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Ramírez-Ortiz, Guadalupe; Caballero-Hoyos, Ramiro; Ramírez-López, Guadalupe; Valente, Thomas W

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The effects of social networks on tobacco use among high-school adolescents in Mexico

Guadalupe Ramírez-Ortiz, D CS,[1] Ramiro Caballero-Hoyos, D CS,[2]
Guadalupe Ramírez-López, D C,[3] Thomas W Valente, PhD.[4]

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Abstract

Objective. To identify the effect of centrality in social network positions on tobacco-use among high-school adolescents in Tonala, Jalisco, Mexico. **Materials and methods**. Longitudinal sociometric social network data were collected among 486 high-school adolescents in 2003 and 399 in 2004. The survey included: social network components, smoking and sociodemographic characteristics. Social network measures of centrality were calculated and multivariate logistic regression was used. **Results**. Ever used tobacco (OR= 44.98), marginalized-low stratum (OR= 2.16) and in-degree (OR=1.10) predicted tobacco use. Out-degree (OR= 0 .89) and out-in-degree (OR= 0.90) protected against tobacco use. **Conclusion**. Nominating more friends rather than receiving such nominations was protective for tobacco use. Popular students, those receiving many nominations, were at higher risk for tobacco use. Involvement of leaders with capacity to influence might be an efficient strategy for dissemination of preventive messages.

Keywords: social networks; tobacco use; adolescents; centrality; friendship; peer pressure

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Resumen

Objetivo. Identificar el efecto de posiciones de centralidad de la red social sobre el uso de tabaco en adolescentes de preparatoria en Tonalá, Jalisco. **Material y métodos**. Estudio longitudinal de redes sociales sociométricas. Participaron 486 bachilleres (2003) y 399 (2004). La encuesta incluyó: componentes de redes sociales, tabaquismo y características sociodemográficas. Se calcularon medidas de centralidad de redes sociales y utilizó regresión logística multivariada. **Resultados**. El consumo alguna vez de tabaco (RM= 44.98), estrato socioeconómico marginado-bajo (RM= 2.16) y vínculos recibidos (RM=1.10) predijeron el tabaquismo; mientras que los vínculos enviados (RM= 0.89) y la diferencia entre vínculos enviados y recibidos (RM= 0.90) protegieron contra el tabaquismo. **Conclusión**. Nombrar más amigos que ser nombrado por otros protegió contra el tabaquismo. Los estudiantes populares, aquellos con muchos nombramientos, tuvieron mayor riesgo de ser consumidores. La inclusión de líderes con influencia podría ser una estrategia eficiente en la diseminación de mensajes preventivos.

Palabras clave: redes sociales; uso de tabaco; adolescentes; centralidad; amistad; presión de pares

(1) Centro de Seguridad Social Manzanillo, Instituto Mexicano del Seguro Social. Colima, Mexico.
(2) Unidad de Investigación en Epidemiología Clínica, Instituto Mexicano del Seguro Social. Colima, Mexico.
(3) Unidad de Investigación Epidemiológica y Servicios de Salud del Adolescente, Instituto Mexicano del Seguro Social. Jalisco, Mexico.
(4) Department of Preventive Medicine, Keck School of Medicine, University of Southern California. USA.

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Corresponding author: Dra. María Guadalupe Ramírez-Ortiz. Centro de Seguridad Social Manzanillo, Instituto Mexicano del Seguro Social. Av. Tonalá 121. 45400 Tonalá, Jalisco, México.
E-mail: ishaoro@hotmail.com

Tobacco use is a significant public health problem for adolescents. Among Mexican adults, tobacco use causes more than 60 000 deaths and generates multiple chronic diseases annually.[1] The National Addictions Survey in Mexico[2] showed that 8.9% of adolescents were active smokers in 2002, and 8.8% in 2008.[3] The Junior and Senior High-School Student Survey in Mexico City reported "ever in your life" tobacco use in boys was 51.1% in 2003 and 47.6% in 2006, while prevalence for girls was 50.1% and 49.4% for the same years. Moreover, "current use" in boys fell from 23.4% in 2003 to 19.7% in 2006 and from 22.2% to 16.4% in girls.[4,5]

An important factor associated with adolescent's smoking is having friends that smoke.[6] To understand factors associated with adolescent tobacco use, social-network methods were used to measure an adolescent's position in the social network. Social network methods can be used to measure social relations and interactions that influence tobacco use.[7-9] Also, it is a useful guide for the development of interventions for prevention and treatment of addictions.[10-12] The social network model is based on relationship systems and communications. The basic data for analysis are the links between nodes (or actors). Studies of social network analysis on smoking have been analyzed from two perspectives: 1) social influence from others derived from group interaction[13] or sociometric positions[14] and 2) actor centrality.[15,16] Social influence studies have repeatedly documented that being exposed to smokers increases smoking risk. In addition, studies have shown that tobacco use was higher among students having links with group members, being group members, liaisons,[17,18] dyads,[14] or even being isolated.[13,14,19] In one notable 32-year cohort study, smokers were increasingly moved to the periphery of the social network, whereas non-smokers moved to the center.[20]

Perhaps the most common indicator extracted from social network data is centrality. The term "centrality" is restricted to the idea of "central actor". It indicates positions in which actors occupy a prominent place or strategic position in the network.[21] Central people may have a greater influence on the opinions and behaviors of others and at the same time may be influenced by others in the network.[22] In this regard, central people can induce the persuasive influence of other peers by signaling cultural acceptability for the behavior.[10]

Centrality, measured as the frequency a person was named as a peer, has been associated with substance use. Valente[23] reviewed studies on the effect of school-based social networks on substance use and found that use is the result of the interaction among peers and their degree of centrality.[24] In this interaction, peer influence[24] and the normative effect of substance-using friends and close relatives were important.[25] Another network study considered two different definitions of centrality: popularity, or the number of friendship nominations received from others (in-degree) and expansiveness, or the number of friendship nominations sent to others (out-degree).[15] The study showed that popular people were more likely to be and to become smokers.[16] Some studies have found an effect of centrality measurements (in-degree, betweenness and Bonachich power centrality) on psychoactive drugs use.[26]

Whether the effect of centrality measurements such as out-in-degree and out-in-closeness may explain this relationship has not been evaluated. The aim of this study was to identify the effect of central positions (in- and out-degree, in- and out-closeness, out-in-degree and out-in-closeness) in social networks on current tobacco use among students of a high-school. The findings will provide information for planning strategies for the prevention of tobacco use.

Material and Methods

Study design and sample: A longitudinal study was conducted in order to collect sociometric social network data[21] in one high-school in Tonalá, Jalisco, Mexico. Tonalá is located in the Guadalajara metropolitan area but some semi-urban traits persist and the lowest strata of the social pyramid predominate. Tonalá High-school had a student body of 2,650 students in 2003, and 2,702 in 2004, from first to sixth semester. From June to July 2003, a total of 490 students from first and second semester were invited to participate in the study. Of them, 486 (99.2%) accepted and 399 were followed-up in 2004.

Procedures: School officials and students gave their written consent. The project was approved by the Local Health Research Committee at the Mexican Social Security Institute.

At the time frame of the study, school regulations prohibited smoking

A self-administered questionnaire was applied at baseline (June 2003) and approximately one year later (May 2004).

Variables: Tobacco use was measured with the following questions: have you ever smoked? (yes/no) and do you smoke currently? (yes/no).

Social network data were collected by asking for the name and sex of each person's six best friends in the school, and communication frequency according to the Pearson and Michell[13] format. Social network indicators included:

Density (D): number of links in the total networks, expressed as a proportion of the maximum number of possible relationships within the networks. Density formula is $l/n\ (n\text{-}1)/2$ where n is the number of nodes (students) and l the number of lines present.[21]
Subgroup density: proportion of connections between actors of an asymmetric valued matrix that share an attribute.[27]

Centrality measurements proposed by Freeman[28] and Valente[29] were calculated and included in-degree, out-degree, in-closeness and out-closeness. Also, two variables of difference were generated: out-in-degree (difference between out-degree and in-degree) and out-in-closeness (difference between out-closeness and in-closeness). Measurement's definitions are described in Table I.

Peer pressure was defined as the subjective experience of feeling encouraged by people of one's own age to do certain things regardless of whether one wants to do them.[30] The measure included 11 items with a 5-point scale ranging from "strongly disagree" to "strongly agree".

Socioeconomic stratum was evaluated according to Basic Geostatistical Areas

Statistical Analysis: Social network structure analysis was performed using NetMiner II 2.4.0.* Chi-square tests were calculated to evaluate prevalence changes

* Cyram NetMiner II: Software for network analysis 2.4.0. Seoul: Cyram Co, Ltd., 2004.

Table I
CENTRALITY MEASUREMENTS

Undirected measurement	*Directed measurement*
Degree Is characterized as a local centrality measure because it can be calculated without reference to the overall structure of the network. Is the number of links to- and from a person. Measures communication activity.	In-degree Number of ties a person receives. Identifies opinion leaders in social networks and popularity in friendship networks. Indicates influence as that is who might try to influence a person. Useful to measure social integration. People with a high value can be recruited to establish a critical mass in favor of a new behavior because they are role models for many people. Out-degree Number of ties sent to others. Represents selection as it indicates whom they select as friends and measures a person's socialness or sociality. Out-in-degree* Difference between out-degree and in-degree. A high value represents a person that has more connections to friends than receiving these connections from friends. Indicates a person who is more sociable than popular.
Closeness Measures the average distance a node is from all other nodes in the network. Someone who is closer to everyone else, on average, is in a central position. Measures the independency or efficiency of communication.	In-closeness Measures the links directed to a person. Is the shortest path that friends go through to reach a specific friend. The highest value represents a person that others can reach in the fewest number of steps to him/her. People with a high value can be recruited to ensure diffusion spreads to the maximum number of people. Out-closeness Is the shortest path an actor goes through to reach his or her friends. The highest out-closeness is the person who can reach others in the fewest number of steps. Out-in-closeness* Difference between out-closeness and in-closeness. Is an actor closer to his/her friends than these are to the actor. A high value represents a person that is closer to their friends than they with him.

Adapted from Freeman L, 1979[28] & Valente TW, 2010[29]
* Variables were generated for the present study

and logistic regression to evaluate associations. The dependent variable was current tobacco use in 2004 and the independent variables were the centrality measurements in 2003 (in-degree, out-degree, in-closeness, out-closeness, out-in-degree and out-in-closeness), peer pressure in 2003, ever tobacco use, occupation, age in 2003, socioeconomic stratum, and sex. A Hosmer-Lemeshow test was used to evaluate goodness-of-fit. Multicollinearity was not observed (variance inflation factor < 2.0 in both models). Statistical analyses were performed with SPSS 15.0 and Stata 9.0.

Results

At baseline (2003), 486 (of 490, 99.2%) freshmen high-school students participated in the study. The baseline refusal rate was less than 1.0%. After one-year (2004), 399 (of 486, 82.1%) students were followedup. Attrition was due to students exclusion due to failing grades or school absenteeism (78 or 89.6%), and voluntary withdrawal from school (9 or 10.3%).

There were no attrition differences by sex and socioeconomic level in the follow-up; however, greater attrition was observed in students working and studying (31.0%) in comparison with those that remained in the study (21.2%, $p= 0.036$). There was greater baseline ever tobacco use (63.5%) among those lost to follow-up than those who remained in the study (46.4%, $p= 0.003$). In-degree of those who withdrew from the study was lower (7.29), than among those who remained (8.60, $p= 0.025$).

The mean age at baseline was 15.7 years (15-19 years), whereas for the follow-up, it was 16.6 years (15-19 years). The increase of students working and studying was 15.1% ($p < 0.010$).

Current tobacco use was 9.5% at baseline and 13.8% at follow-up, an increase of 4.3 percentage points ($p= 0.029$). Tobacco ever use was 49.4% at baseline, 49.9% at follow-up (0.5 percentage points increase, not statistically significant).

Changes in current tobacco use by socio-demographic variables during follow-up are shown in Table II.

Overall network density means increased from 0.011 ± 0.14 to 0.015 ± 0.16 (in 2004), indicating that 1.1% of all possible connections among network members existed during the first year, and 1.5% in the second. Table III reports sub-group density rates in 2003 and 2004 indicating that densities were greater within homogeneous groups (smokers or nonsmokers only) than among heterogeneous groups (smokers-nonsmokers and nonsmokers-smokers). The differences of density among smokers and nonsmokers in both years were statistically significant.

Peer pressure was higher among smokers both years. At one year of follow-up there was a reduction of 5.37 among non-smokers ($p< 0.001$). Smokers had a lower out-degree in comparison with non-smokers at baseline, however at year two it was the opposite ($p= 0.014$) and an increase of 0.63 was found among non-smokers ($p= 0.013$). Smokers had a higher in-degree in comparison with non-smokers at baseline; this was the opposite in the second year ($p= 0.018$) with a 0.78 among non-smokers ($p= 0.013$).

Non-smokers had a higher out-closeness in both measurements; only in 2003 there was a difference ($p < 0.001$). At follow-up there was an increase of 2.57

Table II
Change in current tobacco use by socio-demographic variables, 2003-2004

Variables	Tobacco use 2003 (N = 486) n	%	2004 (N = 399) n	%	Difference over time %	P value
Sex						
Male	25	12*	22	13	+1	0.455
Female	21	7	33	14	+7	0.011
Occupation						
Works and studies	15	13	32	21*	+8	0.072
Only studies	31	8	23	9	+1	0.407
Socioeconomic Stratum						
Margininalized-Low	33	10	32	11*	+1	0.487
Middle	13	9	23	19	+10	0.016

* p value < 0.05, Chi-square test of differences

among smokers (p= 0.021). In-closeness was higher in non-smokers in both measurements with an increase of 2.46 at follow-up (p= 0.001). At baseline the out-in-degree was lower among smokers (p= 0.005). However, at follow-up it was higher, with an increase of 3.96 (p= 0.011). At both times non-smokers had higher out-in-closeness with a reduction of 1.96 in average (p= 0.016) (Table IV).

Models of centrality positions associated with current tobacco use are shown in Table V. In the first model, in-degree, out-degree, in-closeness and out-closeness were evaluated. Tobacco ever use in 2003 and

Table III
TOBACCO USE SUBGROUP DENSITIES BY YEAR

	Current tobacco use					
	2003 (N = 486)			*2004 (N = 399)*		
Current tobacco use	*No*	*Yes*	*P value*	*No*	*Yes*	*P value*
	N = 440	*N = 46*		*N = 344*	*N = 55*	
No	0.012	0.011	0.027	0.016	0.009	0.001
Yes	0.008	0.015		0.010	0.036	

N: Number of nodes (students)
p value: Chi-square permutation test

Table IV
CHANGE IN THE TIME OF PEER PRESSURE PERCEPTION AND CENTRALITY POSITIONS ACCORDING TO CURRENT TOBACCO USE, 2003-2004

		2003 (N = 486)			*2004 (N = 399)*			*Differences (N = 379)*[§]		
Variables		χ	*S.D.*	*P**	χ	*S.D.*	*P**	χ	*S.D.*	*P*[‡]
Social influence perception										
Peer pressure	Yes	29.89	5.39	0.469	26.26	8.20	0.041	-1.52	11.28	0.563
No		29.30	5.18		23.78	8.00		-5.37	9.70	0.000
Centrality positions differences										
Out-degree	Yes	7.74	5.06	0.264	7.72	3.66	0.014	-1.40	5.84	0.337
No		8.46	3.67		9.25	4.25		+0.63	4.51	0.013
In-degree	Yes	9.68	5.65	0.074	7.55	4.19	0.018	-2.56	5.32	0.064
No		8.28	4.48		9.27	5.04		+0.78	5.66	0.013
Out-closeness	Yes	6.41	3.70	0.000	7.93	4.24	0.074	+2.57	4.15	0.021
No		9.24	4.66		9.77	7.32		+0.49	7.63	0.246
In-closeness	Yes	10.77	8.17	0.677	13.70	8.44	0.875	+2.19	11.38	0.438
No		11.38	9.04		13.95	11.14		+2.46	12.81	0.001
Out-in-degree	Yes	-1.94	4.65	0.005	0.17	3.83	0.761	+3.96	5.72	0.011
No		0.17	4.39		-0.03	4.49		-0.15	5.23	0.592
Out- in-closeness	Yes	-4.34	6.65	0.159	-5.78	7.97	0.353	+0.37	9.32	0.871
No		-2.15	9.37		-4.18	12.08		-1.96	14.52	0.016

* Independent-samples *t* test
‡ Paired-samples *t* test according to current tobacco use category (yes/no)
§ Analysis excluded those adolescents who initiated smoking or quitted smoking in 2004

Table V
Factors associated with current tobacco use at follow-up

Prediction factors			*Model 1*		*Model 2*	
	*OR**	*CI 95%*	*AOR‡*	*CI 95%*	*AOR‡*	*CI 95%*
Tobacco ever used 2003						
No§	1.00		1.00		1.00	
Yes	27.49	8.42, 89.83#	42.55	9.83, 184.21#	44.98	10.43, 194.16#
Social influence perception:						
Peer pressure 2003	1.01	0.95, 1.06	0.98	0.91, 1.05	0.98	0.91, 1.05
Centrality positions :						
Out-degree 2003	0.94	0.86, 1.02	0.89	0.80, 0.99#	–	–
In-degree 2003	1.06	1.00, 1.13	1.10	1.01, 1.19#	–	–
Out-closeness 2003	0.88	0.88, 0.95#	0.94	0.86, 1.03	–	–
In-closeness 2003	0.99	0.95, 1.03	0.99	0.95, 1.04	–	–
Out-in-degree 2003	0.89	0.84, 0.97#	–	–	0.90	0.83, 0.97#
Out-in-closeness 2003	0.98	0.95, 1.01	–	–	1.00	0.96, 1.04
Sociodemographics:						
Age 2003	1.30	0.90, 1.87	1.05	0.66, 1.66	1.05	0.66, 1.66
Sex						
Female§	1.00		1.00		1.00	
Male	0.95	0.54, 1.70	1.81	0.81, 4.05	2.12	0.97, 4.60
Occupation 2003						
Only studies§	1.00		1.00		1.00	
Works and studies	0.68	0.35, 1.29	1.26	0.55, 2.90	1.18	0.52, 2.69
Socioeconomic Stratum						
Middle§	1.00		1.00		1.00	
Marginalized-Low	1.62	0.90, 2.91	2.01	0.95, 4.25	2.16	1.04, 4.48#
Hosmer & Lemeshow Adjustment Likelihood Test			χ^2 =7.65; p = 0.47		χ^2 = 9.64; p = 0.29	

* OR= Crude odds ratio
‡ AOR= Adjusted odds ratio
§ Reference category
# *p* value < 0.05

in-degree were associated with current tobacco use in 2004 (OR= 42.55 and OR= 1.10, respectively). In contrast, out-degree was a protective factor for current tobacco use in 2004 (OR= 0.89). In the second model, out-in-degree and out-in-closeness were evaluated. Variables associated with tobacco use in 2004 were: tobacco ever use in 2003 (OR= 44.98), marginalized-low stratum (OR= 2.16) and out-in-degree (OR = 0.90).

Discussion

Having more nominations to peers (out-in-degree) rather than receipt of these nominations was a protective factor for tobacco use. In addition, simply as naming a high number peers (out-degree) was also protective for tobacco use. On the other hand, being named by peers (in-degree) was a risk factor to becoming a smoker. The protective effects of naming

peers indicates that being integrated into school-based friendship networks at this developmental stage has benefits for avoiding risky behavior. Conversely, the positive in-degree association indicates that popular students have a greater probability of becoming smokers. This indicates that current tobacco use is popular; therefore, widespread use is expected in this student social network in the future.

Results for out-in-degree related to tobacco consumption have not been reported before, and indicate that the difference between naming friends and being named may be an important indicator for social position that has an influence on risk behavior.

Our results about in-degree related to tobacco use are similar to findings reported by others.[15,16] Valente and others found that students who were popular in the sixth and seventh grades in the US had greater probability of becoming smokers than less popular ones. Moreover, popular students at schools with high tobacco-use prevalence were more at risk to smoke; this indicates that tobacco use can be attributable to the students' position in the network structure to the extent that position indicates the person's power and susceptibility of being influenced,[15,16] or the process of selecting peers with attributes similar to oneself.[31] In this regard, a popular person is one who receives connections or friendship nominations and is a vertex of high in-degree.[32,33] In a cohort study, smokers moved to the network periphery perhaps due to the advent of public health campaigns against tobacco consumption and rise in anti-tobacco norms.[34] Using networks sociometric positions, smoking was higher among dyads and isolates and it was lower among highercategories of popularity. Maybe, in these instances, cohesive groups applied peer pressure in the opposite direction to enforce non-smoking behavior.[14]

Our results about marginalized-low stratum related to tobacco use are similar to others. These studies demonstrated differential tobacco consumption according to socioeconomic strata, with a significant association with the consuming peer's normative influence.[35,36]

Subgroup density results show that there are subgroups of smokers and nonsmokers within the student network, allowing for the hypothesis that greater cohesion among current tobacco consumers over time suggests that dense social ties can reinforce the use norm over time.[26] This hypothesis also suggests an interaction context in which mutual influence may occur that favors use[6] leading to the formation of subcultures in which tobacco use is a part of their identity. This may influence adolescents in the group to have access to cigarettes, to approve use, and to have mutual emotional support, not unlike that which occurs with other substances.[26,37] The subculture may also contribute to the development of other risk behaviors.[38]

Ever tobacco use predicted a greater risk of current tobacco use. Ever users were more likely to be lost to followup. It is possible that a higher current tobacco use in the follow-up measurement might have increased the associations we find between current tobacco use and centrality since in-degree was also associated with loss to follow-up. Current tobacco-use prevalence in this study was greater than national prevalence[2,3] and less than current-use prevalence among Mexico City high-school students[4,5] which can be explained to the fact that use is greater among youth in contexts of greater urban development.

Limitations: attrition was caused mainly by student dropouts, which was not possible to control. Also, it was not practical to follow-up adolescents who did not remain in the study, since they were no longer exposed to the student network. Attrition in the follow-up is accompanied by differences in in-degree and tobacco-ever-used participants who remained in the study and those who did not, which may cause a selection bias.[39] Also, smoking, in our study, was defined as current tobacco use, while others consider it as smoking at least one cigarette every day in the past 30 days. In our case, as stated by others, we considered that any use is abuse.[40]

The findings of this study describe the formal student network structure that could be complemented by exploring the possible influence of networks outside the school such as the family,[41,42] and neighborhood friends.[34,43,44] It would also be worthwhile to analyze the formation of subgroups by use patterns: light smoker, moderate smoker, and heavy smoker.[2]

Naming more friends was protective for use whereas being named as a friend increased use indicating that smoking may become a shared norm and spread throughout the entire student network over time. Therefore, educational and health promotion programs should prevent initiation into tobacco use and look for strategies to stop the spread of the normative tobacco-use culture. To stop and prevent tobacco use effectively, popular tobacco-consuming students should be convinced and integrated so they will support antismoking norms just as programs need to create a cultural climate where smoking is not perceived as something desirable.[14]

Although our results show that popular students have a higher probability of smoking, this position has been used in interventions to reduce tobacco consumption. Opinion leaders are selected based on in-degree position because they have a prominent position in social networks structure, and may influence towards healthy behaviors.[29] In these interventions opinion leaders are trained to direct educative interventions at the informal interactions with their peers.[10-12] Also, recently approved Mexican regulations restrict tobacco use in public places, and favor non-smoking promotion in schools, which we hope will contribute to a more effective control.

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