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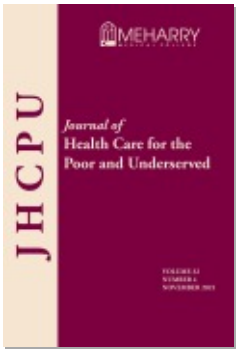

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Correlation of HIV-infection and HIV/HCV Co-infection with Oral Health Status of Inner-City Sub-population in Saskatchewan, Canada

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Abstract: **Objectives**. To identify the correlation of HIV-infection and HIV/HCV co-infection with the oral health status of patients accessing an inner-city dental clinic in Saskatchewan, Canada. **Materials and methods**. A cross-sectional chart review of 2000 electronic patient records was performed from an inner-city community dental clinic. Utilizing Andersen and Newman framework of health service utilization, simple, bivariate and multivariate comparisons were conducted. **Results**. More than half of the patients 53% (n=1,065) were within the ages of 36 to 65. The patient charts represented a mixture of ethnicities including immigrants to Canada (e.g., from Syria, Iran, Europe, China) and Indigenous people. Six percent (n=111) of patients were recorded positive for HIV/AIDS, while 3% (n=46) of patients recorded both HIV/HCV-co-infection. Forty-five percent (n=844) of patients had dental decay. In the bivariate analyses, smoking ([mean]: 3.0 vs. 2.1), being positive for HIV ([mean]: 4.1 vs. 2.6] and HCV ([mean]: 3.7 vs. 2.7) appeared to be associated with higher number of mean decayed teeth. Drug or alcohol addiction (p<.0001), HIV-positive status (p<.0001), and diagnosis of a mental disorder (p=.0037) were associated with the missing teeth. The multivariate analysis confirmed either HIV-positive or HCV-positive had a higher DMF rate compared with those without. Patients who were both HIV and HCV-positive had an estimated DMF rate almost double of those without either condition (IRR=1.84, p<.0001). **Conclusion**. Several psychosocial factors, HIV-infection and HCV-infection were associated with higher number of decayed and missing teeth.

Key words: HIV, HCV, oral health status, dental service utilization.

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Oral care disparities and unmet dental treatment needs are widely reported in vulnerable populations, such as individuals living with HIV, Indigenous populations, and inner-city populations. Many of these disparities are associated with social demographic factors, which may include age, gender, educational status, financial unaffordability, lack of availability of dental services, lack of education, existing medical conditions, and others. These factors have a strong impact on accessibility to dental care services and oral disease patterns, such as dental decay and missing teeth.[1,2]

People living with HIV have commonly reported higher values of decayed, missing, or filled teeth (DMFT) index values which are associated with their poor oral health and quality of life. Correlations between HIV and high DMFT indices, periodontal disease, smoking, and other oral health problems have been shown evidently in a number of studies around the world including in Australia, Portugal, and Brazil.[3,4–9] Variances in DMFT and in other oral health problems across these geographic locations can be attributed to factors such as hygienic, behavioral, stigma and discrimination, access to dental services, and socioeconomic status.[10]

Similar correlations with DMFT have been reported for patients with Hepatitis C (HCV) infections. A study from South Australia reported the mean DMFT of individuals with HCV was 17.9 compared with 13.0 for those in the general population.[11] Gheorghe and colleagues performed a review of the potential links between HCV and oral health; they found that the poor state of HCV-infected patients' oral health could result from the malfunctioning of the liver, poor functioning of the immune system, or the decreased motivation of those afflicted to seek dental care due to physical or stigma-associated reasons.[12] The publicly funded health care system in Canada provides equal and fair access to primary health care services to all its citizens.[13] However, it does not make the same provisions for primary oral care.[14] Consequently, essential oral health care is not covered as a part of the mainstream medical health care system. Not surprisingly, a significant proportion of Canadians have unmet dental treatment needs and have reported irregular dental visits.[15] This becomes more concerning for marginalized and underserved population, such as HIV-positive and HCV-positive community members, with higher unmet dental treatments needs.[16] Although some financial supports are available for populations that qualify for long-term disability and social welfare benefits, the amount granted through these programs is less than optimum to meet the unmet oral health care needs of the underserved population.[17] The inner-city neighborhoods of Saskatoon in Saskatchewan are no exception. According to estimates, the city of Saskatoon has an inner-city population of just over 20,000.[13]

HIV infection incidence rate is a pressing concern for inner-city populations. Nearly half of the diagnoses of HIV in Canada occur in Saskatchewan, with an incidence rate over two times higher than the national incidence rate (16.2/100,000 versus 5.9/100,000, respectively). This elevated incidence rate makes the province an appropriate location to study HIV and oral health care connections. The West Side Dental Clinic (operated by the University of Saskatchewan, College of Dentistry) that is located within the inner-city and primarily serves the inner-city population, provided us with a venue to collect representative data on this population.

In Saskatchewan, HIV infection is in an epidemic state and it is argued that injection drug use (IDU) is the predominant mode of transmission.[16] This population is

also afflicted with high rates of co-infection with HCV, which has been shown to be 10 times more transmissible through injection drug use (IDU) than HIV.[17] More than half of the HIV-positive individuals in Saskatchewan have been or are currently co-infected with HCV.[18] To date, there are no data on the oral health status of people living with HIV and/or HIV/HCV-co-infection in Saskatchewan. Therefore, this study aimed to evaluate the association between the oral health status of an inner-city Saskatoon population with various needs factors, using the Andersen and Newman (A&N) framework of health service utilization.[3] Furthermore, this research will illuminate the correlation between HIV infection and HIV/HCV co-infection and oral health status.

Methods

Data collection. Ethics approval was received from University of Saskatchewan Behavioral Ethics Board. We collaborated with West Side Dental Clinic, a university-managed clinic, to perform a cross-sectional anonymous review of 2000 patient records, using patient records that were routinely filled out as a part of patient care at this facility. Patient records included were for those patients considered to be active patients (by clinic's definition) over the time period of May 2019 to August 2019. Data were gathered by reviewing each patient chart and entering the information into an Excel spreadsheet according to our pre-defined fields. The inclusion criteria included all records for adult patients (age 19 and older), with current and active status.

Study variables. *Outcome variables*. This study included the following outcome variables:

Decayed tooth. (0)—indicative of non-decayed tooth, (1) indicative of decayed tooth.
Missing tooth. (0)—indicative of not missing a tooth, (1) indicative of missing tooth.
Filled tooth. (0)—indicative of un-filled tooth, (1) indicative of filled tooth.
DMF. average of decayed, missing, and filled teeth.
HIV-infection. (0) indicative of no HIV-infection, (1) indicative of HIV-infection.
HCV-infection. (0) indicative of no hepatitis C infection, (1) indicative of hepatitis C infection.
HIV/HCV-co-infection. 0) indicative of no HIV/hepatitis C-co-infection, (1) indicative of HIV/hepatitis C-co-infection.

Independent variables. The independent variables (i.e., factors) were grouped according to the A&N model of dental service utilization. Predisposing variables include: age, gender, self-reported present medical conditions, and medical exam in the past year. Enabling variables include: employment status, social assistance, and dental insurance. Need factors have three subcategories and include: *self-reported medical need factors* such as prescription or non-prescription drugs, hospitalization within past five years, drug or alcohol addiction, HIV-positive status, HCV-positive status, mental health disorders; *self-reported dental need factors* such as oral hygiene practices (brushing teeth, flossing teeth), tobacco smoking, other mouth problems (jaw surgery, jaw pain, clenching jaws, pain in ear/s, mouth breathing), tooth wear, appearance of teeth, problems with previous dental treatment; and *clinical need factors* such as decayed, missing, and filled teeth status; types of restorations (composite; resin restorative dental

material commonly used to fill decayed teeth with shades that resembles natural tooth color, amalgam; metallic (mercury and alloys) restorative dental material commonly used to fill decayed tooth., others); number of teeth restored; pits and fissure sealants (preventive dental procedure commonly performed to seal the deep pits and fissure on posterior teeth to prevent dental decay); root canal treatments (restorative treatment of infected root canals with a thermoplastic filling material, such as *Gutta percha)* and number of tooth extractions.

Statistical analysis. Number of decayed (D), missing (M), filled (F) and DMF teeth were summarized using descriptive statistics (n, mean±SD). Associations between D, M, F, and DMF outcome variables and information in patients' charts, grouped by A&N model of dental service utilization, were compared using Mann-Whitney U tests or Kruskal Wallis one-way ANOVA depending on the levels of the independent variables. Having the presence or absence of HIV-infection, HCV-infection, or HIV/HCV-co-infection were summarized using frequencies and percentages. Comparisons between clinical oral health statuses and these three infection groupings were done using chi-square test of association. Negative binomial analysis was performed to assess the association between HIV and HCV and the number of M and DMF teeth adjusting for age, primary insurance status, and all needs factors described above. Due to excessive zeros in decayed and filled teeth, zero-inflated negative binomial regression was performed with the same set of covariate adjustment. In the zero-inflated negative binomial regression models, intercept-only logit model to account for the large number of zero counts. In both negative binomial regression and zero-inflated negative binomial regression models, the outcome is rate of DMFT. The rate of DMFT is computed as the number of DMFT divided by the total number of teeth. The covariates included in the regression models included age, dental insurance, smoking status, and frequency of brushing teeth, primary insurance, and all needs factors (including presently treated for any condition, medical exam in past year, regular Rx or non Rx medication use, hospitalization within five years, drug or alcohol addition, mental disorder, frequency of brushing teeth, frequency of flossing teeth, other mouth problems, smoking, experience of sore spots in mouth, teeth wearing on the biting surface, appearance of teeth, had a problem with previous dental treatment, type of restoration, number of restored teeth, pit and fissure sealants, and number of root canals). All analyses were conducted using SAS version 9.4 (SAS Institute Inc). Statistical significance was set at p-value <.05.

Results

The sample distribution was grouped according to the A&N model of health service utilization into predisposing, enabling, and need factors. A total of 2,000 charts were reviewed. Following are the descriptive results, bivariate analysis, and multivariate analysis.

Descriptive results. Table 1 shows the descriptive results for the sample. Given that this was a retrospective chart review, not all respondents had data available for every field; thus, n varies by category. The mean age of the sample was 42.3 years (SD = 15.4) with the majority of participants (71%) falling between 19 to 50 years of age. Slightly more than half of the participants were male (53%). The patient charts represented a

Table 1.

DESCRIPTIVE DATA (N=2000)

	N	%
Gender (N=675)		
Male	356	53
Amalgam	319	47
Age, mean (s) (N=2000)	42.3	15.4
Age (N=1962)		
<19	38	2
19–35	735	37
36–50	660	33
51–65	405	20
66+	162	8
Occupation (N=1074)		
Unemployed	171	16
Employed	527	49
Disability	56	5
Retired	92	9
Student	132	12
Homemaker	96	9
Responsible Account (N=2000)		
Self	351	18
Social Assistance	229	11
Other	536	27
Dental Insurance (N=1996)		
None	593	30
One	1372	69
Two	30	2
Primary Insurance (% Yes) (N=1996)	1403	70
Secondary Insurance (% Yes) (N=1994)	31	2
HIV/AIDS (% Yes) (N=1950)	111	6
Hepatitis C (% Yes) (N=1877)	180	10
HIV & Hepatitis C (% Yes) (N=1699)	46	3
Decayed Tooth Structure (% Yes) (N=1860)	844	45
Restoration (% Yes) (N=1855)	1292	70
Restoration Type (N=1299)		
Composite	512	39
Amalgam	470	36
Both	232	18
Other	85	7
Pit & Fissure Sealants (% Yes) (N=1860)	48	3
Decayed teeth (mean, sd) (N=1858)	2.39	3.8
Missing teeth (mean, sd) (N=1858)	9.09	9.3
Filled teeth (mean, sd) (N=1857)	4.63	4.8
DMF (mean, sd) (N=1860)	5.37	3.5

(*continued on p. 1894*)

Table 1. (*continued*)

	N	%
How often do you brush your teeth/day? (N=1640)		
Never	237	14
1 Time	679	41
2+ times	724	44
How often do you floss your teeth/day? (N=1630)		
Never	1072	66
1–3 times	284	17
Other	274	17
Other mouth problems (jaw surgery, jaw pain, clenching, pain in ear and mouth breathing) (N=2000)		
Yes	1176	59
No	824	44
Do you smoke cigarettes? (N=1837)		
Yes	1010	55
No	826	45
Have you experienced any growth or sore spots in your mouth? (N=1788)		
Yes	264	15
No	1461	82
Maybe	63	4
Are your teeth wearing on the biting surface? (N=1309)		
Yes	385	29
No	602	46
Maybe	322	25
Do you like the appearance of your teeth? (N=1248)		
Yes	303	24
No	781	63
Maybe	164	13
Are your teeth chipped? (N=1180)		
Yes	583	49
No	577	49
Maybe	20	2
Have you ever had a problem with previous dental treatment? (N=1487)		
Yes	174	12
No	1313	88

mixture of ethnicities including immigrants to Canada (e.g., from Syria, Iran, Europe, China) and Indigenous people. Of the 1,950 participants with data, 111 (6%) self-identified as HIV-positive, 180 (10%) charts reported hepatitis C-positive status, and 46 (3%) charts reported living with both HIV and HCV.

The majority of participants (85%) brushed their teeth at least one time per day;

however, 66% of participants did not floss their teeth daily. Forty-five percent (45%) of the participants had decayed tooth structure. Seventy percent had at least one restoration; most of the reported restorations were composite (39%) and amalgam (36%), with 18% having both composite and amalgam, and 7% were "other." Only 3% of patient charts indicated the application of pits and fissure sealants. The mean and SD for decayed teeth was 2.39 ± 3.8; for missing teeth was 9.09 ± 9.3; and for filled teeth was 4.63 ± 4.8. Combining DMF together, the mean and SD was 5.37 ± 3.5 (Table 1).

Bivariate analysis. *Outcome 1: Decayed, missing, filled, and DMF teeth*. The results of the bivariate analysis for predisposing and enabling factors, self-reported medical need factors, and self-reported dental need factors are summarized below and presented in Tables 2–4, respectively.

Outcome 1a: Decayed teeth. The predisposing and enabling factors (Table 2) that were significantly related to the study outcome, *decayed teeth*, include age (p<.0001), dental insurance (p<.0001). None of the self-reported medical need factors were significantly associated with decayed teeth (Table 3). The self-reported dental need factors (Table 4) that were significantly associated with *decayed teeth* include frequency of flossing per day (p=.00141) and cigarette smoking (p=.0010).

Outcome 1b: Missing teeth. The following predisposing and enabling factors (Table 2) were significantly related to the study outcome, *missing teeth*: age (p<.0001), occupation (p<.0001), social assistance (p<.0001), and dental insurance (p<.0001). All of the self-reported medical need factors (Table 3) that were surveyed were found to be significantly associated with *missing teeth*: current treatment for a condition (p<.0001), hospitalization within the previous five years (p<.0001), drug or alcohol addiction (p<.0001), HIV-positive status (p<.0001), diagnosis of a mental disorder (p=.0037).

More than half of the self-reported dental need factors (Table 4) were significantly associated with *missing teeth*: frequency of brushing per day (p<.0001), frequency of flossing per day (p=.00067), cigarette smoking (p<.0001), and appearance of the teeth (p<.0001)

Outcome 1c: Filled teeth. Among predisposing and enabling factors (Table 2), the following were significantly associated with the study outcome, *filled teeth*: dental insurance (p<.0001), with age and social assistance to a lesser degree (p=.0209) and (.0247), respectively. Interestingly, there were very few self-reported medical need factors (Table 3) or self-reported dental need factors (Table 4) that were significantly associated with *filled teeth*, including drug and alcohol addiction (p=.0211), teeth wear on biting surface (p=.0123), and appearance of teeth (p=.0046).

Outcome 1d: DMF teeth. When considering the study outcome of *DMF*, all of the predisposing and enabling variables (Table 2), except sex, were found to be significantly associated: age (p<.0001), employment status (p<.0001), social assistance (p<.0001), and dental insurance (p<.0001). Similarly, most of the self-reported medical need factors (Table 3) were found to be significantly associated with the *DMF*: current treatment for a condition (p<.0001), hospitalization within the previous five years (p<.0001), drug or alcohol addiction (p<.0001), HIV-positive status (p<.0001). Nearly all of the self-reported dental need factors (Table 3) were significantly associated with the *DMF* including: frequency of brushing per day (p<.0001), frequency of flossing per day

Table 2.

BIVARIATE CORRELATIONAL ANALYSIS OF PREDISPOSING AND ENABLING VARIABLES WITH DECAYED MISSING FILLED (DMF) TEETH

Mean (sd)		N	Decayed Teeth	p-value	N	Missing Teeth	p-value	N	Filled Teeth	p-value	N	DMF Teeth	p-value
Age	19–35	683	3.03 (4.18)	<.0001	684	5.20 (5.84)	<.0001	683	4.95 (4.99)	.0209	684	4.39 (3.08)	<.0001
	36–65	995	2.19 (3.55)		996	11.35 (10.07)		995	4.57 (4.79)		996	6.04 (3.57)	
	66+	146	0.85 (2.50)		145	13.72 (9.94)		146	3.85 (4.60)		146	6.12 (3.55)	
Gender	Male	336	1.93 (3.47)	.3489	336	8.76 (9.78)	.7293	335	3.55 (4.29)	.2308	336	4.75 (3.48)	.7837
	Female	306	2.06 (3.47)		306	8.32 (9.32)		306	4.08 (4.79)		307	4.83 (3.48)	
Occupation	Unemployed	159	2.27 (3.58)	.0378	160	10.94 (9.93)	<.0001	160	4.46 (4.75)	.2589	160	5.92 (3.45)	<.0001
	Employed	486	2.16 (3.68)		485	8.33 (8.90)		485	4.07 (4.40)		486	4.85 (3.62)	
	Disability	55	1.91 (3.15)		55	12.71 (11.10)		55	5.45 (5.25)		55	6.69 (3.39)	
	Retired	83	1.12 (2.82)		83	13.43 (9.79)		83	4.07 (4.62)		83	6.21 (3.36)	
	Student	124	2.30 (3.44)		124	5.10 (6.93)		124	5.16 (5.23)		124	4.19 (3.01)	
	Homemaker	90	2.30 (3.63)		90	11.39 (10.39)		90	4.47 (4.75)		90	6.05 (3.67)	
Social Assistance	Yes	219	2.36 (3.36)	.5816	219	10.90 (9.69)	<.0001	219	5.48 (5.34)	.0247	219	6.25 (3.28)	<.0001
	No	1639	2.40 (3.82)		1639	8.85 (9.18)		1638	4.51 (4.75)		1641	5.25 (3.50)	
	No	1386	2.16 (3.63)		1386	8.58 (9.19)		1385	4.19 (4.70)		1388	4.98 (3.49)	
Dental Insurance	None	530	1.72 (3.27)	<.0001	529	7.26 (8.70)	<.0001	528	2.81 (3.88)	<.0001	530	3.93 (3.36)	<.0001
	One	1293	2.70 (3.95)		1294	9.87 (9.35)		1294	5.34 (4.98)		1295	5.97 (3.36)	
	Two	30	1.07 (2.05)		30	8.63 (10.83)		30	5.43 (5.26)		30	5.04 (3.41)	

Table 3.

BIVARIATE CORRELATIONAL ANALYSIS OF SELF-REPORTED MEDICAL NEED FACTORS WITH DECAYED MISSING FILLED (DMF) TEETH

Mean (sd)		N	Decayed Teeth	p-value	N	Missing Teeth	p-value	N	Filled Teeth	p-value	N	DMF Teeth	p-value
Presently Being Treated for Any Condition	Yes	508	2.29 (3.87)	.1972	507	12.36 (10.23)	<.0001	508	4.33 (4.60)	.1568	508	6.32 (3.42)	<.0001
	No	1299	2.42 (3.73)		1299	7.90 (8.56)		1297	4.76 (4.94)		1300	5.03 (3.44)	
Medical Exam in Past Year	Yes	833	2.30 (3.76)	.3039	831	9.71 (9.48)	.0163	832	4.46 (4.63)	.4781	833	5.49 (3.53)	.2811
	No	972	2.45 (3.78)		973	8.68 (9.09)		971	4.80 (5.02)		973	5.31 (3.45)	
Regular Rx or non-Rx Medication Use	Yes	757	2.32 (3.81)	.3816	756	11.36 (10.04)	<.0001	757	4.49 (4.76)	.2568	757	6.05 (3.49)	<.0001
	No	1051	2.43 (3.74)		1051	7.57 (8.33)		1049	4.76 (4.92)		1052	4.92 (3.40)	
Hospitalized in 5 years	Yes	483	2.45 (3.90)	.9298	482	10.62 (9.92)	<.0001	483	5.01 (4.98)	.0492	483	6.02 (3.49)	<.0001
	No	1327	2.36 (3.72)		1327	8.63 (8.98)		1325	4.51 (4.80)		1328	5.17 (3.45)	
Drug or Alcohol Addition	Yes	281	2.64 (4.12)	.4794	281	12.68 (10.47)	<.0001	281	5.21 (4.94)	.0211	281	6.84 (3.31)	<.0001
	No	1532	2.33 (3.70)		1531	8.51 (8.89)		1530	4.55 (4.83)		1533	5.13 (3.45)	
HIVAIDS	Yes	111	3.60 (4.60)	.0033	111	17.40 (10.43)	<.0001	111	4.59 (4.49)	.9267	111	8.53 (2.72)	<.0001
	No	1702	2.30 (3.69)		1701	8.62 (8.94)		1700	4.66 (4.87)		1703	5.19 (3.43)	
Herpes	Yes	24	1.92 (3.12)	.5148	24	14.33 (12.01)	.0131	24	4.83 (4.91)	.9637	24	7.03 (3.35)	.0175
	No	1789	2.39 (3.77)		1788	9.09 (9.22)		1787	4.65 (4.85)		1790	5.37 (3.48)	
Mental Disorder	Yes	141	2.12 (3.72)	.2764	141	11.33 (9.87)	.0004	141	5.08 (4.90)	.2376	141	6.18 (3.44)	.0044
	No	1672	2.40 (3.77)		1671	8.97 (9.20)		1670	4.61 (4.85)		1673	5.33 (3.48)	

Table 4.

BIVARIATE CORRELATIONAL ANALYSIS OF SELF-REPORTED DENTAL NEED FACTORS WITH DECAYED MISSING FILLED (DMF) TEETH

		N	Decayed Teeth	p-value	N	Missing Teeth	p-value	N	Filled Teeth	p-value	N	DMF Teeth	p-value
How often do you brush your teeth/day?	Never	225	2.56 (4.44)	.6664	225	12.79 (11.02)	<.0001	225	4.07 (4.95)	.0046	225	6.47 (3.77)	<.0001
	1 Time	627	2.53 (3.78)		625	8.25 (8.66)		626	5.11 (5.02)		627	5.29 (3.40)	
	2+ times	673	2.31 (3.56)		673	7.69 (7.76)		671	4.83 (4.77)		673	4.94 (3.26)	
How often do you floss your teeth/day?	Never	998	2.65 (3.98)	.0141	996	9.29 (9.31)	.0067	997	4.69 (4.99)	.0238	998	5.54 (3.47)	.0011
	1–3 times	257	2.20 (3.58)		257	7.43 (7.24)		257	5.23 (4.62)		257	4.95 (3.37)	
	Other	261	1.89 (3.18)		261	7.45 (8.08)		260	5.04 (4.90)		261	4.79 (3.26)	
Other mouth problems (jaw surgery, jaw pain, clenching, pain in ear and mouth breathing)	Yes	1106	2.42 (3.82)	.7098	1105	9.30 (9.27)	.0366	1104	4.56 (4.74)	.7316	1106	5.43 (3.52)	.4192
	No	752	2.35 (3.69)		753	8.78 (9.24)		753	4.72 (4.97)		754	5.29 (3.44)	
Do you smoke cigarettes?	Yes	944	2.73 (4.11)	.0010	944	10.48 (9.78)	<.0001	943	4.76 (5.02)	.8333	944	5.99 (3.56)	<.0001
	No	762	1.90 (3.16)		761	7.22 (7.93)		761	4.69 (4.73)		763	4.61 (3.18)	
Have you experienced any growth or sore spots in your mouth?	Yes	248	2.68 (3.94)	.0785	247	9.49 (9.32)	.4720	248	4.95 (5.27)	.3163	248	5.70 (3.68)	.1419
	No	1354	2.30 (3.66)		1354	8.73 (8.97)		1352	4.68 (4.82)		1355	5.24 (3.40)	
	Maybe	58	3.02 (4.62)		58	8.43 (7.94)		58	5.84 (5.45)		58	5.76 (3.55)	
Are your teeth wearing on the biting surface?	Yes	360	2.70 (3.99)	.2802	359	10.73 (9.56)	<.0001	360	5.33 (5.23)	.0123	360	6.24 (3.47)	<.0001
	No	553	2.25 (3.50)		553	8.66 (9.22)		552	4.59 (4.78)		554	5.18 (3.42)	
	Maybe	300	2.51 (3.76)		300	6.91 (7.15)		300	5.49 (5.04)		300	4.97 (3.14)	
Do you like the appearance of your teeth?	Yes	276	2.38 (3.48)	.8339	275	6.70 (7.43)	<.0001	276	5.17 (4.65)	.0006	276	4.74 (3.08)	.0013
	No	734	2.46 (3.86)		734	9.82 (9.58)		734	4.74 (5.06)		735	5.68 (3.56)	
	Maybe	147	2.39 (3.61)		147	7.35 (7.21)		147	6.19 (5.16)		147	5.31 (3.19)	
Have you ever had a problem with previous dental treatment?	Yes	163	2.42 (3.60)	.7095	163	9.94 (9.22)	.0259	163	4.83 (4.92)	.7693	163	5.73 (3.36)	.1365
	No	1214	2.43 (3.80)		1214	8.63 (8.87)		1212	4.94 (4.99)		1215	5.34 (3.45)	

(p=.0011), cigarette smoking (p<.0001), teeth wearing on the biting surface (p<.0001), and whether the participant liked the appearance of his or her teeth (p=.00013).

The enabling factor of dental insurance was also found to be significantly associated across all study sub-outcomes.

Outcome 2: HIV-infection, HCV-infection, and HIV/HCV-co-infection. Table 5 presents a bivariate comparison of clinical oral health status with the HIV and HCV status of participants. For participants who self-reported as HIV-positive, HCV-positive, or both HIV and HCV-positive concurrently, there was a significant association with the number of extractions (p<.001 for the three comparisons). Half (50%) of HIV-positive participants had 15 or more extractions compared with 20% of the HIV-negative participants. Similarly, 40% of HCV-positive participants versus 20% of HCV-negative participants had 15 or more extractions. For the HIV/HCV-co-infection group of participants, 50% of the concurrently HIV and HCV-positive participants had 15 or more extractions compared with 19% for those without the illnesses.

Multivariate analysis. Table 6 shows results from zero-inflated negative binomial and negative binomial regression, which was used to evaluate the association between HIV-infection, HCV-infection and HIV/HCV-co-infection and D, M, F and DMFT after adjusting for age, dental insurance, smoking status, and frequency of brushing teeth. Table 6 shows that those participants who are either HIV-positive or HCV-positive have a higher DMF rate compared with those without the conditions. Additionally, those who are both HIV and HCV-positive have an estimated DMF rate almost double of those without either condition (IRR=1.84, p<.0001). In more detail, when HIV-positive participants were compared with HIV-negative participants, the rate of missing teeth, and DMF teeth for HIV-positive participants is 1.94 times (IRR=3.60, p<.0001), and 2.09 times (IRR=2.09, p<.0001) compared with HIV-negative patients, respectively. For HCV-positive versus HCV-negative participants (comparison 2), HCV-positive participants reported a higher rate of decayed teeth (IRR=1.32, p=.0308), missing teeth (IRR=1.85, p<.0001), and rate of DMF teeth (IRR=1.50, p<.0001) compared with HCV-negative patients. Lastly, for HIV and HCV-positive versus HIV and HCV-negative (comparison 3), those participants who were HIV and HCV-positive reported a higher rate of decayed teeth (IRR=1.83, p=.0015), missing teeth (IRR=2.22, p=.0001), and DMF teeth (IRR=1.84, p<.0001) compared with those with HIV and HCV-negative.

Discussion

This is the first study to identify the factors related to oral health status in an inner-city population in Saskatchewan, with a focus on the oral health status of HIV-positive, HCV-positive, and HIV and HCV-positive patients. The A&N model of health service utilization was chosen to identify the significant factors of the outcome variables (D, M, F, and DMF) in the studied population. Several *predisposing factors* were significantly correlated with the outcome variables including age, HIV-positive status, HCV-positive status, and HIV/HCV-co-infection status. Detailed discussion related to HIV, HCV, and HIV and HCV status will follow a discussion of *predisposing*, *enabling*, and *needs* factors.

In this retrospective chart review, patients who were 45 years or older had a higher number of missing teeth than restored teeth (Table 1). Other studies have shown that

Table 5.

BIVARIATE COMPARISON OF CLINICAL ORAL HEALTH STATUS WITH HIV AND NON-HIV, HCV AND NON-HCV AND, HIV/HCV WITH NON-HIV/HCV PARTICIPANTS

	HIV-positive	HIV-negative	p-value	HCV-positive	HCV-negative	p-value	HIV/HCV-positive	HIV/HCV-negative	p-value
% with Restoration present	76 (69%)	1186 (70%)	.8815	118 (67%)	1099 (70%)	.4747	30 (65%)	1068 (70%)	.4830
Type of Restoration			.4211			.7711			.7136
Composite	25 (33%)	506 (42%)		45 (38%)	470 (43%)		10 (33%)	461 (43%)	
Amalgam	11 (14%)	141 (12%)		14 (12%)	133 (12%)		5 (17%)	128 (12%)	
Both	40 (53%)	543 (46%)		59 (50%)	500 (45%)		15 (50%)	483 (45%)	
Number of restored teeth			.1303			.5134			.2369
1–4	24 (32%)	473 (40%)		41 (8%)	443 (40%)		10 (33%)	433 (40%)	
5–9	37 (49%)	423 (35%)		42 (36%)	398 (36%)		16 (53%)	384 (36%)	
10–14	10 (13%)	217 (18%)		26 (22%)	191 (17%)		3 (10%)	186 (17%)	
15+	5 (7%)	79 (7%)		9 (8%)	73 (7%)		1 (3%)	71 (7%)	
% with Pit and Fissure Sealants	0 (0%)	44 (3%)	.0880	0 (0%)	44 (2.8%)	.0250	0 (0%)	44 (3%)	.2432
Root canals			.6834			.4946			.4982
1 to 2	32 (86%)	326 (74%)		37 (79%)	304 (74%)		13 (81%)	291 (74%)	
3 or more	5 (14%)	114 (26%)		10 (21%)	106 (26%)		3 (19%)	104 (26%)	
Extractions			<.0001			<.0001			<.0001
1 to 4	5 (5%)	583 (38%)		24 (14%)	553 (39%)		4 (9%)	552 (40%)	
5 to 9	25 (23%)	448 (29%)		43 (25%)	412 (29%)		9 (20%)	400 (29%)	
10–14	26 (24%)	201 (13%)		37 (21%)	175 (12%)		10 (22%)	164 (12%)	
15 +	53 (49%)	314 (20%)		69 (40%)	278 (20%)		23 (50%)	258 (19%)	

Table 6.

NEGATIVE BINOMIAL ANALYSIS COMPARISON 1 (HIV VS NON-HIV), COMPARISON 2 (HIV AND HCV VS NON- HIV AND NON- HCV) AND COMPARISON 3 (HCV VS NON-HCV) WITH DECAYED MISSING FILLED (DMF) TEETH[A]

	Rate Ratio (95% CI)	p-value
Decayed [b]		
HIV vs. non-HIV	1.21 (0.78, 1.88)	.9876
Hep C vs. non-Hep C	1.32 (1.03, 1.70)	.1283
HIV & Hep C vs. non-HIV & non-Hep C	1.83 (1.26, 2.67)	.0015
Missing		
HIV vs. non-HIV	3.60 (2.32, 5.61)	<.0001
Hep C vs. non-Hep C	1.85 (1.46, 2.34)	<.0001
HIV & Hep C vs. non-HIV & non-Hep C	2.22 (1.48, 3.34)	.0001
Filled [b]		
HIV vs. non-HIV	1.10 (0.78, 1.56)	.5876
Hep C vs. non-Hep C	1.10 (0.91, 1.33)	.3026
HIV & Hep C vs. non-HIV & non-Hep C	0.99 (0.71, 1.38)	.4357
DFT		
HIV vs. non-HIV	2.09 (1.50, 2.93)	<.0001
Hep C vs. non-Hep C	1.50 (1.26, 1.80)	<.0001
HIV & Hep C vs. non-HIV & non-Hep C	1.84 (1.36, 2.50)	<.0001

Notes:
[a]Model adjust for age, dental insurance, smoking status, and frequency of brushing teeth.
[b]Zero-inflated negative binomial regression model was performed when the outcome is the rate of decayed and filled teeth.

age has a direct correlation with the number of decayed and missing teeth. This could be due to several reasons such as progressive periodontal disease, lower mortality rates, lack of access to dental care, among others.[19,20] The lack of access to primary dental care can be a contributing factor to this finding. It has been well-documented that people from a low socioeconomic status often delay or neglect visiting to an oral health professional due to economic and social barriers such as lack of affordability.[21] This could have a serious impact on the timely diagnosis of dental decay which can be reversed or restored if diagnosed in the initial (i.e., reversible or restorable) phases. If it is not done in a timely manner, this can lead to a severe damage of the tooth structure which can lead to costly rehabilitation, or an unrestorable state.[22] Hence, in such patients, extraction could be a choice of treatment as it was identified in our chart review. Other possible reasons for a higher number of extractions includes problems related to an addiction, substance abuse, lack of oral health education, and lack of oral hygiene to sustain long-term restorations.[23] Many patients presenting at Saskatoon West Dental Clinic experience common inner-city issues including competing priorities when it

comes to their oral health, such as stable housing, job security, and food security.[24] This could lead to higher unmet dental treatment needs or emergency driven dental treatments such as extractions.[25]

The A&N *enabling factors* (Table 2) that were significant with the outcome variables in our retrospective review included employment status and dental insurance; the latter was also found to be significantly associated across all study sub-outcomes. Around three quarters of the participants had dental insurance, and those with insurance had elevated D, M, F, and DMF scores compared with those without dental insurance. Although the people with dental insurance are more likely to access dental care services, having dental insurance does not necessarily entail experiencing less oral disease.[26–27] Rather, factors such as appropriate and conservative dental treatment, trauma-informed care for vulnerable populations, and patient compliance determine the long-term sustainability of a dental treatment that could improve an overall oral health-related quality of life, especially in marginalized populations such as people living with HIV and HCV.[28]

The majority of the patient charts indicated one or more unmet *medical and dental treatment need factors* (Tables 3 and 4). We found a significant correlation between the oral hygiene routine of patients and their DMF scores. For instance, patients who reported brushing their teeth twice a day had a lower DMF index. This is not surprising as evidence suggests that having regular oral hygiene routine can have a positive impact on dental health.[28] However, maintaining optimum oral hygiene practices are influenced by factors such as having oral health education, medical conditions, addiction and substance abuse. Sixteen percent (16%) of the study population reported having some form of addiction including drug or alcohol abuse. This significantly correlated with the missing number of teeth in our results. Missing teeth are commonly found among substance abuse populations, as reported in the meta-analysis by Baghaie et al. in 2017.[29] Studies have shown a direct correlation between oral health and substance abuse (such substances as cannabis, amphetamines, and opioids). In addition, substance abuse disorders can lead to behavioural changes such as self-neglect, lack of social and financial support, and consumption of sweetened foods, which can contribute to dental decay and other dental conditions.[29] Almost all of the need factors (both medical and dental) were associated with missing teeth in the population. As reported by the U.S. Surgeon General in the 2000 Oral Health Report, oral health and general health are intimately linked to each other since the mouth acts as a route of entry for many diseases, and conversely there are many oral manifestations of bodily diseases.[28] Similar results were reported in studies conducted by Foger et al. and Benyamini et al., where participants with past medical conditions also reported having unmet dental treatment needs including dental decay and periodontal disease.[30,31]

Most importantly, this study found an important correlation between the patient's oral health and their HIV, HCV, and HIV and HCV infection/co-infection status. In comparison with uninfected individuals, all three infection groups were found to have higher numbers of decayed, missing, and DMF teeth. Interestingly, all three groups had lower numbers of filled teeth. These higher DMFT levels may be due to lack of access to dental care, stigma, discrimination by oral care providers, and lack of social support in HIV-positive populations.[32] With high rates of HIV infection in Saskatchewan, this

may also be a problem in the context of our study population. In 2017, the Saskatchewan Ministry of Health reported 177 (rate of 15.1 per 100,000) new cases of HIV in the province of Saskatchewan (rate of 15.1 per 100,000), which is 2.4 times higher than the 2016 national rates of 6.4 per 100,000.[18] In fact, these rates are comparable to many developing countries.[33] Alarmingly, 63% of HIV-positive individuals have been or are currently co-infected with HCV, which further complicates their general and oral health related well-being.[18] This co-infection can further diminish an individual's oral health status, as confirmed in our findings.[34]

Conclusion. This is the first study of its kind in Saskatchewan and in Canada that attempted to understand the correlation of HIV-infection and HIV/HCV-co-infection with oral health status in an inner-city population. Through retrospective analysis, predisposing (age), enabling (employment, dental insurance), and need factors (oral hygiene routine, substance use disorders) were found to be associated with higher DMFT scores in the studied population. We also found a significant correlation with HIV-infection and HCV-co-infection. This study highlights that people living with chronic infections such as HIV and HCV have higher unmet dental needs and could benefit from preventative oral care services, such as those offered through interdisciplinary care programs.[35]

Limitations. This investigation is limited by the group who self-select to visit the Saskatoon West Dental Clinic. Our study captures a higher proportion of insured patients than reflected in the general population, which may lead to underestimation of the problem and improved DMFT scores.[28] Fear of discrimination and stigmatization in the HIV-positive and HCV-positive population may have led to underreported rates of HIV and HCV. Lastly, we do not have data from the non-inner-city population with which to compare our results. Despite these limitations, this work provided insight into a population that has not been investigated in this manner previously (inner-city population of Saskatoon and the HIV/HCV-co-infection group). We hope that this investigation will heighten the awareness of the needs of this population, provide preliminary data for future in-depth studies, and provide a tool in the education of health care providers for this population.

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