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**Appendix**2 **Table S1.** The list of codes used in the study.

Variables		
Disease	ICD-9-CM codes	ICD-10-CM codes
Immune-related diseases of interest		
Ankylosing spondylitis	720.0	M45.x
Crohn's disease	555.x	K50.x
Psoriatic arthritis	696.0	L40.5x
Rheumatoid arthritis	714.0	M05.x, M06.x
Ulcerative colitis	556.x	K51.x
Other immune-related diseases		
Autoimmune myositis	710.3, 710.4	M33.x
Systemic lupus erythematosus	710.0	M32.x
Systemic sclerosis	710.1	M34.x
Systemic vasculitis	446.0–446.7	M30.x, M31.x
Comorbidities		
Diabetes mellitus	250.x	E08.x-E13.x
Dyslipidemia	272.x	E78.x

Hypertension	401.x-405.x	I10.x-I15.x
Other chronic liver diseases		
Autoimmune hepatitis	571.42	K75.4
Primary biliary cirrhosis	571.6	K74.3
Primary sclerosing cholangitis	576.1	K83.01
Wilson's disease	275.1	E83.01
Hemochromatosis	275.0	E83.11
Alpha-1-antitrypsin deficiency	273.4	E88.01
Alcoholic liver disease	571.0, 571.1, 571.3	K70
Liver outcomes		
Cirrhosis	571.5	K74.6x
Non-alcoholic fatty liver disease	571.8	K76.0, K75.81
Non-alcoholic steatohepatitis	N.A.	K75.81

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Medications                      National Drug Codes (the first 9 digits)

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### Biologics

#### Anti-TNF- $\alpha$ agent

Adalimumab                      000740067, 000740124, 000740243, 000740554, 000740616, 000740817, 000741539, 000742540, 000743799,  
000744339, 000746347, 000749374, 500903530

Certolizumab	504740700, 504740710
Etanercept	500903531, 584060425, 584060435, 584060445, 584060446, 584060455, 584060456
Golimumab	578940070, 578940071, 578940350
Infliximab	000064305, 000690809, 578940030
Anti-IL-6 agent	
Tocilizumab	502420135, 502420136, 502420137, 502420138
Anti-IL-12/23 agent	
Ustekinumab	578940054, 578940060, 578940061
Anti-IL-17 agent	
Ixezumab	000021445, 000027724
Secukinumab	000780639
Abatacept	000032187, 000032188, 000032814, 000032818
Rituximab	502420051, 502420053, 502420108, 502420109
<b>Oral medications</b>	
Corticosteroids	
Hydrocortisone	000090012, 000090031, 000090044, 001151696, 001151697, 001151700, 001431252, 001431253, 001431254, 001790056, 001790058, 001790155, 006033899, 006033900, 006033901, 009042674, 425430140, 425430141, 425430142, 430630208, 430630386, 437420563, 437421275, 449110275, 545050331, 545050332, 545050333, 597620073, 597620074, 597620075, 636297241, 680840469, 680840789, 680840930, 681512269, 681514021, 713350812
Prednisone	000540017, 000540018, 000540019, 000543721, 000543722, 000544728, 000544741, 000544742, 000548724, 000548739, 000548740, 001439738, 001439739, 001439740, 004408165, 004408167, 004636141, 004636155, 005915052, 005915442, 005915443, 006035335, 006035336, 006035337, 006035338, 006035339, 006150536,

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Prednisolone

Methylprednisolone

Dexamethasone

	584630014, 584630015, 584630016, 584630017, 604320466, 619190269, 631870383, 631870561, 636293742, 636297806, 646790810, 649800509, 662670067, 663360479, 672960326, 672961090, 680470702, 680470702, 680714127, 681515026, 687887142, 687887267, 687889938, 687889939, 705180843, 705181534, 712050012, 712050013, 713350077, 713350177
Methotrexate	000544550, 000548550, 003780014, 005550572, 216950111, 422540110, 422910594, 430630439, 473350235, 500900294, 510790670, 512850366, 512850367, 512850368, 512850369, 514070121, 526522001, 663360338, 672530320, 683820775, 692381423, 705180223, 705181251, 705181398, 707711058, 713350782, 758400111
Other hepatotoxic medications	
Azathioprine	003781005, 006157568, 216950484, 332610758, 433530686, 433530745, 510790620, 547660590, 602191076, 654830590, 656490231, 656490241, 658410602, 680840229, 683820003, 683820118, 683820119, 683820120, 684620502, 684620502, 692381076, 707711139, 707711140, 707711141, 716100124
Leflunomide	000882160, 000882161, 000882162, 009551735, 009551737, 138110677, 138110678, 231550043, 231550044, 467080436, 467080437, 605052502, 605052503, 623320061, 623320062, 682582992
Sulfasalazine	000130101, 000130102, 001790174, 005910796, 006035801, 105440288, 332610756, 433530495, 500900086, 502680730, 597620104, 597625000, 636295688, 680714215, 687889021, 705180185

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Medications	Current Procedural Terminology (CPT) codes
Anti-TNF- $\alpha$ agent	
Adalimumab	J0135
Certolizumab	J0717, J0718
Etanercept	J1438
Golimumab	J1602

Infliximab	J1745, Q5102
Anti-IL-6 agent	
Tocilizumab	J3262
Anti-IL-17 agent	
Ixezumab	N.A.
Secukinumab	N.A.
Anti-IL-12/23 agent	
Ustekinumab	J3357, J3358
Abatacept	J0129
Rituximab	J9310, J9312

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Procedures	Current Procedural Terminology (CPT) codes
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Alanine transaminase	84460
Aspartate transaminase	84450
Liver sonography	76700, 76705, 93975

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1 IL, interleukin; N.A., not available; TNF, tumor necrosis factor.

1 **Table S2.** The average recommended dosing interval for anti-TNF- $\alpha$  agent for immune-related diseases.

Dosing interval (days)	AS	IBD	PsA	RA
Adalimumab	14	14	14	14
Certolizumab	21	21	21	21
Etanercept	5	5	5	5
Golimumab	42	28	42	42
Infliximab	42	56	56	56

2 AS, ankylosing spondylitis; IBD, inflammatory bowel disease; PsA, psoriatic arthritis; RA, rheumatoid  
3 arthritis; TNF, tumor necrosis factor.

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1 **Table S3.** Estimation of the coefficient (SD) of the variables contributing to the propensity of anti-TNF- $\alpha$  agent use. One  
 2 model was created per outcome because the timing of the outcome changed and anti-TNF- $\alpha$  agent use was determined  
 3 prior to outcome.

	Age	Sex	Diabetes mellitus	Corticosteroids use	Methotrexate use	Other hepatotoxic medications use <sup>#</sup>	Other biologics use <sup>##</sup>
<b>Composite</b>							
Overall	-0.02 (0.03)	-0.12 (0.01)	-0.09 (0.02)	0.92 (0.02)	1.42 (0.02)	0.84 (0.04)	0.79 (0.05)
AS	-0.03 (0.00)	-0.07 (0.06)	-0.08 (0.11)	1.07 (0.13)	1.66 (0.16)	0.78 (0.14)	0.42 (0.59)
IBD	-0.03 (0.00)	-0.16 (0.02)	-0.22 (0.05)	1.71 (0.03)	1.89 (0.28)	0.66 (0.07)	-0.57 (0.38)
PsA	-0.02 (0.00)	-0.14 (0.03)	-0.03 (0.05)	0.66 (0.07)	0.67 (0.04)	0.37 (0.09)	-0.21 (0.11)
RA	-0.02 (0.00)	0.11 (0.02)	-0.11 (0.03)	0.73 (0.02)	1.49 (0.02)	0.97 (0.05)	0.94 (0.06)
<b>Cirrhosis</b>							
Overall	-0.02 (0.00)	-0.11 (0.01)	-0.07 (0.02)	0.92 (0.02)	1.42 (0.02)	0.84 (0.04)	0.69 (0.05)
AS	-0.03 (0.00)	-0.07 (0.05)	-0.07 (0.11)	1.08 (0.13)	1.65 (0.16)	0.78 (0.14)	0.42 (0.59)
IBD	-0.03 (0.00)	-0.16 (0.02)	-0.20 (0.05)	1.72 (0.03)	1.87 (0.28)	0.66 (0.07)	-0.75 (0.40)
PsA	-0.02 (0.00)	-0.14 (0.03)	-0.01 (0.05)	0.66 (0.07)	0.67 (0.04)	0.36 (0.09)	-0.34 (0.11)
RA	-0.02 (0.00)	0.11 (0.02)	-0.09 (0.03)	0.73 (0.02)	1.49 (0.02)	0.97 (0.05)	0.86 (0.06)
<b>NAFLD or NASH</b>							
Overall	-0.02 (0.00)	-0.11 (0.01)	-0.08 (0.02)	0.93 (0.02)	1.42 (0.02)	0.85 (0.04)	1.27 (0.04)
AS	-0.03 (0.00)	-0.07 (0.06)	-0.06 (0.11)	1.05 (0.14)	1.63 (0.16)	0.84 (0.14)	0.89 (0.45)

	Age	Sex	Diabetes mellitus	Corticosteroids use	Methotrexate use	Other hepatotoxic medications use <sup>#</sup>	Other biologics use <sup>##</sup>
IBD	-0.03 (0.00)	-0.15 (0.02)	-0.21 (0.06)	1.74 (0.03)	1.92 (0.28)	0.65 (0.07)	-0.03 (0.30)
PsA	-0.02 (0.00)	-0.13 (0.03)	-0.03 (0.05)	0.67 (0.07)	0.70 (0.04)	0.41 (0.09)	0.23 (0.09)
RA	-0.02 (0.00)	0.12 (0.02)	-0.10 (0.03)	0.74 (0.02)	1.51 (0.02)	0.98 (0.05)	1.44 (0.05)

1 <sup>#</sup>Other hepatotoxic medications include azathioprine, leflunomide, and/or sulfasalazine.

2 <sup>##</sup>Other biologics include tocilizumab, ustekinumab, secukinumab, ixekinumab, abatacept, and/or rituximab.

3 AS, ankylosing spondylitis; IBD, inflammatory bowel disease; NAFLD, non-alcoholic fatty liver disease; PsA, psoriatic

4 arthritis; RA, rheumatoid arthritis; SD, standard deviation; TNF, tumor necrosis factor.

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1 **Table S4.** Rates of clinical encounter (outpatient, inpatient and service), liver function test (alanine transaminase or aspartate transaminase), or  
 2 liver sonography per year for each anti-TNF- $\alpha$  agent use and non-use period (within the first 84 days or the whole period).

Variable	AS		IBD		PsA		RA	
	Use	Non-use	Use	Non-use	Use	Non-use	Use	Non-use
<b>Within the first 84 days</b>								
Rate of clinical encounter	31.3	43.1	88.2	49.2	28.6	40.8	41.9	45.0
Rate of liver function test	8.6	9.7	13.4	10.2	10.0	11.1	10.6	11.1
Rate of liver sonography	8.5	7.6	8.3	7.8	7.5	7.5	7.9	7.2
<b>Within the whole period</b>								
Rate of clinical encounter	20.1	10.3	50.8	11.5	17.9	12.2	30.8	15.1
Rate of liver function test	3.0	1.8	3.16	1.41	3.6	2.8	4.8	3.0
Rate of liver sonography	1.0	0.7	1.1	0.8	1.0	0.8	1.0	0.7

3 AS, ankylosing spondylitis; IBD, inflammatory bowel disease; PsA, psoriatic arthritis; RA, rheumatoid arthritis; TNF, tumor necrosis factor.

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