rituximab and janus kinase inhibitors.

Outcomes, follow-up and covariates

We defined the following outcomes: (1) hospitalisation listing influenza (main and contributory diagnoses based on data from the NPR, and with influenza defined as ICD-10=J09 J11), and (2) death from influenza (main and contributory causes based on data from the Cause of Death register). Hospitalisation and deaths listing any cause were also identified to contextualise the influenza-specific outcomes. We followed individuals from the start of the influenza season to the first recorded event of interest (ie, multiple events within each influenza season were not allowed), or censoring at death, migration from Sweden or end of the influenza season.

Information on age, sex, region, socioeconomic factors (education, civil status and country of birth), influenza hospitalisation during the previous year and comorbidities (history of cancer, diabetes, heart failure, ischaemic heart disease, lung disease, stroke, surgery, venous thrombotic event and kidney failure) at the start of each influenza season was obtained from the NPR and the Prescribed Drug Register (online supplemental table S3).

Statistical methods

Absolute risks of outcomes of interest were presented as percentages and calculated as the number of events divided by the number of individuals at risk; this was averaged across seasons for influenza outcomes.

To assess whether the risk of our outcomes was elevated in IJD versus the general population, we estimated crude rates per week (number of events per person–time at risk) for each outcome for each influenza season. We estimated HRs comparing patients with IJD to comparators via Cox proportional hazards models adjusted for influenza season, and with age, sex and region accommodated by the matched design, and further covariate adjustment for socioeconomic factors and comorbidities.

In order to determine the role of DMARDs on the risk of influenza outcomes, we estimated absolute risks and HRs comparing bDMARDs/tsDMARDs to csDMARDs via Cox proportional hazards models. Robust cluster SEs were used in order to account for the fact that one individual could contribute data from more than one influenza season. Cox regressions models were adjusted in the same way as described earlier, plus adjustments for disease duration, Disease Activity Score on 28 joints (DAS28), number of previous bDMARDs/tsDMARDs and concomitant steroid use. No imputation of missing data was performed; sensitivity analyses were performed to determine the effect of missing DAS28 values included in the DMARD treatment analyses (see online supplemental table S10 for details). Comparative analyses were not performed where the number of events in one group was less than five.

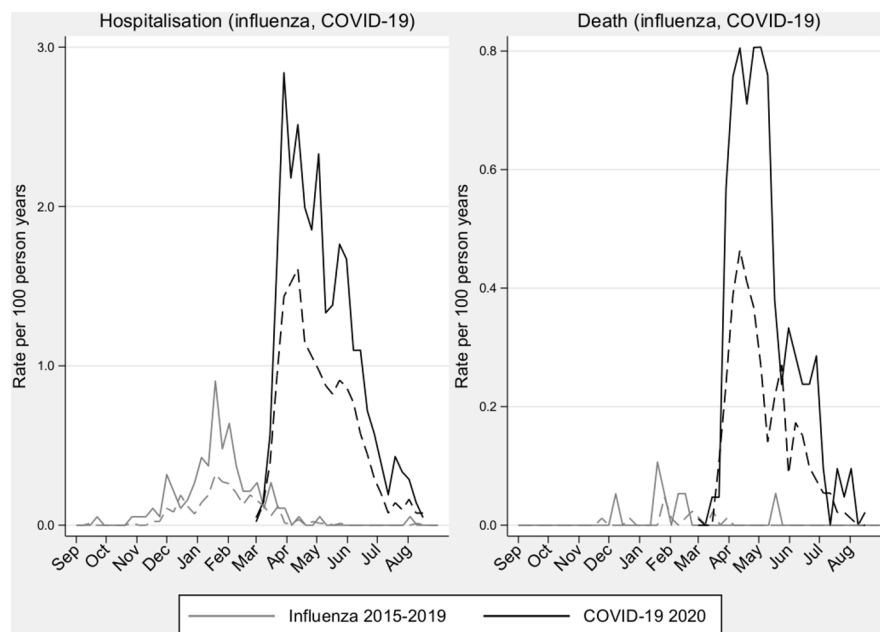


Figure 1 Weekly rate per 100 person-years of hospitalisation and death listing influenza during seasons 2015/2016–2018/2019 and COVID-19 during 2020, for individuals with inflammatory joint diseases (solid lines) and population comparators (dashed lines) in Sweden.

RESULTS

Role of IJD during the influenza seasons 2015–2019

We identified 116 989 unique patients with IJD contributing data to at least one of the four influenza seasons (99 175, 102 811, 106 360 and 109 465 patients during the influenza seasons 2015–2016, 2016–2017, 2017–2018 and 2018–2019, respectively). Descriptive statistics can be found in online supplemental tables S4–S6.

Crude absolute rates (see [figure 1](#)) showed an increased rate of hospitalisation listing influenza and death due to influenza for patients with IJD versus the general population. The average absolute risk of influenza outcomes per season in patients with IJD was approximately three times that seen in the general population, although all risks were low ([table 1](#), left panel; for hospitalisation listing influenza: 0.25% and 0.1% for IJD and comparators, respectively (one additional hospitalisation for influenza for every 666 patients with IJD); for death listing influenza: 0.015% and 0.006% (one additional death from influenza for every 11 111 patients with IJD), respectively).

Prior to adjustment for comorbidities and socioeconomic factors, HRs comparing IJD to the general population for hospitalisation listing influenza and death due to influenza were 2.38 (95% CI 2.21 to 2.56) and 2.63 (95% CI 1.93 to 3.58), respectively ([table 1](#), left panel). Following adjustment, the HRs decreased to 1.44 (95% CI 1.33 to 1.56) for hospitalisation listing influenza and 1.46 (95% CI 1.07 to 2.01) for death due to influenza; similar reductions after adjustment were seen for hospitalisation and deaths due to any cause (online supplemental table S7). Using an alternative definition of death due to influenza, defined as any death occurring 30 days after a hospitalisation listing influenza, we obtained similar results (online supplemental table S8).

When considering patients with RA separately (whose mean age was higher than that of other IJDs), absolute risks were slightly higher than for all IJDs, but the pattern of crude and adjusted relative risks (HRs) remained similar ([table 1](#), left panel).

Role of DMARDs during the influenza seasons 2015–2019

Comparing b/tsDMARDs to csDMARDs, we found a 32% increased rate of hospitalisation listing influenza (adjusted HR=1.32, 95% CI 1.06 to 1.64) but no statistically significantly different rates for death from influenza. A minor but statistically significant higher rate of all-cause hospitalisation was found in bDMARDs/tsDMARDs compared with csDMARDs (online supplemental table S9; adjusted HR=1.08, 95% CI 1.05 to 1.12), but no increased risk for death due to any cause. With respect to specific bDMARDs/tsDMARDs, we noted increased HRs for hospitalisation listing influenza for abatacept and for rituximab ([table 2](#)).

Contextualising risks with COVID-19

The right panels in [tables 1 and 2](#) and [figure 1](#) display corresponding risk estimates from our study on COVID-19.¹¹ The pattern of HRs and the impact of adjustment were largely similar for seasonal influenza, although the decline in disease-specific HRs (here: hospitalisation and death specifically from influenza) following adjustment was somewhat less pronounced for seasonal influenza than for COVID-19. The crude rates for hospitalisation and death presented in [figure 1](#) were much higher for COVID-19 outcomes than for influenza outcomes. Results for hospitalisation listing any cause and death due to any cause can be found in online supplemental table S7 (n.b., the study period was 8 months for seasonal influenza vs 6 months for COVID-19, and they further spanned different calendar months).

DISCUSSION

In this study, one of the few to date that have investigated the pattern of absolute and relative risks for hospitalisation and deaths associated with seasonal influenza in patients with IJD and with currently available DMARDs as used in clinical practice, we noted that the absolute risk of each of the four outcomes under study was higher in IJD (in RA in particular) compared with the general population, but also that a large part (though not all) of these increases could be explained

Table 1 Number of events, absolute risk, excess risk and HRs estimated from Cox proportional hazards models comparing patients with IJDs to matched comparators for outcomes hospitalisation listing influenza (during 2015/2016–2018/2019 influenza seasons) or COVID-19 (during the first wave of COVID-19 2020), and death listing influenza (influenza seasons 2015–2019) or COVID-19 (during the first wave of COVID-19 2020)

		COVID-19 2020*									
Outcome	Events (n) in IJD cohort	Events (n) (average risk, %) in general population	Crude excess risk per 100 patients	HR 1†	HR 2‡	Outcome	Risk (%) in IJD cohort	Risk (%) in general population	Crude excess risk per 100 patients	HR 1†	HR 2‡
All IJD											
Hospitalisation listing influenza	1066 (0.25)	2011 (0.1)	0.15	2.38 (2.21 to 2.56)	1.44 (1.33 to 1.56)	Hospitalisation listing COVID-19	(0.5)	(0.3)	0.2	1.77 (1.61 to 1.95)	1.32 (1.19 to 1.46)
Death listing influenza	64 (0.015)	109 (0.006)	0.009	2.63 (1.93 to 3.58)	1.46 (1.07 to 2.01)	Death listing COVID-19	(0.10)	(0.07)	0.03	2.09 (1.73 to 2.52)	1.18 (0.97 to 1.44)
RA											
Hospitalisation listing influenza	743 (0.35)	1312 (0.15)	0.2	2.41 (2.21 to 2.64)	1.47 (1.34 to 1.62)	Hospitalisation listing COVID-19	(0.7)	(0.4)	0.3	2.02 (1.78 to 2.28)	1.40 (1.23 to 1.60)
Death listing influenza	50 (0.02)	78 (0.009)	0.011	2.73 (1.91 to 3.90)	1.56 (1.08 to 2.27)	Death listing COVID-19	(0.30)	(0.11)	0.19	2.28 (1.85 to 2.81)	1.27 (1.02 to 1.59)

* COVID-19 data taken from Bower *et al.*¹¹ from Cox models fitted identically to those of †. Note that season lengths differ for COVID-19, and for influenza, the former was from March to September (6 months) 2020, whereas the latter was from September to May (8 months) each year 2015–2019.

†HR 1 accounts for age, sex and region via the matching (and for influenza season via adjustment for influenza analyses).

‡HR 2 additionally adjusts for socioeconomic factors (education, civil status and country of birth), influenza hospitalisation in the previous year (in influenza analyses) and comorbidities (history of the following diseases: cancer, diabetes, heart failure, ischaemic heart disease, lung disease, stroke, surgery, venous thrombotic event and kidney failure).

IJD, inflammatory joint disease; RA, rheumatoid arthritis.

Table 2 HRs comparing the rates of hospitalisation listing influenza and death listing influenza (during 2015/2016–2018/2019 influenza seasons) in patients with inflammatory joint diseases receiving csDMARDs to patients receiving bDMARDs/tsDMARDs in Sweden

Outcome	Cohort	Events (n)	Absolute risk (%)	HR 1 (95% CI)*	HR 2 (95% CI)†	HR 2 COVID-19 (95% CI)‡
Hospitalisation	csDMARD	327	0.3	1 (ref)	1 (ref)	1 (ref)
	TNFi	110	0.2	0.54 (0.43 to 0.66)	1.18 (0.92 to 1.52)	1.05 (0.67 to 1.64)
	Abatacept	25	0.6	2.05 (1.33 to 3.16)	2.01 (1.26 to 3.19)	0.49 (0.15 to 1.59)
	Tocilizumab	9	0.2	0.74 (0.38 to 1.43)	1.28 (0.65 to 2.51)	–
	Rituximab	42	0.5	1.83 (1.33 to 2.52)	1.49 (1.04 to 2.14)	1.03 (0.58 to 1.81)
	All bDMARDs/tsDMARDs combined§	191	0.2	0.75 (0.62 to 0.89)	1.32 (1.06 to 1.64)	1.08 (0.73 to 1.58)
Death	csDMARD	21	0.02	1 (ref)	1 (ref)	1 (ref)
	TNFi	3	0.004	–	–	1.03 (0.40 to 2.61)
	Abatacept	1	0.02	–	–	–
	Tocilizumab	0	0	–	–	–
	Rituximab	1	0.01	–	–	3.20 (1.19 to 8.57)
	All bDMARDs/tsDMARDs combined§	5	0.006	0.30 (0.11 to 0.81)	0.65 (0.04 to 12.00)	1.26 (0.60 to 2.64)

Note: Results only presented where treatment cohorts have five or more events.

Previously published corresponding HRs for COVID-19 are in the rightmost column.

*Adjusted for influenza season; age, sex and region accounted for via matching.

†Additionally adjusted for disease duration, Disease Activity Score on 28 joints, number of previous bDMARDs/tsDMARDs and concomitant steroid use, socioeconomic factors (education, civil status and country of birth), influenza hospitalisation in the previous year and comorbidities (history of the following diseases: cancer, diabetes, heart failure, ischaemic heart disease, lung disease, stroke, surgery, venous thrombotic event and kidney failure).

‡Taken from the COVID analyses presented in Bower *et al*,¹¹ adjusted for the same factors as †, but via inverse probability treatment weighting via propensity score estimation.

§Includes Janus kinase inhibitors.

bDMARD, biological disease-modifying antirheumatic drug; csDMARD, conventional synthetic disease-modifying antirheumatic drug; ref, reference; TNFi, tumour necrosis factor inhibitor; tsDMARD, targeted synthetic disease-modifying antirheumatic drug.

by socioeconomic and associated comorbidities. Further, and for the same outcomes, we noted no major differences in risk with bDMARDs/tsDMARDs compared with csDMARDs, although we noted signals (for the outcome hospitalisation listing influenza) with abatacept and rituximab. When put next to our previously published data on risks and relative risks with COVID-19, we noted that whereas the absolute risks of influenza outcomes were around half (hospitalisation) and one-tenth (death) those for COVID-19, the pattern of relative risks for influenza-specific outcomes and for COVID-19-specific outcomes comparing IJD to the general population was qualitatively quite similar.

As mentioned, there is a scarcity of data on risks, relative risks and risk determinants for outcomes of seasonal influenza infections in patients with IJD and with DMARDs. Historically, rheumatic disease has been identified as a risk factor for influenza hospitalisation in the elderly.^{4,5} Our results suggest that despite marked improvements in the general disease status of patients with IJD during the past decades, the relative risk increase (a 50%–100% increase compared with the general population) remains.

We noted a strong effect on our HRs of adjustment for comorbidities and other contextual factors. Although little studied previously, this is in keeping with observations from at least one previous study.⁹ While the increased risks signal a need for clinical vigilance or preventive measures, the marked attenuation of the strength of the association following adjustments suggests that much of the increase is related to the clinical context rather than the rheumatic disease diagnosis itself, although our results

formally do not rule out any level of risk increase in individuals with IJD in remission but otherwise at full health.

With respect to DMARDs, we noted no clear overall difference in influenza outcomes with bDMARDs/tsDMARDs versus csDMARDs, but signals for certain bDMARDs (and too small numbers to make explicit comparisons with tsDMARDs). In the few previous studies, one similarly reported little effect of bDMARDs.⁹ While seemingly in keeping, our results are not comparable as that study focused on risks of influenza rather than risks of adverse influenza outcomes, and (using data until 2007) effectively only studied TNFis. By contrast, a small Dutch questionnaire-based study and a small Italian study (both also based on data from more than 10 years ago) indicated no higher and an increased prevalence, respectively, of influenza-like illness in those patients treated with TNFis.^{6,7}

Despite the fact that the vulnerable population is similar for COVID-19 and seasonal influenza, direct comparisons of absolute risks in COVID-19 versus seasonal influenza are not straightforward since they hit during different(-ly long) seasons, and since the underlying rates for our outcomes (death and hospitalisation for all causes) also have a seasonal variation. Relative risks, however, should be more directly comparable as they accommodate this seasonal effect. Further, it is important to remember that during our study period, SARS-CoV-2 was a new virus, for which no herd immunity, specific treatment or vaccine existed. For COVID-19, our results thus reflect effects of the virus per se, social distancing, absence of immunity (whether from previous infection or from vaccination) and a largely trial-and-error based treatment of severe COVID-19. By contrast, for influenza, our results are reflective of the impact of seasonal influenza per se,

plus the seasonal public health influenza campaigns and the effects of immunity from previous epidemics or vaccination, and antiviral treatment for severe cases of influenza.

Our study has limitations. We studied outcomes of seasonal influenza but did not have individual-level data to assess risks of acquiring influenza infection in the first place, or individual-level information on host protection against severe influenza outcomes, either through previous influenza infection or from vaccination. In Sweden, the yearly influenza vaccine is recommended for all individuals above 65 years of age and for individuals with certain comorbidities (but not specifically IJD, although Swedish rheumatologists likely encourage their patients to get vaccinated). The proportion vaccinated in the IJD cohort could thus be expected to be somewhat higher than that in the general population, which would make our observed increased risk in IJD an underestimate for what would be observed in a completely unvaccinated population. However, a sensitivity analysis restricted to only those aged 65 years and over showed almost identical results (results not shown), suggesting that differences in vaccination rate have not had a major impact on our data. We also cannot infer whether or to what extent RA, other IJDs or DMARDs increase the susceptibility to influenza infection, only that patients with RA and other IJDs are at increased risk of unfavourable outcomes once infected. Further, since influenza may progress to pneumonia, death (and to some extent also hospitalisation) may be recorded as being due to pneumonia rather than to influenza. This may lead to an underestimation of the influenza-specific outcomes, but we believe this will impact for the IJD and the population comparator subjects equally. Similarly, our influenza definition may be subject to misclassification since we did not have access to data which could confirm the physician-assigned diagnosis. Treatment switches during follow-up are clinically relevant, but were not accounted for in this study to align with the approach taken in our COVID-19 study. However, since <1.1% of patients changed treatment cohort during each influenza season, we do not expect this to measurably alter the results. Although we accommodated many comorbid and contextual factors, our adjusted HRs may contain residual or unmeasured confounding, including (for the drug-specific comparisons, eg, for rituximab) residual confounding by indication.

To conclude, in absolute terms, IJD is a risk factor for hospitalisation and death following seasonal influenza, but the impact of COVID-19 on patients with IJD outnumbered that of seasonal influenza. On the other hand, and compared with the general population, IJD is a risk factor of similar (relative) strength for seasonal influenza as previously observed for COVID-19. In both instances, much of this increase can be explained by other factors suggesting that merely having IJD is in itself not a strong risk factor (although having its comorbid consequences may increase risk). Overall, bDMARD/tsDMARD treatment does not seem to markedly increase risk of adverse influenza outcomes, but signals for abatacept and rituximab call for replication. Our results underscore the continued need to optimise risk-mitigation measures against epidemic infections beyond COVID-19 in the rheumatic disease population.

Acknowledgements The authors thank the patients and care providers who contributed data to the Swedish Rheumatology Quality register and the members of the ARTIS Study Group. The ARTIS Study Group conducts scientific analyses using data from the Swedish Biologics Register ARTIS, run by the Swedish Society for Rheumatology. The following were members of the ARTIS Study Group during study completion: Gerd-Marie Ahlenius (Department of Public Health and Clinical Medicine/Rheumatology, Umeå University); Eva Baecklund (Department of Medical Sciences, Uppsala University); Katerina Chatzidionysiou (Department of Medicine Solna, Karolinska Institutet); Nils Felteus (Swedish Medical Products Agency, Department of Public Health and Caring Sciences, Uppsala University); Helena Forsblad-d'Elia (Department of Rheumatology and Inflammation Research, Sahlgrenska Academy, University of Gothenburg); Alf Kastbom (Department of Biomedical and Clinical Sciences, Linköping University); Lars Klareskog (Department

of Medicine Solna, Karolinska Institutet); Elisabet Lindqvist (Department of Clinical Sciences, Rheumatology, Lund University, Skåne University Hospital); Ulf Lindström (Department of Rheumatology and Inflammation Research, Sahlgrenska Academy, University of Gothenburg); Carl Turesson (Rheumatology, Department of Clinical Sciences, Malmö, Lund University); Christopher Sjöwall (Department of Biomedical and Clinical Sciences, Linköping University); and Johan Askling (Department of Medicine Solna, Karolinska Institutet).

Contributors HB conducted the statistical analyses. HB and JA contributed to the drafting of the manuscript. All authors participated in the design of the study and contributed to the interpretation of the results and the critical revision of the manuscript for important intellectual content. HB is responsible for the overall content as guarantor.

Funding The underlying linkages and some of the salary costs for the ARTIS biological disease-modifying antirheumatic drugs/targeted synthetic disease-modifying antirheumatic drug safety monitoring programme were covered through agreements between Karolinska Institutet and the following companies: Abbvie, BMS, Eli Lilly, MSD, Pfizer, Samsung Bioepis and Sanofi. The research environment was also supported through grants from the Swedish Research Council, the Swedish Heart-Lung foundation, the Swedish Cancer Society, NordForsk, the Foundation for Research in Rheumatology, and agreements between Region Stockholm and Karolinska Institutet (ALF).

Competing interests Karolinska Institutet, with JA as principal investigator, has or has had research agreements with Abbvie, Astra-Zeneca, BMS, Eli Lilly, MSD, Pfizer, Roche, Samsung Bioepis, Sanofi and UCB, mainly in the context of safety monitoring of biologics via ARTIS/Swedish Biologics Register.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Swedish Ethical Review Authority (2020-01756).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

This article is made freely available for use in accordance with BMJ's website terms and conditions for the duration of the covid-19 pandemic or until otherwise determined by BMJ. You may use, download and print the article for any lawful, non-commercial purpose (including text and data mining) provided that all copyright notices and trade marks are retained.

ORCID iDs

Hannah Bower <http://orcid.org/0000-0002-2046-3833>

Thomas Frisell <http://orcid.org/0000-0002-5735-9626>

Johan Askling <http://orcid.org/0000-0003-0433-0616>

REFERENCES

- Askling J, Forell CM, Brandt L, *et al*. Time-Dependent increase in risk of hospitalisation with infection among Swedish RA patients treated with TNF antagonists. *Ann Rheum Dis* 2007;66:1339-44.
- Grøn KL, Arkema EV, Glinthorg B, *et al*. Risk of serious infections in patients with rheumatoid arthritis treated in routine care with abatacept, rituximab and tocilizumab in Denmark and Sweden. *Ann Rheum Dis* 2019;78:320-7.
- Socialstyrelsen (The National Board of Health and Welfare). Statistik Om influensa, säsongerna 2015-2016 till 2018-2019
- Hak E, Nordin J, Wei F, *et al*. Influence of high-risk medical conditions on the effectiveness of influenza vaccination among elderly members of 3 large managed-care organizations. *Clin Infect Dis* 2002;35:370-7.
- Nichol KL, Wuorenma J, von Sternberg T. Benefits of influenza vaccination for low-, intermediate-, and high-risk senior citizens. *Arch Intern Med* 1998;158:1769-76.
- Bello SL, Serafino L, Bonali C, *et al*. Incidence of influenza-like illness into a cohort of patients affected by chronic inflammatory rheumatism and treated with biological agents. *Reumatismo* 2012;64:299-306.
- Dirven L, Huizinga TWJ, Allaart CF. Risk factors for reported influenza and influenza-like symptoms in patients with rheumatoid arthritis. *Scand J Rheumatol* 2012;41:359-65.
- Furer V, Rondaan C, Heijstek M, *et al*. Incidence and prevalence of vaccine preventable infections in adult patients with autoimmune inflammatory rheumatic diseases (AIIRD): a systemic literature review Informing the 2019 update of the

- EULAR recommendations for vaccination in adult patients with AIIRD. *RMD Open* 2019;5:e001041.
- 9 Blumentals WA, Arreglado A, Napalkov P, *et al.* Rheumatoid arthritis and the incidence of influenza and influenza-related complications: a retrospective cohort study. *BMC Musculoskelet Disord* 2012;13:158.
 - 10 Kapetanovic MC, Saxne T, Nilsson J-A, *et al.* Influenza vaccination as model for testing immune modulation induced by anti-TNF and methotrexate therapy in rheumatoid arthritis patients. *Rheumatology* 2007;46:608–11.
 - 11 Bower H, Frisell T, Di Giuseppe D, *et al.* Impact of the COVID-19 pandemic on morbidity and mortality in patients with inflammatory joint diseases and in the general population: a nationwide Swedish cohort study. *Ann Rheum Dis* 2021. doi:10.1136/annrheumdis-2021-219845. [Epub ahead of print: 23 Feb 2021].
 - 12 Wadström H, Frisell T, Askling J, *et al.* Malignant neoplasms in patients with rheumatoid arthritis treated with tumor necrosis factor inhibitors, tocilizumab, abatacept, or rituximab in clinical practice: a nationwide cohort study from Sweden. *JAMA Intern Med* 2017;177:1605–12.