Salivary Parameters (Salivary Flow, pH and Buffering Capacity) in Stimulated Saliva of Mexican Elders 60 Years Old and Older

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ABSTRACT

Objective: *To compare a limited array of chewing-stimulated saliva features (salivary flow, pH and buffer capacity) in a sample of elderly Mexicans with clinical, sociodemographic and socio-economic variables.*

Subjects and Methods*: A cross-sectional study was carried out in 139 adults, 60 years old and older, from two retirement homes and a senior day care centre in the city of Pachuca, Mexico. Socio-demographic, socio-economic and behavioural variables were collected through a questionnaire. A trained and standardized examiner obtained the oral clinical variables. Chewing-stimulated saliva (paraffin method) was collected and the salivary flow rate, pH and buffer capacity were measured. The analysis was performed using non-parametric tests in Stata 9.0.*

Results: *Mean age was 79.1 ± 9.8 years. Most of the subjects included were women (69.1%). Mean chewing-stimulated salivary flow was 0.75 ± 0.80 mL/minute, and the pH and buffer capacity were 7.88 ± 0.83 and 4.20 ± 1.24, respectively. Mean chewing-stimulated salivary flow varied (*$p < 0.05$*) across type of retirement home, tooth brushing frequency, number of missing teeth and use of dental prostheses. pH varied across the type of retirement home (*$p < 0.05$*) and marginally by age (*$p = 0.087$*); buffer capacity (*$p < 0.05$*) varied across type of retirement home, tobacco consumption and the number of missing teeth.*

Conclusions: *These exploratory data add to the body of knowledge with regard to chewing-stimulated salivary features (salivary flow rate, pH and buffer capacity) and outline the variability of those features across selected sociodemographic, socio-economic and behavioural variables in a group of Mexican elders.*

Keywords: Buffer capacity, elderly, pH, saliva, salivary flow

Parámetros Salivales (Flujo Salival, pH y Capacidad Amortiguadora) en la Saliva Estimulada de Mexicanos 60 Años y Más

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RESUMEN

Objetivo: *Comparar una serie limitada de características de saliva estimulada por la masticación (capacidad de flujo, pH y capacidad amortiguadora o tampón) tomada de una muestra de ancianos mexicanos, con clínicas, sociodemográficas y variables socio-económicas.*

Sujetos y métodos: *Se realizó un estudio transversal con 139 adultos de 60 años o más, en dos hogares de ancianos retirados, y un centro de cuidados a personas de la tercera edad, en la ciudad de Pachuca, México. Las variables sociodemográficas, socio-económicas, y conductuales fueron recogidas a través*

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de un cuestionario. Un examinador entrenado y estandarizado obtuvo las variables clínicas orales. La saliva estimulada por masticación (método de parafina) fue recogida, y se midieron la tasa de flujo salival, el pH y la capacidad amortiguadora o tampón. El análisis se realizó mediante pruebas no paramétricas en Stata 9.0.

Resultados: *La edad promedio fue 79.1 ± 9.8 años. La mayoría de los sujetos incluidos fueron mujeres (69.1%). El flujo salival promedio estimulado mediante masticación fue 0.75 ± 0.80 mL/minuto, y la capacidad tampón y pH fueron 7.88 ± 0.83 y 4.20 ± 1.24, respectivamente. El flujo salival promedio estimulador mediante masticación varió (*$p < 0.05$*) de acuerdo con el tipo de casa de retiro, frecuencia de cepillado, número de dientes perdidos, y el uso de una prótesis dental. El pH varió de acuerdo con el tipo de casa de retiro (*$p < 0.05$*), y marginalmente con la edad (*$p = 0.087$*); la capacidad amortiguadora (*$p < 0.05$*) varió según el tipo de casa de retiro, el consumo de tabaco, y el número de dientes perdidos.*

Conclusiones: *Estos datos exploratorios se añaden al conjunto de conocimientos con respecto a las características salivales estimuladas por masticación (tasa de flujo salival, pH y capacidad amortiguadora), y describen la variabilidad de las características a través de variables socio-demográficas, socioeconómicas y conductuales seleccionadas en un grupo de ancianos mexicanos.*

Palabras claves: Capacidad amortiguadora, ancianos, pH, saliva, flujo salival

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INTRODUCTION

Strictly speaking, saliva is defined as a mixed exocrine fluid secretion produced by the salivary glands (parotid, submandibular, sublingual and minor salivary glands). The term saliva usually refers to the hypotonic fluid secreted by the salivary glands, but it is also used to represent the combination of all oral fluids. Saliva contains water, mucin, protein, minerals, enzymes, blood, food and cellular debris and resident micro-organisms of the mouth. Its production is controlled by the autonomic nervous system (1, 2). It can have a fluid or viscous texture and it can also have certain biochemical variation depending on the gland producing it.

Human saliva does not only lubricate the oral tissues, it also helps other functions such as speaking, eating, swallowing and protecting teeth and oral mucosa. Resting saliva mainly serves the lubrication and antimicrobial functions. In contrast, stimulated saliva is primarily involved in washing off food debris and harmful agents (3). Furthermore, saliva also has some important biological properties such as its capacity to act as a buffer against the acids produced by micro-organisms or ingested through the diet, allowing it to keep a relatively constant pH (4). The protective functions of the saliva are not limited to the above functions (3, 5).

From the standpoint of dentistry, the most important functions of saliva in preventing caries are its rinsing and buffering effects, in addition to moderating the demineralization and remineralization processes by supplying a constant source of calcium and phosphates. Jawed *et al* (6) found that certain salivary parameters such as salivary flow and pH are related to one another. A reduction in salivary flow results in a significant decline in the oral defence systems, which can cause caries and inflammation of the oral mucosa (3, 4, 7). Moreover, it entails a number of significant clinical problems and discomfort that may manifest as caries increment, increased susceptibility to thrush, altered taste sensation, and halitosis, among other problems (8).

Ageing produces many biological, chemical and physiological changes that may contribute to modifying salivary characteristics (9, 10). Elderly people generally have health problems that force them to take medications, further altering saliva characteristics (9). To our knowledge, the clinical characteristics of the saliva in the elderly have not been fully ascertained. The aim of the present study was to compare a limited array of salivary parameters (salivary flow, pH and buffer capacity) among Mexican elderly subjects, 60 years old and older, with associated clinical, sociodemographic and socio-economic variables.

SUBJECTS AND METHODS

The present exploratory analysis is a part of a project that measured various indicators of oral health in the elderly. It complied with the national and international ethical regulations in force and it was approved by the research ethics committee of the Post Graduate and Research Unit of the Academic Area of Dentistry, the Autonomous University of the State of Hidalgo, in Pachuca, Hidalgo, Mexico. Part of the methodology, including risk indicators for edentulism (11) and root caries (12), has been previously published.

We conducted a cross-sectional study in elderly individuals, 60 years old and older, who were living in two retirement homes or attending a day care group of elderly people living independently. The retirement homes were "the Home for the Elderly of the State Government" – a public retirement home and the "Maria Dominguez Widow of Alvarez Foundation Retirement Home" – a private retirement home; the rest of the group were members of the senior day care centre, "Searching for a friend", part of the ISSSTE – Institute for Social Security and Services for State Workers.

After obtaining the relevant permits, we invited the subjects to participate in the study, informing them about the aims of the research, the confidentiality in data management, and the fact that they could stop participating at any moment in the study. Inclusion criteria were: 1) subjects of either gender, 2) individuals 60 years and older and 3) seniors wishing to participate in the research. Exclusion criteria were: 1) people under 60 years old, 2) individuals with a hearing or a language impairment that could affect the interview and 3) individuals with some kind of physical or mental disability that could preclude the oral examination. We did not use any sampling approach. The initial study group included 151 subjects. Only 12 refused to participate in the study or did not meet the inclusion/exclusion criteria. The final sample was 139 subjects.

Variables and data collection

The dependent variables were salivary flow, pH and buffer capacity. To obtain the stimulated salivary flow, we followed standard procedures (13). The samples were collected at 7:30 am, when the elders said they had not eaten any food or drunk any kind of liquid, nor smoked, tooth brushed or rinsed for at least one hour before the sample was taken. Each patient sat in an upright and relaxed posture, and was given one gram of paraffin (Merck 7159) to chew in order to stimulate saliva production; then the patient was placed with the head tilted forward so saliva could be collected from the floor of the mouth. Saliva was collected for five minutes into calibrated sterile tubes; in order to calculate the salivary flow (mL/min), we divided by five the saliva collected. Samples were prepared and taken to the potentiometer (Radiometer Copenhagen PHM 250® Mod.) with a glass combination electrode Orion 910600® that was previously calibrated with Cole Palmer buffer solutions, with pH 4.01, 7 and 10. Salivary pH measurements were recorded for each sample. Then samples of one millilitre of saliva were prepared to measure salivary buffer capacity through a standardized method of hydrochloric acid titration (14). In this procedure, we added 3 mL of hydrochloric acid (HCl; 0.005 M) to each salivary sample using an Echromtech® micropipette; 20 minutes later, we measured the buffer capacity. For the analysis of pH and buffer capacity, 22 subjects were excluded because we could not obtain the necessary amount of saliva for the analysis, so for these two variables, only the results for 117 subjects were presented.

Questionnaires were used to collect information on sociodemographic variables such as age, gender and marital status; socio-economic variables included type of senior organization, having received social security support and maximum level of schooling, as well as other information such as having received radiation on the head or the neck, tobacco consumption, soda consumption, presence of chronic diseases, medication use and frequency of tooth brushing. Also, a clinical examination was performed to identify oral health indicators, such as number of missing teeth, edentate status and use of denture status. The latter variable was coded as 0 = subjects who had lost all of their teeth (edentulous) but used dentures, 1 = subjects who had lost at least one tooth and used fixed or removable prostheses, 2 = subjects who lost all their teeth (edentulous) and did not use dentures, 3 = subjects with functional dentition without prosthesis (people who had at least 20 natural teeth and had no prostheses) and 4 = subjects who had less than 20 natural teeth and had no prosthesis. Clinical examination was performed by a single examiner who was previously standardized and trained, using a flat dental mirror and a World Health Organization (WHO) type periodontal probe on the patient sitting in a room with artificial light.

Data analysis

The information collected from questionnaires and clinical examination was analysed in Stata 9.0®. First, we performed a descriptive analysis of the population by using central tendency and dispersion measures for the quantitative variables, and frequency and percentages for the qualitative variables. Subsequently, bivariate analyses were performed to determine if there was any difference in the distribution of chewing-stimulated salivary characteristics (flow, salivary pH and buffer capacity) across the different variables included in the study. As a first step, we verified the salivary variables distribution with the Shapiro-Wilk test. As long as they had a non-normal distribution according to the measurement scale of variables tested, the non-parametric tests of Mann-Whitney and Kruskal-Wallis, and the non-parametric test for trends were used.

RESULTS

The study included 139 elderly subjects, 60 years old and older. Table 1 shows the descriptive results of the sample.

Table 1: Characteristics of the subjects included in the study (n = 139)

	Mean ± SD	Range
Age (year)	79.1 ± 9.8	60–100
Missing teeth	20.02 ± 8.61	0–28
	Frequency	**Percentage**
Gender		
Male	43	30.9
Female	96	69.1
Marital status		
Single	52	37.4
Married/common-law union	25	18.0
Divorced/widowed	62	44.6
Social security recipient		
Yes	64	46.0
No	75	53.0
Maximum level of schooling		
Elementary school and more	49	35.3
Less than elementary school	90	64.7
Type of senior organization		
Public	84	60.4
Private	31	22.3
Day care	24	17.3

Has received radiation		
No, never	133	95.7
Yes, some time	6	4.3
Tobacco use		
No	117	84.2
Yes	22	15.8
Regular soda use		
Yes	46	33.1
Sometimes	48	34.5
No	45	32.4
Chronic diseases		
None	37	26.6
Diabetes with/without other	12	8.6
Hypertension with/without other	20	14.4
Diabetes with hypertension	7	5.0
Others	63	45.3
Tooth brushing		
Less than twice/day	90	64.7
Two or more times/day	49	35.3
Dental status		
Edentulous with prosthesis	27	19.6
Lost teeth with prosthesis	37	26.8
Edentulous without prosthesis	27	19.6
Lost teeth (< 21) without prosthesis	33	23.9
Lost teeth (> 20) without prosthesis	13	10.1

Most of them were women (69.1%) and the mean age was 79.1 ± 9.8 years. As for marital status, most of them were divorced/widowed (44.6%). Regarding socio-economic status variables, unfavourable features were often observed: most subjects had no access to social security (53.0%), reported not having completed elementary school or to be illiterate (64.7%), or were in a publicly-funded retirement home (60.4 %). Table 1 also shows that only a relatively small percentage was free of chronic diseases (26.6%). At least 16% of respondents reported tobacco consumption daily or occasionally. It was observed that only 4.3% of study subjects had received radiation treatment. A third of the subjects consumed soft drinks frequently (33.1%). Tooth brushing was practiced frequently by 35.3%. With regard to dental features, tooth loss numbering zero to 10 teeth, 11 to 20 teeth, and 21 to 28 teeth were 15.8%, 29.5%, and 54.7%, respectively. Mean missing teeth were 20.02 ± 8.61. One subject had not lost any teeth and of those who had at least one missing tooth (n = 138), 53.6% did not use prostheses. Mean chewing-stimulated salivary flow for 139 participants was 0.75 ± 0.80 mL/minute. For the subjects in whom the pH and buffer capacity could be calculated (n = 117), mean values were 7.88 ± 0.83 and 4.20 ± 1.24, respectively.

Salivary flow

Table 2 shows the bivariate analysis results for chewing-stimulated salivary flow in mL/minute. Subjects with a tooth brushing frequency at least twice a day had higher chewing-stimulated salivary flow than those with lower frequency (0.96 *vs* 0.63; $p < 0.05$). We observed a significant difference in the number of natural teeth in the mouth with the Kruskal-Wallis test ($p < 0.01$). Also, in the non-parametric test for trends, a negative trend was observed: the higher the number of missing teeth, the lower the chewing-stimulated salivary flow ($p < 0.01$). The use of any type of dental prosthesis had a marginal effect on chewing-stimulated salivary flow (0.75 *vs* 0.71, $p = 0.0699$). Those who replaced their missing teeth had higher chewing-stimulated salivary flow than those who did not replace them.

Although men had higher chewing-stimulated salivary flow than women, the difference was not significant ($p > 0.05$). This situation was replicated with respect to age, marital status, schooling, whether or not social security was received, the type of retirement home, having received radiation therapy, tobacco or soft drinks consumption, or the presence of chronic diseases.

Salivary pH

Table 3 shows the bivariate analysis of salivary pH across categories of independent variables. We only observed statistically significant differences across type of retirement home ($p < 0.01$). Seniors in the private home had the highest pH (8.23 ± 0.59), while those living in the public retirement home had the lowest pH (7.71 ± 0.96). Age had no significant difference but we could observe a slight trend in pH values: when the age increased, so did the pH ($p = 0.087$).

Gender, marital status, having social security, maximum level of schooling, having received radiation, tobacco or soda consumption, presence of chronic diseases, tooth brushing patterns, the number of missing teeth, and denture use did not show significant differences.

Buffer capacity

With regard to buffer capacity, results are shown in Table 4. The type of retirement home had significant differences: subjects living in the public retirement home had lower buffer capacity compared to those living in the private retirement home and those attending the senior day care centre ($p < 0.01$). It was also noticed that subjects who smoked had lower buffer capacity than non-smokers ($p < 0.05$). When incorporating the buffer capacity and the number of missing teeth to the Kruskal-Wallis test, there was a slight significant difference ($p = 0.0636$). But we noticed a negative trend between the variables when the non-parametric test for trends was used: when the number of missing teeth increased, the buffer capacity of saliva decreased ($p > 0.05$). Results of other independent variables (non-significant) are shown in Table 4.

Table 2: Bivariate analysis of salivary flow (saliva amount) and the independent variables included in the study (n = 139)

	Quantity, mL/min (media)	*p*-value	Multiple comparison
Gender			
Male	0.94 ± 1.03 (0.60)	z = 0.861*	
Female	0.66 ± 0.67 (0.56)	*p* = 0.3892	
Age (year)			
60 to 74	0.70 ± 0.61 (0.64)		
75 to 84	0.68 ± 0.72 (0.50)	X^2 = 0.336†	
85 and older	0.86 ± 1.04 (0.61)	*p* = 0.8456	
Marital status			
Single	0.71 ± 0.77 (0.53)		
Married/common-law union	0.76 ± 0.65 (0.60)	X^2 = 0.582†	
Divorced/widowed	0.78 ± 0.90 (0.56)	*p* = 0.7474	
Social security recipient			
Yes	0.77 ± 0.76 (0.60)	z = 1.199*	
No	0.73 ± 0.84 (0.50)	*p* = 0.2306	
Maximum level of schooling			
Elementary school and more	0.68 ± 0.55 (0.60)	z = 0.466*	
Less than elementary school	0.78 ± 0.91 (0.57)	*p* = 0.6410	
Type of senior organization			Adjusted *p*-value for
Public	0.66 ± 0.79 (0.42)		significance is 0.0083
Private	0.92 ±1.03 (0.70)	X^2 = 8.478†	
Day care	0.83 ± 0.43 (0.74)	*p* = 0.0144	
Has received radiation			1 *vs* 3 = 0.0039
No, never	0.74 ± 0.80 (0.57)	z = -0.826*	
Yes, some time	0.99 ± 0.85 (0.80)	*p* = 0.4088	
Tobacco use			
No	0.77 ± 0.83 (0.60)	z = 0.983*	
Yes	0.62 ± 0.65 (0.41)	*p* = 0.3254	
Regular soda use			
Yes	0.62 ± 0.59 (0.57)		
Sometimes	0.88 ± 0.97 (0.57)	X^2 = 1.076†	
No	0.73 ± 0.80 (=.56)	*p* = 0.5838	
Chronic diseases			
None	0.72 ± 0.75 (0.50)		
Diabetes with/without other	0.79 ± 0.58 (0.70)		
Hypertension with/without other	0.73 ± 0.52 (0.62)		
Diabetes with hypertension	0.52 ± 0.49 (0.50)	X^2 = 1.854†	
Others	0.79 ± 0.97 (0.57)	*p* = 0.7625	
Tooth brushing			
Less than twice/day	0.63 ± 0.69 (0.50)	z = -2.382*	
Two or more times/day	0.96 ± 0.95 (0.73)	*p* = 0.0172	
Number of missing teeth		X^2 = 12.038†	Adjusted *p*-value for
From 0 to 10	1.02 ± 0.99 (0.75)	*p* = 0.0024	significance is 0.0083
From 11 to 20	0.96 ± 0.98 (0.66)	z = -3.40‡	1 *vs* 3 = 0.0015
From 21 to 28	0.55 ± 0.56 (0.43)	*p* = 0.001	2 *vs* 3 = 0.0051
Dental status			Adjusted *p*-value for
Edentulous with prosthesis	0.76 ± 0.62 (0.61)		significance is 0.0025
Lost teeth with prosthesis	0.75 ± 0.56 (0.66)		
Edentulous without prosthesis	0.36 ± 0.38 (0.33)		2 *vs* 3 = 0.0016
Lost teeth (< 21) without prosthesis	1.10 ± 1.20 (0.75)	X^2 = 16.248†	3 *vs* 4 = 0.0003
Lost teeth (> 20) without prosthesis	0.48 ± 0.61 (0.29)	*p* = 0.0027	

*Mann-Whitney test, †Kruskal-Wallis test, ‡Non-parametric tendency test

Table 3: Bivariate analysis of salivary pH and independent variables included in the study (n = 117)

	pH	*p*-value
Gender		
Male	7.80 ± 1.02	z = -0.408*
Female	7.92 ± 0.75	*p* = 0.6831
Age (year)		X^2 = 3.564†
60 to 74	7.76 ± 0.91	*p* = 0.1683
75 to 84	7.86 ± 0.67	z = 1.71‡
85 and older	8.04 ± 0.89	*p* = 0.087
Marital status		
Single	7.89 ± 0.73	
Married/common-law union	7.92 ± 0.61	X^2 = 0.170†
Divorced/widowed	7.86 ± 0.98	*p* = 0.9184
Social security recipient		
Yes	7.89 ± 0.65	z = -1.118*
No	7.87 ± 0.98	*p* = 0.2637
Maximum level of schooling		
Elementary school and more	7.82 ± 0.81	Z = -0.898*
Less than elementary school	7.92 ± 0.85	*p* = 0.3692
Type of senior organization		
Public	7.71 ± 0.96	
Private	8.23 ± 0.59	X^2 = 10.099†
Day care	7.96 ± 0.52	*p* = 0.0064
Has received radiation		
No, never	7.88 ± 0.84	z = 0.263*
Yes, some time	7.90 ± 0.61	*p* = 0.7927
Tobacco use		
No	7.88 ± 0.82	z = -0.106*
Yes	7.86 ± 0.93	*p* = 0.9158
Regular soda use		
Yes	7.84 ± 1.05	
Sometimes	7.95 ± 0.82	X^2 = 1.972†
No	7.84 ± 0.60	*p* = 0.3731
Chronic diseases		
None	7.88 ± 0.77	
Diabetes with/without other	7.96 ± 0.58	
Hypertension with/without other	7.74 ± 1.05	
Diabetes with hypertension	8.08 ± 0.63	X^2 = 0.866†
Others	7.90 ± 0.86	*p* = 0.9294
Tooth brushing		
Less than twice/day	7.83 ± 0.95	z = -0.367*
Two or more times/day	7.96 ± 0.61	*p* = 0.7136
Number of missing teeth		X^2 = 1.269†
From 0 to 10	8.03 ± 0.66	*p* = 0.5301
From 11 to 20	7.99 ± 0.53	z = -1.10
From 21 to 28	7.75 ± 1.02	*p* = 0.270
Dental status		
Edentulous with prosthesis	7.77 ± 0.94	
Lost teeth with prosthesis	7.96 ± 0.56	
Edentulous without prosthesis	7.71 ± 1.19	
Lost teeth (< 21) without prosthesis	8.05 ± 0.62	X^2 = 2.275†
Lost teeth (> 20) without prosthesis	7.55 ± 1.22	*p* = 0.6854

*Mann-Whitney test, †Kruskal-Wallis test, ‡Non-parametric tendency test

Table 4: Bivariate analysis of salivary buffer capacity and the independent variables included in the study (n = 117)

	Buffer	*p*-value
Gender		
Men	4.21 ± 1.26	z = 0.033*
Women	4.18 ± 1.23	*p* = 0.9737
Age (year)		
60 to 74	4.04 ± 1.27	
75 to 84	4.26 ± 1.09	X^2 = 1.400†
85 and older	4.28 ± 1. 35	*p* = 0.4966
Marital status		
Single	4.37 ± 1.28	
Married/common-law union	4.35 ± 1.09	X^2 = 3.009†
Divorced/widow	3.99 ± 1.25	*p* = 0.2222
Social security recipient		
Yes	4.05 ± 1.11	z = -1.058*
No	4.33 ± 1.34	*p* = 0.2902
Maximum level of schooling		
Elementary school and more	4.01 ± 1.19	z = -1.170*
Less than elementary school	4.31 ± 1.26	*p* = 0.2419
Type of senior organization		
Public	3.85 ± 1.07	
Private	4.75 ± 1.52	X^2 = 10.250†
Day care	4.49 ± 1.03	*p* = 0.0059
Has received radiation		
No, never	4.19 ± 1.23	z = -0.094*
Yes, some time	4.24 ± 1.51	*p* = 0.9248
Tobacco use		
No	4.30 ± 1.24	z = 2.365*
Yes	3.59 ±1.05	*p* = 0.0181
Regular soda use		
Yes	4.05 ± 1.12	
Sometimes	4.36 ± 1.36	X^2 = 0.810†
No	4.14 ±1.21	*p* = 0.6669
Chronic diseases		
None	4.35 ± 1.11	
Diabetes with/without other	4.74 ± 0.97	
Hypertension with/without other	3.91 ± 0.92	
Diabetes with hypertension	4.32 ± 1.32	X^2 = 5.098†
Others	4.08 ± 1.42	*p* = 0.2773
Tooth brushing		
Less than twice/day	4.21 ± 1.27	z = 0.305*
Two or more times/day	4.16 ± 1.19	*p* = 0.7601
Number of missing teeth		X^2 = 5.512†
From 0 to 10	4.71 ± 1.34	*p* = 0.0636
From 11 to 20	4.28 ± 1.23	z = -2.34‡
From 21 to 28	3.94 ± 1.15	*p* = 0.019
Dental status		
Edentulous with prosthesis	4.22 ± 1.19	
Lost teeth with prosthesis	4.22 ± 1.19	
Edentulous without prosthesis	3.57 ± 1.02	
Lost teeth (< 21) without prosthesis	4.53 ± 1.38	X^2 = 6.903†
Lost teeth (> 20) without prosthesis	3.89 ± 1.14	*p* = 0.1411

*Mann-Whitney test, †Kruskal-Wallis test, ‡Non-parametric tendency test

In correlation analyses, we observed modest associations between the salivary flow and pH (r = 0.2475, p = 0.0071), salivary flow and buffer capacity (r = 0.3900, $p <$ 0.0001) and between pH and buffering capacity (r = 0.4241, $p < 0.0001$). In this study, no differences were observed in salivary parameters and medication use ($p > 0.05$).

DISCUSSION

The present manuscript characterized chewing-stimulated salivary flow, pH and buffer capacity in a group of elderly Mexicans, showing that there are some changes that may be associated with certain clinical, socio-economic and behavioural variables. These features are useful as adjuncts in the diagnosis of various oral and systemic diseases and

therefore the information has clinical value from a dental practice perspective (15). Salivary flow varies according to the different parts of the mouth where it is measured, and also between persons and across different biological situations. A number of studies that focussed on salivary flow evaluation revealed wide variations between individuals from different origins. For example, in Greek adults, the average was 1 to 4.1 mL/minute [mean 2.2] (16). In Japanese adults 60 years old and older, it was 1.36 mL/minute (17), higher than the mean value we found, which was 0.75 ± 0.80 mL/minute. Our values were similar to those reported in Brazil, which was 0.78 mL/minute (18), but lower than the 0.67 reported in Spain (19). For our study subjects in whom pH could actually be calculated, the mean was 7.88 ± 0.83, higher than the values observed in Brazilian subjects, which was 7.0 (18) and Venezuelan subjects, which were 6.5 (20) or 7.05 (21). The buffer capacity reported in our study was 4.20 ± 1.24, similar to that found in study subjects in Chile, which was 4.15 (22), but lower than the values observed in Brazilian subjects, which was 3.7 (18). These differences may be due to the age of the subjects in the samples, the ethnic group, the methodology used for collecting and measuring saliva, or the type of subjects studied – community living individuals, or patients.

An association between salivary flow and the number of teeth present in the mouth has been documented in other studies. Sawair *et al* (23) conducted a study among adults in Jordan and found that the greater the number of missing teeth, the lower the salivary flow. In a study conducted in Japan (17), they observed that a greater number of teeth in the mouth was directly associated with salivary flow. Our results are consistent with both studies. Although not explicitly studied, we observed that when missing teeth were replaced through prostheses, salivary flow was higher. It has been suggested that both chewing and biting force are involved in salivary gland secretion (17); this link has been documented in experimental studies in which periodontal mechanic receptor activation leads to salivary flow increase (24). It is possible that there is an increased stimulation in subjects with more natural or prosthetic teeth, apparently confirmed by the results of this study. Although the buffer capacity in relation to the number of teeth present was not specifically addressed in the present research, we also observed that the higher the number of missing teeth, the lower the buffer capacity values.

Hoek *et al* (25) demonstrated that salivary flow increased 15% after tooth brushing. A study conducted in Japan (26) observed that tooth brushing increased the secretion of the parotid gland, probably *via* the activation of periodontal mechanoreceptors. In another study (27), tooth brushing increased the production of saliva in patients affected by xerostomia. Our results are consistent with these findings.

Although the impact of variables other than biologic or physiologic factors on salivary flow has been sparsely studied, we observed that a socio-economic indicator appeared to be related: elders living in the public retirement home had lower salivary flow. Conversely, elders living in private retirement home (presumably with higher socio-economic background, a reasonable assumption for the location in which the study was conducted) showed higher pH readings and buffer capacity that those in the public retirement home. In the health literature, it has been documented that the economic position of an individual in a society is generally a strong predictor of both morbidity and mortality: generally, individuals with better socio-economic status have better health conditions (28). The exact mechanism by which health and socio-economic status are associated is not very clear, because this variable is a multidimensional construct (29). However, Krieger (30) introduced the concept of "biological expression of social inequality", which refers to how people biologically incorporate and express their experiences of economic and social inequality, from *in utero* to death, thereby manifesting social inequalities across a wide range of health aspects. Future research ought to specifically address the individual contributing impacts in relation to the salivary parameters studied.

Our results did not confirm a significant association of salivary flow for age, gender, or other relevant variables, such as receiving therapeutic radiation, of having chronic diseases, as has been documented in other studies (17, 31). It may be that the size of the population under study did not allow sufficient power to detect such differences, although trends often were in the directions reported in the literature.

Although several studies have reported variation between tobacco smokers and non-smokers, our results were not consistent in terms of salivary flow and pH. However, they were consistent with other studies concerning buffer capacity. As in the present study, a study conducted in Poland (32) in middle-aged adults found that smokers had significantly lower buffer capacity than non-smokers. Similar results were observed in Sweden by Wikner and Söder (33).

Finally, our findings replicated other studies (6, 34) in that they found a correlation between these three salivary parameters, suggesting mutual impact on each other. Monitoring some of the clinical characteristics of saliva (flow, pH and buffer capacity) could be an important step in the oral healthcare of older adults, since abnormal readings could suggest oral or systemic diseases. As with other biological measurements, it is necessary to first establish what the normal ranges of such salivary characteristics are in the Mexican population. The present study has reported some of the first data relevant to this group.

The present study has some limitations so its interpretation should be cautious and its design, that of a cross-sectional study, is affected by temporal ambiguity. The cause and the effect were measured at the same time. For this reason, causal relationships could not be established, but rather associations only.

Based on these exploratory data, we suggest that the three salivary characteristics (salivary flow rate, pH and buffering capacity) studied in this group of Mexican elderly subjects varied in relation to selected socio-economic, clinical, and behavioural variables. Sociodemographic variables such as age and gender had no discernible effect on the parameters studied.

DISCLOSURE STATEMENT

No potential conflicts of interest were disclosed.

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