REVIEW

Infections as Risk Factor of Sjögren's Syndrome

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Purpose: Sjögren's syndrome (SS) is an autoimmune disease targeting exocrine glands, leading to low body fluids production, especially on the salivary and lacrimal glands. Due to the low saliva and tear production, the common symptoms of Sjögren's syndrome are dry eyes and dry mouth, later on leading to uncomfortable sensations on the eye surface, cornea destruction, dental caries, and oral cavity infections. Several infections are known to cause similar side-effects to Sjögren's syndrome symptoms, including low saliva flow; therefore, infection is hypothesized as one of the risk factors of Sjögren's syndrome.

Results: Based on our literature research, there are several infectious agents which cause similar disease manifestations to Sjögren's syndrome, including infections of hepatitis C virus, Epstein–Barr virus, cytomegalovirus, and human T-lymphotropic virus-1 (HTLV-1), and these four agents are found to cause persistent infection on the salivary gland after the first infection and later lead to organ destruction, thus causing sicca syndrome in the oral cavity. Other findings show possible *Heliobacter pylori* infection might lead on the increasing level of anti-Ro/SSA and anti-La/SSB of infected individuals.

Conclusion: Some research has shown persistent infection could trigger autoimmune disorders due to continuous T-cells and B-cells activation in an attempt of infected cells eradication, leading to autoimmune reaction and high autoreactive cells concentration around the healthy cells causing the immune cells to eradicate the healthy cells nearby. However, the results in this literature study found persistent infection is not the only risk factor of Sjögren's syndrome but there are various unknown factors that trigger infection to develop into Sjögren's syndrome.

Keywords: autoimmune diseases, Sjögren's syndrome, infections, pathogens

Purpose

Sjögren's syndrome (SS) is one of the autoimmune disorders generally targeting exocrine glands, leading to low body fluids production such as in salivary and lacrimal glands.[1,2] Low body fluids production on salivary and lacrimal glands leads to sicca syndrome or dry eyes and mouth syndrome which might lead to further health problems such as cornea damage, blurry vision, tooth caries, and digestive problems.[3,4] Worldwide, the prevalence of SS is around 0.1–0.5% of the total population,[5] and t is the second highest autoimmune disorder in the US, with total population of up to 4 million people.[6] Based on epidemiological studies, females have a higher risk of SS compared to males, with a ratio of 9:1, and the risk escalates at the age of 40 to the late 50s.[3,7,8]

There are two types of SS based on the complexity of the disease, primary SS and secondary SS. A patient is diagnosed with primary SS if they are not diagnosed with other autoimmune disorders, and diagnosed with secondary SS if they are diagnosed with another autoimmune disorder and later diagnosed with SS.[5,9,10]

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Between the two types of SS, the main symptoms are ocular and oral cavity sicca syndrome, musculoskeletal pain, and fatigue, and among the secondary SS patients might also followed by the secondary autoimmune disorder's manifestations.[11,12] Due to the general and various symptoms, SS is known as the thousand faces disease, because of the long observation period necessary to conclusively diagnose SS.[4,13] To diagnose SS among patients, the medical examiners observed and later classified the patients based on SS criteria released by the American-European Consensus.[9,13] There are six criteria to define SS classification, 1) dry eyes, 2) Schirmer test results showing the patient has dry eyes, 3) dry oral cavity, 4) salivary glands test results showing low saliva production, 5) salivary glands biopsy results $\geq$1 FOCI per 4 mm^2, and 6) immunology results showing reactivity towards anti-Ro/SSA and/or anti-La/SSB. Another SS criteria was developed by ACR-EULAR; with five criteria including 1) salivary glands biopsy shows $\geq$50 inflammatory mononuclear cell per 4 mm^2, 2) ocular staining score $\geq$5 on at least one eye, 3) the presence of anti-SSA, 4) Schirmer's test result shows low tear production by $\leq$5 mm/5 minutes, and 5) low unstimulated saliva production by $\leq$0,1 mL per minute, the ACR-EULAR criteria also mentioned the exclusion of patients with a history of head or neck radiation treatment, patients with active hepatitis C infection, patients with immunodeficiency syndrome, sarcoidosis, amyloidosis, graft versus host disease, and patients with IgG4-related diseases (Table 1).[14] A patient will be diagnosed with primary SS if they fulfillat least four out of the six criteria including biopsy results and immunology results, meanwhile, a patient will be diagnosed with secondary SS if they fulfill two-to-three out of the six criteria including biopsy results and dry eyes/mouth symptoms.[6,13,15]

To this day, risk factors and the pathogenesis of SS remain inconclusive. But there are several suspects of SS potential risk factors, which are infection[15,16] and genetic susceptibilities.[17,18] Infection is believed to be one of the potential risk factors for Sjögren's syndrome, especially persistent infections,[19,20] which lead to an over-stimulated immune system and organ damage due to the high concentration of autoreactive and non-specific T-cells.[21,22] Genetic susceptibility is believed to be one of the potential risks for Sjögren's syndrome due to degeneration in DNA protein structures, leading to false protein transcription and translation, and causing the immune system to continue producing T-cell self-antigen but not followed with constant apoptosis

to prevent high self-antigen cells.[23,24] In this review paper, we will identify and analyze the role of infections towards the development of Sjögren's syndrome based on various published research articles.

Method

This article is a review article towards various published research articles under the keyword "Infections and Sjögren's syndrome", using Google as the search engine and through journal homepages including Elsevier, Springer, ScienceDirect, NCBI, etc. The articles went through a screening process fulfilling the main criteria: 1) the article mentioned the infectious agent infecting the patient/suspect of Sjögren's syndrome, 2) the article mentioned the patient/subject's clinical test results including antibody test results, and 3) the article was published between 1990 and 2019. With exclusion criteria including 1) the article is a research article, not a review or systematic review article, and 2) the article is fully accessible. Articles which fulfilled all the criteria were synthesized and used to create a conclusion to answer the main purpose of this article (Figure 1).

Results

Under the keyword, "Infections and Sjögren's syndrome" there were 48 published articles, consisting of research articles and review articles. After the screening and criteria fulfillment, 16 research articles were obtained to synthesize.

Infectious Agents as Potential Risk Factors of Sjögren's Syndrome

Based on 19 research articles reviewed in this paper, there are six infectious agents which might contribute in SS development due to the similar manifestation caused by the agents and the capability of the agents to stimulate anti-Ro/SSA or anti-La/SSB production. There are several infectious agents that are suspected to play significant roles in the development of SS, such as cytomegalovirus (CMV), Epstein–Barr virus, hepatitis C virus, human T-cell lymphotropic virus-1 (HTLV-1), *Staphylococcus saccharolyticus*, and *Heliobacter pylori* (Table 2).

Infectious Agents Role in Sjögren's Syndrome

In this review, we describe the different roles and impacts of the six infectious agents towards the histology and physical manifestation post-infection (Table 3).

Table 1 Sjögren's Syndrome Classification Criteria

No.	Association	Criteria	Definition
1.	American-European Consensus Criteria[9]	Dry eyes	Dry eyes lasted for at least 3 months, foreign sensation in the eyes, and/or high dependency for artificial tears (≥3 times a day).
		Dry oral cavity	Dry oral cavity lasted for at least 3 months, recurrent or persistent salivary glands inflammation, and/or swallowing difficulties.
		Abnormal Schirmer's test	Schirmer's test results low tear production (≤5 mm/5 minutes), and/or positive vital dye staining on the eye surface.
		Low saliva production	Low unstimulated salivary flow (≤1.5 mL/15 minutes), abnormal parotid sialography, and/or abnormal salivary scintigraphy.
		Salivary glands biopsy	Salivary gland biopsy shows focal lymphocytic sialoadenitis (focus score ≥1 per 4 mm^2).
		Autoantibodies reactivity	Reactivity towards anti-Ro and/or anti-La.
2.	EULAR Criteria[14]	Focus Score of ≥1	Salivary gland biopsy shows ≥50 inflammatory mononuclear-cell per 4 mm^2.
		Presence of anti-SSA	Autoantibody test shows the presence of anti-Ro60.
		Ocular staining score ≥5	Fluorescein and lissamine green staining scores ≥5 indicating ocular sicca severity.
		Low Schirmer's test	Tear production assessment using Schirmer's test shows result ≤5 mm/5 minutes.
		Low salivary flow	Low unstimulated saliva production measured by collecting saliva volume for at least 5 minutes after swallowing, with results ≤0,1 mL per minutes shows low salivary flow.

HTLV-1

HTLV-1 infections are known to have the capability to cause sicca syndrome, mimicking one of the SS symptoms,[25,26] but the infections are not known to cause any reactivity towards anti-Ro/SSA nor anti-La/SSB.[27] The prevalence of antibodies towards HTLV-1 is higher among the SS population compared to the healthy population.[28] This finding shows the susceptibility towards HTLV-1 infection is rather higher among the SS population.[25,28]

Epstein–Barr Virus

Another potential agent is Epstein–Barr Virus (EBV), the prevalence of antibody towards EBV and viral reactivation rate among SS patients is higher compared to normal or healthy populations.[29,30] It is shown in the higher EBV luciferase activity induced by saliva of SS patients, while not showing any activity when induced by healthy individual's saliva.[31,32] A higher viral reactivation rate in SS patients is hypothesized to play a role in autoantibody anti-Ro/SSA and/or anti-La/SSB production. This shows a higher concentration of anti-Ro/SSA and anti-La/SSB in SS patients with an antibody towards EBV compared to SS patients without antibody towards EBV.[31,32] Other research also shows EBV infection rates are higher among

SS patients with the presence of both anti-SSA and anti-SSB autoantibodies compared to SS patients with only anti-SSA or without the presence of both the autoantibodies.[33] Therefore it is highly speculated that EBV reactivity increases due to the presence of both anti-SSA and anti-SSB.

Hepatitis C Virus

Hepatitis C virus infection is known to cause similar manifestations to SS which is sicca syndrome, leading to HCV patients diagnosed with SS.[34–36] Despite similar sicca syndrome manifestation among HCV patients diagnosed with SS, from the histology perspective, HCV related SS patients have different immunology characteristics compared to the primary SS patients. In HCV related SS the common symptoms among the patients is un-reactivity towards anti-Ro/SSA and/or anti-La/SSB antigens,[34–36] followed with different cytokines concentration with Th2 concentration is higher than Th1 concentration among HCV related SS while in primary SS patients show higher Th1 concentration than Th2.[37,38] The differences between HCV related SS and primary SS indicate the HCV related Sjögren's syndrome is classified as secondary SS.
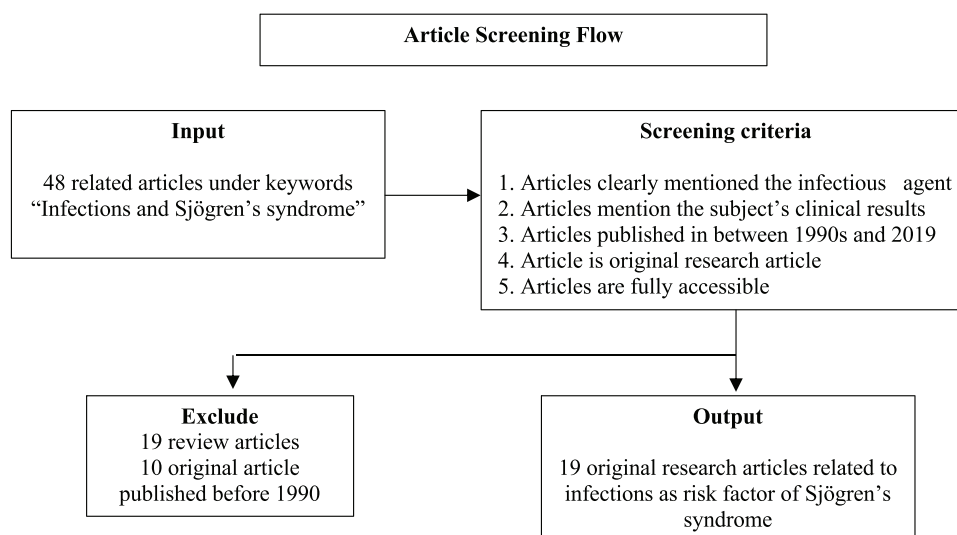
Article Screening Flow

Input 48 related articles under keywords "Infections and Sjögren's syndrome"	**Screening criteria** 1. Articles clearly mentioned the infectious agent 2. Articles mention the subject's clinical results 3. Articles published in between 1990s and 2019 4. Article is original research article 5. Articles are fully accessible

Exclude 19 review articles 10 original article published before 1990	**Output** 19 original research articles related to infections as risk factor of Sjögren's syndrome

Figure 1 Article Screening and Exclusion Flow.

Cytomegalovirus

Based on experiments towards several murines, which showed cytomegalovirus infection might play a role in the development of SS on specific individuals. The experiment conducted towards four different varieties of murine shows persistent infection on murine with specific genetic susceptibility towards autoimmune disorder due to Fas deficiency (B6-*lpr/*lpr) and on murine with zero tumor necrosis factor (TNFR).[39] On murine with Fas deficiency shows persistent infection on mononuclear cells level followed by severe salivary glands damage leading to low saliva production, while on murine with zero tumor necrosis factor (TNFR) shows delayed viral eradication compared to the normal murine. High anti-Ro/SSA and anti-La/SSB production and tissue damage are shown in the salivary glands of murine with persistent infection (B6-*lpr/*lpr), while similar results are not shown in any other murines.[39] Another experiment was conducted towards four different varieties of murines, including NZM2328, which has the tendency to develop SLE-like symptoms spontaneously by the age of 5 months, and B6-*lpr/lpr* murines.[40] The result shows severe structural damage on the salivary glands of female NZM2328 murine and female B6-*lpr/lpr* murine, but this was not shown in male NZM2328 murine.[40] The result contras show there is a higher risk of persistent infection followed by structural damage among female murines with genetic susceptibilities compared to male murines from similar varieties.[39,40] Meanwhile, from an immunology aspect we see the elevation of anti-Ro/SSA and anti-La/SSB production on B6-*lpr/lpr* murine with severe salivary glands damage and persistent

infection,[39] while similar results are not shown in the NZM2328 murine with similar organ damage.[40]

Coxsackievirus

Another potential risk factor is Coxsackievirus. The results show a higher coxsackievirus infection rate among patients with primary SS compared to patients with secondary SS or healthy samples. The higher infection rates are shown in both PCR results and minor salivary glands biopsy, from the histopathology perspectives it's hypothesized the high infection rate is due to the presence of anti-SSA autoantibody.[41] Another research towards the reaction of Coxsackievirus peptide and anti-SSA/SSB autoantibodies shows out of 27 pSS patients with the presence of both anti-SSA and anti-SSB, nine of the patients recognized the Coxsackievirus peptide. The number is higher in pSS patients compared to SLE patients (7/28), while similar results are not shown among the healthy individuals. The results also show pSS patients with the presence of both anti-SSA and anti-SSB have a higher detected cross-reaction with Coxsackievirus peptide compared to pSS patients with the presence of anti-SSA.[42] Both articles initiate the significant roles of anti-SSA, but it is also suggested that the presence of both autoantibodies increases the reactivity with Coxsackievirus peptide.

Bacteria Infections

Bacteria infections among SS patients show higher prevalence compared to a healthy population followed with higher infection severity.[43] On *Heliobacter pylori* infection, there are significant infection prevalence gaps among

Table 2 Potential Infectious Agents

No.	Author (Year)	Agent	Journal
1.	Fleck et al (1998)	Cytomegalovirus	Arthritis & Rheumatism (14, 2175–2184)
2.	Ohyama et al (2006)	Cytomegalovirus	Journal of Immunology (177, 7391–7397)
3.	Nagata et al (2004)	Epstein–Barr Virus	Journal of Immunology (111, 223–229)
4.	Inoue et al (2012)	Epstein–Barr Virus	Journal of Immunology (188, 4654–4662)
5.	Kivity et al (2014)	Epstein–Barr Virus	Journal of Autoimmunity
6.	Pasoto et al (2013)	Epstein–Barr Virus	Rheumatology International (33, 1149–1157)
7.	Sanosyan et al (2019)	Epstein–Barr Virus	Frontiers in Immunology (10, 1153)
8.	Prunoiu et al (2008)	Hepatitis C Virus	Romanian Journal of Morphology and Embryology (49, 557–562)
9.	Ramos-Casals et al (2002)	Hepatitis C Virus	Seminars in Arthritis and Rheumatism (32, 56–63)
10.	Dinescu et al (2017)	Hepatitis C Virus	Health Science Journal (43, 78–82)
11.	Loustaud-Ratti et al (2001)	Hepatitis C Virus	Journal of Rheumatology (28, 2245–2251)
12.	Bureta et al (2018)	HTLV-1	International journal of surgery case reports (45, 22–28)
13.	Nakamura et al (2015)	HTLV-1	BMC Musculoskeletal Disorder (16(335))
14.	Terada et al (1994)	HTLV-1	The Lancet (344, 1116–1119)
15.	Lima et al (2016)	HTLV-1	Journal of Immunology Research
16.	Triantafyllopoulou et al (2004)	Coxsackievirus	Arthritis & Rheumatism (50(9), 2897–2902)
17.	Stathopoulou et al (2005)	Coxsackievirus	Clinical and Experimental Immunology (141, 148–154)
18.	Sughimoto et al (2006)	*Staphylococcus saccharolyticus*	Asian Cardiovascular & Thoracic Annals (4, e115- e117)
19.	El Miedany et al (2005)	*Heliobacter pylori*	Joint Bone Spine (72, 135–141)
20.	Fabris et al (2013)	*Chlamydophila psittaci*	Clinical and Experimental Rheumatology (31)

the SS population and healthy population or SLE patients. This is shown by the higher prevalence of antibody towards *Heliobacter pylori* among SS patients.[43,44] Another evidence of bacterial infection is the high severity of endocardium tissue damage due to *Staphyloccocus saccharolyticus* infection on a patient diagnosed with SS.[45] Another study shows a high *Chalmydophila psittaci* DNA infection among secondary SS based on PCR analysis. The high *Clamydophila psittaci* infections are specifically detected among MALT dan MESA patients with the presence of rheumatoid factor but without the presence of anti-SSA/SSB autoantibodies.[46] But from all the articles, the writers have not been able to conclude the main role of bacteria infection in the development of SS, and further investigations are needed to conclude whether bacteria infection plays a role as a risk factor or as an impact of SS itself.

Population Characteristic

From 17 research articles we can see that the population with a higher risk of developing SS or SS-like manifestation due to infections is women (88%), with the highest prevalence between the ages of 40 to the early 60s. From an ethnicity perspective, the majority of the research subjects have Asian ethnicity (41%), followed by Europeans (35%) (Table 4).

Discussion
Persistent Infection, Bystander Activation, and Sjögren's Syndrome

Viral infections are known to have the possibility to develop into persistent infections due to the agent's capability to invade not only tissues but also mononuclear cells leading to undetected infection on tissue level biopsy.[47] Persistent infection and inflammation due to infectious agents lead to immune system responses such as bystander activation,[16,48] which is an immune response mechanism to eradicate infected cells by releasing antigen-presenting cells (APCs) and autoreactive non-specific T-cells to stimulate various immune cells to migrate towards the infected area.[49] Meanwhile, at the hotspot area, CD8+ releases cytotoxin[22,50] carrying the main purpose to trigger cell apoptosis to prevent further infection. To prevent further infection and inflammation, the immune system not only releases CD+ but also other various immune responses such as tumor necrosis factor (TNF)-α,[50,51] lymphotoxin, and nitrite oxide. During the bystander activation, the apoptosis also affects healthy cells nearby and leads to autoimmune reactions[16,52,53] due to the immune system attacking the healthy cells. In normal or healthy individuals, bystander activation could work optimally due to the body's capability to eradicate self-antigen immune cells to prevent high self-antigen antibody production.[54] Meanwhile, on immunosuppressive individuals, their immune system is unable to

Table 3 Antibody and Autoantibody Prevalence, and the Manifestation of Sjögren's Syndrome

No.	Author(Year)	Subjects (n)	(+) Agent Antibody	Sicca Syndrome	Sjögren's Syndrome	(+)Anti-SSA or Anti-SSB
Cytomegalovirus						
1.	Fleck et al (1998)	4	4	1/4	1/4	1/4
2.	Ohyama et al (2006)	4	4	2/4	1/4	0/4
Epstein–Barr Virus						
3.	Nagata et al (2004)	22	8/12 (SS)	12/22	12/22	6/12 (SS)
4.	Inoue et al (2012)	38	6/19 (SS)	9/38	19/38	6/19 (SS)
5.	Kivity et al (2014)	221	21 (SS)/11	-	82/221	64/221
6.	Pasoto et al (2013)	189	36 (SS)/4	-	100/189	92/100 (SS)
7.	Sanosyan et al (2019)	360	138/360	-	360	360
Hepatitis C Virus						
8.	Prunoiu et al (2008)	1	1	1	1	0
9.	Ramos-Casals et al (2002)	67	20/67	-	67/67	25/67
10.	Dinescu et al (2017)	2	2	2	2	1/2
11.	Loustaud-Ratti et al (2001)	45	45	28/45	21/45	0
HTLV-1						
12.	Bureta et al (2018)	1	1	1	1	1
13.	Nakamura et al (2015)	150	125/150	124/150	25/150	122/150
14.	Terada et al (1994)	27429	8777/27429	-	74/27429	-
15.	Lima et al (2016)	272	272	59/272	0	0
Coxsackievirus						
16.	Triantafyllopoulou et al (2004)	23	6/13 (SS)	-	13/23	7/13
17.	Stathopoulou et al (2005)	50	27/50	-	25/50	27
Bacteria						
18.	Sughimoto et al (2006)	1	1	4/4	3/4	-
19.	El Miedany et al (2005)	177	40/177	-	67/177	38/130
20.	Fabris et al (2013)	299	10/74	-	74/299	-

Table 4 Research Subjects Characteristics

No.	Author (Year)	Subjects with SS/Sicca Syndrome	Mean Age (Years)	Gender (M/F)	Race
1.	Fleck et al (1998)	1	–	0/1	–
2.	Ohyama et al (2006)	2	–	0/2	–
3.	Nagata et al (2004)	12	56	0/12	Asian
4.	Inoue et al (2012)	19	61.9	0/19	Asian
5.	Kivity et al (2014)	82	40	2/80	Asian
6.	Pasoto et al (2013)	100	47	3/97	South American
7.	Sanosyan et al (2019)	360	57	7/353	European
8.	Prunoiu et al (2008)	1	27	0/1	European
9.	Ramos-Casals et al (2002)	67	63	4/63	Hispanic
10.	Dinescu et al (2017)	2	58	0/2	European
11.	Loustaud-Ratti et al (2001)	24	55.5	12/12	European
12.	Bureta et al (2018)	1	78	0/1	Asian
13.	Nakamura et al (2015)	150	61	8/142	Asian
14.	Terada et al (1994)	147	44	2/145	Asian
15.	Lima et al (2016)	59	46	19/40	South American
16.	Triantafyllopoullou et al (2004)	74	50	3/71	European
17.	Stathopoulou et al (2005)	27	-	-	European
18.	Sughimoto et al (2006)	1	42	1/0	Asian
19.	El Miedany et al (2005)	67	53	12/55	African
20.	Fabris et al (2013)	74	55	4/70	European

eradicate self-antigens antibodies, leading to the high level of self-antigens antibody in the system and during persistent infection, the amount of immune response towards the infection site is high and constant, causing high self-antigens antibody release and stimulating apoptosis among the healthy cells.[21,55,56]

Based on the 19 research articles reviewed in this paper, Sjögren's syndrome and persistent infection are not detected in every infected individual. The results show there is a specific factor which plays a significant role in the development of persistent infection and leads to Sjögren's syndrome. The other potential factors, in this case, are possibly genetic susceptibilities and gender-related factors.

Genetic Susceptibility and Personal Characteristics

Genetics is believed to contribute 50% as a potential risk factor of Sjögren's syndrome, while the other 50% is from environment stimulants.[56,57] Based on cytomegalovirus infection research, persistent infection only developed in murine with specific genetic susceptibilities towards autoimmune disorder. In B6-*lpr/lpr* murine with Fas deficiency,[20,39] persistent infection is detected on mononuclear cell level without any infection detected on tissue biopsy, while in murine with zero tumor necrosis factor shows a significant delay on viral eradication

without mononuclear level infection.[39] Another research on NZM2328 murines with genetic susceptibilities towards spontaneously developing SLE-like symptoms shows persistent infection only detected on female NZM2328 murine leading to severe salivary gland damage but not detected on male NZM2328.[40] These results indicate there are significant roles of gender susceptibility on female murines towards the development of persistent infection.

Meanwhile, in human subjects, genetic susceptibilities and personal characteristics might contribute to the development of Sjögren's syndrome or disease manifestation mimicking Sjögren's syndrome.[16,58] It is shown from the higher Sjögren's syndrome prevalence among females compared to males, and genetic susceptibility is also shown from a higher prevalence of sicca syndrome due to HTLV-1 infection among the Asian population,[25] meanwhile, there is a significant gap of sicca syndrome manifestation due to HTLV-1 infection among the infected population and non-infected population in South America.[27] These findings show there is a role played by the different genetic structure in different races to cause susceptibility towards the development of sicca syndrome or later Sjögren's syndrome.

Sjögren's syndrome is known as a high complexity disease and could not be concluded from basic

Mendelian law due to complex variables which may play the role of the disease development.[59] The genetic role in Sjögren's syndrome is believed not only due to single cell disruption, but more complex and multi-cells involvement,[18,60] which is one of the reasons for the difficulty in diagnosing the diseases. Until these days, researchers have hypothesized the genetic susceptibility role in Sjögren's syndrome is related to non-major histocompatibility complex (MHC) class II protein,[18,61] and in humans is known as human leukocyte antigen (HLA). MHC or HLA is responsible for the immune system's development and antibody production.[18,23] Every race have different HLA structures, such as different HLA-DR and HLA-DQ due to different environment stimulants and different protein structures inherited from ancestors.[23,–60–62] Different HLA structures between every race or every population with different environment stimulant lead to different susceptibility rates towards the development of Sjögren's syndrome, this might be shown from the different anti-Ro/SSA and anti-La/SSB production level between the same races in different environment stimulants.[54,–60,–63–65]

Conclusion

Sjögren's syndrome is a complex disease and has various inconclusive risk factors which may contribute to the disease development, such as environmental factors and genetic susceptibility factors. One of the suspected environmental factors of SS is persistent infections. Several infectious agents have the capability to cause post-infection manifestations mimicking SS main symptoms, such as sicca syndrome based on salivary gland biopsy and low salivary flow. In several cases the persistent infection leads to high anti-Ro/SSA and anti-La/SSB production at the infected site. But there are also various manifestations on every infectious agent in every population. In HTLV-1 and hepatitis C virus infection, both of the persistent infections lead to sicca syndrome manifestation without fulfilling the histology criteria. However, in HTLV-1 infection, the dryness symptom only occurs in a specific population while in another populations the infection did not cause any sicca syndrome. Epstein–Barr virus and cytomegalovirus infection show the persistent infection due to both of the agents leads to increasing anti-SSA/SSB production and severe salivary gland damage. It is also shown that the Epstein–Barr virus reactivity is more likely to happen among SS patients with the presence of both anti-SSA and anti-SSB, whilst the infection rate of

Coxsackievirus is more likely to happen among SS patients with the presence of anti-SSA. Meanwhile, bacterial infections are still unable to be concluded and in need of further research to see whether the high prevalence and severity of the bacterial infection plays any role in SS development or the infection severity in the impact of SS, but it is shown that bacterial infection rates among SS patients are higher compared to healthy individuals. And due to the very limited research upon SS and pathogen infections, we suggest more research in epidemiological and molecular perspectives on wider populations to identify the role of personal or population characteristic in the development of Sjögren's syndrome and to identify the role and pathogenesis of infectious agents in the development of Sjögren's syndrome.

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Disclosure

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