2023

Ethnic variations in the association between obstructive sleep apnea and tooth loss

BOSTON UNIVERSITY

HENRY M. GOLDMAN SCHOOL OF DENTAL MEDICINE

THESIS

ETHNIC VARIATIONS IN THE ASSOCIATION BETWEEN OBSTRUCTIVE SLEEP APNEA AND TOOTH LOSS

by

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B.D.S Himachal Pradesh University 2020

Submitted in partial fulfillment of the

requirements for the degree of

Master of Science in Dentistry in the Department of
Health Policy and Health Services Research
2023

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DEDICATION

I would like to dedicate this work to my Grandparents Mrs. Beant Virk, Mr. Hardayal Virk and Mrs. Gurlakhwinder Kaur

ACKNOWLEDGMENTS

Countless people supported my effort in this thesis. Professor Elizabeth Kaye and Thayer Scott provided invaluable feedback on my analysis and framing, at times responding to emails late at night and early in the morning. I especially want to thank Robert McDonough for his help in my research project. I would like to thank my thesis committee members for their encouragement to write this thesis which made me confident that the topic was worthy of my investigation—and that my investigation was worthy of the topic.

I am indebted also to several Boston University students. Khuloud Al Mugbel, Fatima Chaudhary, and Roya Yavari who supported me in my research project.

Lastly, my family deserves endless gratitude: my father and uncle Dr. Bobby Virk to support me throughout my studies here at Boston University, my mother, and my brother for encouraging me throughout in my studies during my academic year to my family, I give everything, including this.

ETHNIC VARIATIONS IN THE ASSOCIATION BETWEEN OBSTRUCTIVE SLEEP APNEA AND TOOTH LOSS

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ABSTRACT

Objectives- Obstructive sleep apnea (OSA) is the most prevalent life-threatening sleeping disorder with adverse consequences. Tooth loss is a suggested morphologic risk factor for OSA with a scope of racial variation. The goal of this study is to examine the racial variations that different group experiences for the tooth loss-Obstructive Sleep Apnea relationship.

Methods- A cross-sectional study was done to assess the racial variation for the tooth loss-Obstructive Sleep Apnea relationship using data from the 2005–2006 and 2007–2008 cycles of NHANES. It included the sleep health questionnaire to identify the primary outcome variable, OSA, and received an oral health examination that counted the number of teeth. We chose to explore OSA using the OSA questions and summary OSA variables based on Sanders et al who used the STOP questionnaire including snoring, snorting/gasping daytime sleepiness, and hypertension based on signs and symptoms recommended by the Academy of Sleep Medicine.

Results- Non-Hispanic whites constituted the highest percentage of people with high-risk OSA based on the STOP questionnaire. They had the highest percentage of individuals responding 'yes' to the OSA component questions for snorting/gasping, daytime sleepiness, and having been told by a healthcare professional that they had a sleep disorder. After controlling for potential confounders, in our race/ ethnicity stratified models, Hispanics had lower odds of OSA for each additional tooth present.

Conclusion- OSA is underdiagnosed in the US population, and in a consistent manner across various race categories. Dentists should consider identifying individuals who are currently underdiagnosed or undiagnosed and refer them to a specialist. The effects of tooth loss on OSA are stronger for Hispanics than for other races, hence Hispanics should be targeted since they have the lowest diagnosis rate.

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INTRODUCTION

Obstructive Sleep Apnea (OSA) is the most prevalent and life-threatening sleep disorder, with almost 1 billion people affected globally.[1] OSA is characterized by episodes of the complete or partial collapse of the airway tract and is associated with decreased oxygen saturation and arousal from sleep.[1] The symptoms of OSA include loud snoring, abrupt awakenings during sleep, excessive daytime sleepiness, and difficulty concentrating. OSA is a prevalent disorder with significant adverse consequences.[1] The impacts of this disorder on the individual include fragmented and non-restorative sleep, daytime sleepiness, and many times depression, memory loss, and slower reactions to stimuli.[2] OSA has also been identified as playing a role in traffic collisions and is strongly associated with cardiovascular diseases (like stroke, hypertension, coronary artery disease, and atrial fibrillation) and chronic kidney diseases.[3]

Males have higher chances of developing OSA than women in the US.[11] Other risk factors for OSA include being from a racial minority with higher prevalence reported in Hispanic, Black, and Asian populations in the US.[1] Obese /overweight individuals[4], tobacco smokers [5], and diabetics are also at high risk for developing OSA.

Several morphologic components play a role in OSA. Independent of obesity, excess cervical tissue puts pressure on the pharynx leading to the narrowing of the airway tract.[6] Another OSA risk factor is open-mouth breathing which can narrow the space behind the palate thus further aggravating OSA symptoms.[10]

Tooth loss is a suggested morphologic risk factor because it alters the morphologic appearance of the orofacial region and narrows the airway, reducing airway patency, the vertical and horizontal dimensions of alveolar ridges are decreased, and upward rotation

of the mandible decreases the facial height, reducing overall upper airway space.[6] Complete tooth loss can cause upper airway obstruction during sleep, perhaps by decreasing the retropharyngeal space which elevates oral and exhaled NO concentrations.[26] Another factor may be that wearing dentures may aggravate pharyngeal inflammation caused by repeated airway closure and reopening during OSA.[26] Another study states that tooth loss also leads to disuse atrophy of the masseter muscle and changes the soft tissues of lips and chin, predisposing them to chronic mouth breathing.[6] Collectively these factors predispose people with edentulism to obstructive sleep apnea. However other studies suggest a protective effect for nighttime denture wearing, and it holds the airway open.[26]

One study, Sanders et al, analyzed the relationship between tooth loss and OSA in a population of individuals aged 25 and older(NHANES 2005-2008) and found that for each additional tooth loss, the prevalence of OSA increased by 2%, after an adjustment for confounders.[6] The strength of the association between tooth loss and OSA was found to be highest in adults aged 25- 64 years as compared to older adults (aged >65 years).[6] While Bucca et al stated that there is a protective effect for OSA for patients who sleep with their dentures at night.[26]

While some studies have demonstrated that tooth loss can increase the risk of OSA, it is unknown whether there are any racial effects on this association. The CDC reports racial variations in edentulism for adults 65 years and older based on NHANES 2011-2014 cycle data. Non-Hispanic black adults have the highest edentulism prevalence (27%) with

Non- Hispanic Asians (18%), Hispanic Adults (16.4%), and Non-Hispanic white adults (16.2%) having somewhat similar prevalence.[28]

We hypothesize that – racial/ethnic groups experience different predispositions for the tooth loss-Obstructive Sleep Apnea relationship.

METHODS

The National Health and Nutrition Examination Survey (NHANES) utilizes a multistage, probability sampling methodology to obtain a sample for the civilian non-institutionalized US population.[7] This analysis used data from the 2005–2006 and 2007–2008 cycles of NHANES because these NHANES cycles included the sleep health questionnaire to identify the primary outcome variable, OSA, and received an oral health examination that counted the number of teeth. Data collection protocols were approved by the Centers for Disease Control and Prevention/National Center for Health Statistics Ethics Review Board and all participants gave informed consent.[7]

Individuals aged 25 years and above, who answered the denture status question answered the sleep questionnaire, and underwent a dental exam were included in the study. Individuals with missing data were removed from the analysis and only the participants who reported complete information for all the considered variables were included. The IRB reviewed the research and determined that it was not human subjects research and therefore had no requirement to obtain informed consent.

The dependent variable for analysis, OSA, was derived from NHANES 2007- 2008 sleep questions. These questions were adapted from the Sleep Habits Questionnaire used by the

Sleep Heart Health Study, Cleveland Family Study, and the Wisconsin Sleep Cohort Study.[6] Data was collected using the sleep disorder questions which were administered during in-home interviews using the computer-Assisted Personal Interviewing-CAPI system.[8]

We chose to explore OSA using the OSA questions and summary OSA variables based on Sanders et al, who chose their questions from the STOP questionnaire including snoring, snorting/gasping daytime sleepiness, and hypertension based on signs and symptoms recommended by the Academy of Sleep Medicine.[6] Individuals were asked "*In the past 12 months, how often did you/SP snort, gasp or stop breathing (while you/s/he was) asleep?*" and *"How often do you snore?"* scored as never, rarely (1-2 nights/week), occasionally (3-4 nights/week) or frequently (5-7 nights/week) with frequent responses considered to be a present response. Participants were also asked *"How often feel unrested during the day?"* scored as never, rarely (1 time a month), sometimes (2-4 times a month) or often (5-15 times a month), almost always (16-30 times a month) with individuals experiencing feeling unrested almost always in the month coded as yes. Hypertension (Yes/No) was also considered for the study participants based on their responses to – "Ever told you had blood pressure" [8] A summary high-risk OSA variable was then calculated based on 2 or more 'yes' responses to any of the four questions. If an individual self-reported that a doctor or other healthcare professional said they had OSA, they were coded as having OSA.

The primary independent variable for this analysis was the number of teeth. Trained dental health professionals recorded the presence of each of the 32 permanent teeth. Root

tips were counted as a missing tooth while an implant was considered as a tooth present. Mean values of total and posterior teeth were recorded and the position of the tooth's effect on OSA was explored. We categorized tooth present as 0, 1-20, 21-27, or 28+ teeth present. We also studied the number of posterior teeth present and categorized them as 0, 1-10, 11-15, and 16 + (including wisdom teeth). The potential modifying variable is race/ethnicity. Participants were classified based on their self-reported race/ ethnicity into 4 categories- Hispanics (Mexican Americans and other Hispanic populations), Non-Hispanic Blacks, Non- Hispanic Whites, and other races including multiracial.

Covariates

Potential confounding factors included demographic characteristics such as age (25-44, 45-64, and >65 years), gender (male/ female), highest attained education level (High school education level and below or any college education and above), and income level (Ratio of family income to poverty: 0- 0.99, 1.00-1.99, 2.00-2.99, 3.00-3.99, and ≥4.00). As research shows that body mass index (BMI) is strongly associated with OSA and this was analyzed as being underweight or healthy (<25 kg/m^2); overweight (25 – 30 kg/m^2); and obese(>30 kg/m^2). Smoking was explored as a potential explanatory variable coded as non-smokers (SP who answered 'no' to smoked at least 100 cigarettes in life), former smokers (Study Participant (SP) who has a history of smoking but is not currently smoking), or current smokers (SP who smoke every day/ someday).

The oral health examination included a denture questionnaire with which the patients >25 years old were evaluated for denture status by health technologists. Denture status (Yes/No) was evaluated with participants asked questions like "*Do you usually wear*

complete/partial maxillary dentures during the day?" and "*Do you usually wear complete/partial mandibular dentures during the day?*" and scored as yes if participants answered 'yes' to one of the questions.

Sleep duration was categorized based on the National Sleep Foundation's updated sleep duration report which states that individuals aged 26 – 64 years require seven to nine hours of sleep per day. For older adults aged ≥65 years, seven to eight hours of sleep per day is recommended by the panel.[12] As a measure of sleep duration, participants were asked how much sleep they usually get on weekdays or workdays to which responses were recorded in hours.[6] This sleep duration variable was categorized as <6 hours, 6-6.9 hours, and ≥7 hours.

Statistical Analysis

Data analysis was performed using SAS (version 9.4). Descriptive analyses were performed (frequencies and means) for the OSA questions, other confounding variables, and the summary OSA variable following stratification by race/ethnicity. Race/ ethnicity stratified multivariable logistic regression was done to assess the effect of tooth loss or posterior tooth loss as both a continuous variable and as categories. All analyses were performed considering NHANES' complex sampling procedure.

RESULTS

Table 1 shows the overall weighted percentages among various races/ethnicities including Hispanics (11%), non-Hispanic blacks (10%), non-Hispanic whites (73%), and other race/ethnicities (6%). Out of the total participants, the highest percentage of

individuals were in the 25-44-year-old range. More Hispanics were in this youngest category while the oldest category (> 65 years) was more prevalent in non-Hispanic Whites. Non-Hispanic blacks were slightly more likely to be females, while Hispanics were slightly more likely to be males. Higher percentages of Hispanics and non-Hispanic blacks have at least a high school education and are in the poor/near poor income levels, while non-Hispanic whites and 'other' races were more likely to have higher levels of education, along with high-income levels. Non- Hispanic blacks accounted for the highest population of current smokers, individuals who slept for fewer than 6 hours, had diabetes, obesity, or hypertension. Edentulism (total or posterior teeth), and denture-wearing were also more prevalent among the non-Hispanic Black population.

1. **Table- Description of the study population stratified by Race/ethnicity. (Weighted %s)**

	Hispanics (11%)	*Non-Hispanic Blacks* (10%)	*Non- Hispanic Whites* (73%)	*Others (Multi)* (6%)
Age				
25-44 years	62%	48%	40%	53%
45-64 years	30%	39%	42%	39%
≥65 years	8%	13%	19%	7%
Gender				
Male	53%	46%	49%	49%
Female	47%	54%	51%	51%
Education				
High School Education and below	65%	51%	37%	38%
College Education and above	35%	49%	63%	62%
Income level				
0-0.99(Poor)	25%	17%	7%	12%
1.00-1.99(near poor)	32%	26%	15%	18%
2.00-2.99(middle income)	14%	19%	15%	15%
3.00- 3.99(High income)	11%	15%	16%	14%

≥4.00(Wealthy)	18%	22%	47%	41%
Smoking				
Non-smoker	63%	57%	48%	62%
Former smoker	20%	16%	29%	16%
Current smoker	17%	26%	22%	21%
The total duration of sleep				
<6 hours	14%	27%	11%	17%
6-6.9 hours	24%	26%	22%	28%
≥7 hours	63%	46%	67%	54%
Diabetes				
Yes	10%	14%	7%	9%
No	90%	86%	93%	91%
Obesity				
Underweight/Normal(<25kg/m^2)	23%	23%	32%	49%
Overweight (25-30 kg/m^2)	39%	32%	35%	28%
Obese (>30kg/m^2)	37%	44%	34%	23%
Hypertension				
Yes	20%	40%	32%	30%
No	80%	60%	68%	70%
Denture Status				
Yes	10%	19%	16%	15%
No	90%	81%	84%	85%
Total number of teeth				
0	3%	7%	7%	3%
1-20	10%	19%	11%	12%
21-27	31%	30%	34%	34%
28+	57%	43%	48%	51%
Number of Posterior teeth				
0	3%	8%	8%	4%
1-10	11%	21%	14%	12%
11-15	27%	26%	30%	29%
16+	59%	45%	49%	54%

Table 2 is based on the STOP questionnaire and its component questions. Non-Hispanic whites constituted the highest percentage of people with high-risk OSA based on the STOP questionnaire. They had the highest percentage of individuals responding ‘yes’ to the OSA component questions for snorting/gasping, daytime sleepiness, and having been told by a healthcare professional that they had a sleep disorder. Non- Hispanic Blacks

reported a higher prevalence of hypertension, while Hispanics reported a higher prevalence of snoring. Dudley et al reported a greater prevalence of snoring among Hispanics.[14]

2. **Table - sleep disorder questionnaire and its component questions, stratified by race-ethnicity.**

		Overall	*Hispanics*	*Non-Hispanic Blacks*	*Non-Hispanic Whites*	*Others*
High-risk OSA	Yes-1 (>/=2 yes)	24.6%	21.7%	23.6%	26.4%	24.4%
In the past 12 months, how often did you/SP snort, gasp, or stop breathing while sleeping?	Yes (5 or more nights/week)	6.4%	5.9%	5.3%	7.1%	8.1%
How often do you snore?	Yes (5 or more nights/week)	32.9%	37.0%	30.4%	32.0%	33.6%
How often do you feel unrested during the day?	Yes (Almost always 16-30 times a month)	9.3%	7.6%	7.8%	10.7%	11.8%
Ever been told you had blood pressure?	Yes	35.4%	25.9%	45.8%	36.2%	30.3%
Have you/SP ever been told by a doctor or other health professional that you have a sleep disorder?	Yes	7.9%	6.6%	7.6%	8.9%	7.4%

Table 3 shows the logistic regression results predicting OSA with the total number of teeth as the primary independent variable, stratified by race. After controlling for potential confounders, in our race/ ethnicity stratified models, Hispanics had lower odds of OSA for each additional tooth present. A trend of increasing odds for OSA with

increasing age was found among Hispanics and non-Hispanic Whites, while the highest odds among non-Hispanic Blacks were seen in younger ages (45-64), and the 'Other' race demonstrated their higher odds at the older age. The only statistically significant difference by sex was found for non-Hispanic white males who are more likely to have OSA as compared to non-Hispanic white females. Income demonstrated a statistically significant difference for Hispanics near-poor income levels having 0.56 times the odds of having OSA compared to wealthy Hispanics, while high-income non-Hispanic whites had 0.68 times the odds of having OSA compared to wealthy non-Hispanic whites. Increasing trends of tobacco exposure produced elevated odds of OSA for Hispanics and Non- Hispanic blacks while being a current smoker was the only elevated odds among non-Hispanic white current smokers. As sleep deficits increased, the odds of OSA increased for Hispanics and non-Hispanic whites, while only the shortest sleep category showed statistically significant higher odds for non-Hispanic blacks. All races, except the 'other' race showed higher odds of OSA among diabetics. Non- Hispanic blacks and non-Hispanic whites showed increased odds of OSA as their BMI increased, while Hispanics and 'other' races only demonstrated elevated odds among obese individuals. No statistically significant relationships were found among the non-Hispanic blacks and whites, 'other' race by education level.

3. Table - Multi-variable logistic model for predicting OSA stratified by race; total number of teeth.

	Hispanics			*Non- Hispanic Blacks*			*Non- Hispanic whites*			*Others*		
Effect	**Odds ratio**	95% CI		**Odds Ratio**	95% CI		**Odds ratio**	95% CI		**Odds Ratio**	95% CI	
Age (Ref= 25-44 years)												
45-64 years	**2.76***	**1.94**	**3.93**	**2.22***	**1.60**	**3.06**	**1.56***	**1.26**	**1.93**	1.14	0.44	2.93
>65 years	**3.32***	**2.10**	**5.25**	1.71	0.90	3.28	**2.04***	**1.52**	**2.74**	**11.05***	**2.55**	**47.9**
Male (Ref=Female)	1.07	0.73	1.57	1.03	0.70	1.49	**1.45***	**1.24**	**1.70**	1.44	0.68	3.04
High school education and below (Ref = college education and above)	0.96	0.60	1.52	0.91	0.66	1.25	1.18	0.97	1.44	1.79	0.79	4.04
Income level (Ref = >4.00)												
0-0.99(poor)	1.01	0.59	1.72	0.98	0.61	1.57	1.17	0.87	1.57	0.99	0.39	2.52
1.00-1.99 (near poor)	**0.56***	**0.34**	**0.92**	0.95	0.58	1.56	0.80	0.60	1.07	1.24	0.45	3.48
2.00- 2.99(middle income)	0.92	0.50	1.69	1.15	0.70	1.88	0.92	0.72	1.18	0.53	0.15	1.85
3.00-3.99(high income)	0.90	0.45	1.82	0.62	0.37	1.04	**0.68***	**0.53**	**0.86**	0.65	0.29	1.42
Smoking (Ref = Non-smokers)												
Former smoker	**1.83***	**1.19**	**2.80**	**1.59***	**1.06**	**2.38**	1.21	0.98	1.49	0.83	0.20	3.47
Current smoker	**2.28***	**1.43**	**3.66**	**1.72***	**1.09**	**2.75**	**1.55***	**1.11**	**2.17**	0.68	0.36	1.29
The total duration of sleep (Ref =>7 hours)												
6-6.9 hours	**1.68***	**1.11**	**2.54**	**1.26**	0.86	1.84	**1.35***	**1.08**	**1.69**	0.99	0.40	2.44
<6 hours	**3.23***	**2.37**	**4.40**	**1.76***	**1.25**	**2.48**	**2.99***	**2.26**	**3.97**	**3.59***	**1.64**	**7.87**
Diabetes (Ref =Yes)	**2.70***	**1.64**	**4.45**	**1.91***	**1.39**	**2.64**	**1.57***	**1.14**	**2.15**	0.74	0.18	3.09
Obesity (Ref = Normal)												
Overweight	1.23	0.69	2.18	**1.83***	**1.24**	**2.70**	**2.05***	**1.55**	**2.72**	2.43	0.91	6.50
Obese	**2.79***	**1.55**	**5.03**	**3.38***	**2.29**	**4.97**	**4.37***	**3.39**	**5.64**	**10.12***	**3.78**	**27.13**
Total number of teeth$^{\pm}$	**0.97***	**0.96**	**0.98**	1.00	0.99	1.00	-	-	-	0.99	0.97	1.01

*p<0.05

- Non-Hispanic whites are the reference group (in the interaction analysis)

[±] number of teeth*race interaction p-value =0.04

Table 4 shows a sensitivity analysis that substitutes the total number of posterior teeth lost for the total number of teeth, as one might expect that due to their position at the back of the mouth, they would play a greater role in maintaining airway patency. However, multivariable logistic regression results did not change when using posterior teeth count as the primary independent variable, demonstrating an association between the number of posterior teeth and individuals having OSA. Hispanics have lower odds of developing OSA with additional tooth present as compared to non-Hispanic whites where non-Hispanic blacks and the 'other' race category did not show any association.

4. Table - Multi-variable logistic model for predicting OSA stratified by race; number of posterior teeth

	Hispanics			*Non- Hispanic Blacks*			*Non- Hispanic whites*			*Others*		
Effect	**Odds ratio**	95% CI		**Odds Ratio**	95% CI		**Odds ratio**	95% CI		**Odds Ratio**	95% CI	
Age (Ref= 25-44 years)												
45-64 years	**2.75***	**1.92**	**3.93**	**2.18***	**1.57**	**3.04**	**1.55***	**1.25**	**1.92**	1.11	0.43	2.89
>65 years	**3.31***	**2.04**	**5.37**	1.66	0.87	3.16	**2.01***	**1.46**	**2.76**	**9.87***	**2.35**	**41.45**
Male (Ref=Female)	1.07	0.73	1.57	1.03	0.71	1.51	**1.45***	**1.24**	**1.70**	1.45	0.68	3.08
High school education and below (Ref = college education and above)	0.96	0.61	1.52	0.91	0.66	1.25	1.18	0.97	1.43	1.73	0.75	4.00
Income level (Ref = >4.00)												
0-0.99(poor)	1.01	0.60	1.73	0.98	0.61	1.56	1.16	0.86	1.56	0.99	0.40	2.49
1.00-1.99 (near poor)	**0.56***	**0.34**	**0.92**	0.95	0.58	1.56	0.80	0.59	1.10	1.25	0.45	3.45
2.00-2.99(middle income)	0.92	0.50	1.68	1.15	0.70	1.87	0.92	0.71	1.18	0.53	0.15	1.85

3.00-3.99(high income)	0.90	0.45	1.81	0.62	0.37	1.04	**0.68***	**0.53**	**0.86**	0.64	0.29	1.43
Smoking (Ref= Non-smokers)												
Current	**2.28***	**1.43**	**3.65**	**1.72***	**1.07**	**2.76**	**1.54***	**1.10**	**2.15**	0.67	0.35	1.29
Former smoker	**1.83***	**1.19**	**2.80**	**1.58***	**1.05**	**2.37**	1.21	0.98	1.48	0.84	0.20	3.54
The total duration of sleep (Ref= >7 hours)												
<6 hours	**3.22***	**2.36**	**4.40**	**1.76***	**1.25**	**2.48**	**2.99***	**2.26**	**3.96**	**3.57***	**1.63**	**7.85**
6-6.9 hours	**1.67***	**1.10**	**2.54**	1.26	0.86	1.84	**1.35***	**1.08**	**1.69**	0.99	0.40	2.46
Diabetes (Ref =Yes)	**2.71***	**1.65**	**4.44**	**1.90***	**1.38**	**2.61**	**1.56***	**1.14**	**2.14**	0.74	0.17	3.17
Obesity (Ref =Normal)												
Overweight	1.23	0.69	2.18	**1.84***	**1.24**	**2.71**	**2.05***	**1.55**	**2.72**	2.41	0.91	6.34
Obese	**2.79***	**1.55**	**5.03**	**3.38***	**2.29**	**4.99**	**4.37***	**3.39**	**5.64**	**10.0***	**3.80**	**26.33**
Number of posterior teeth	**0.96***	**0.94**	**0.97**	0.99	0.98	1.00	-	-	-	0.98	0.95	1.01

*p value <0.05

±Number of posterior teeth*race interaction term p-value =0.07

- Non-Hispanic whites are the reference group

DISCUSSION

Our study found an association between OSA and tooth loss among Hispanics based on an individual's total number of teeth. We also ran a sensitivity analysis substituting the posterior tooth loss for the number of teeth and the Hispanics again showed a statistically significant relationship between OSA and posterior tooth loss. Hispanics demonstrated 3% lower odds of getting OSA with each additional tooth retained and 4% lower odds of getting OSA with each additional posterior tooth retained. Retention of teeth is important for Hispanics, so targeting this population should be emphasized compared to the other races. Hispanics have a 6.6% diagnosis rate of OSA which is the lowest among all the races.

A prior study reported a graded association between OSA and tooth loss after adjustment for the confounders.[6] Sander et al stated that the prevalence of high-risk OSA increased by 2% for each additional tooth lost with the strongest effect among young adults .[6] Sanders et al[6] reported 2% decreased odds of OSA for each additional tooth retained which is slightly less than our results for Hispanics. Our results find that the relationship is maintained among Hispanics with a 3% decrease in odds for each additional tooth retained, however, no statistically significant relationship was detected among non-Hispanic blacks, whites, or the 'other' race category. Similar trends were found when the primary independent variable was, the number of posterior teeth. This demonstrates a racial difference between OSA and tooth loss in our study, which expands upon the Sander et al study. A prior study of Mexican Americans and other Hispanics in the US reports that these populations have less difficulty falling asleep, daytime sleepiness, and non-restorative sleep as compared to non-Hispanic whites.[24] One possible explanation for the reduced odds of developing OSA in Hispanics with each additional tooth retained could be the bigger tooth size in Mexican Americans which can be the potential factor for an increase in the size of the back of the mouth.[22]

We found that older age (> 65 years) increased the odds of having OSA for all race categories except non- Hispanics blacks as compared to individuals aged 45-64 years which agrees with reports that increasing age is the second major risk factor for OSA.[20] Our study also showed that diabetics have higher odds of getting OSA as compared to those who were not diabetic across all races/ ethnicities except the 'other' race category. A prior study suggests that OSA prevalence is higher in hypertensive and obese

individuals.[18] CDC statistics demonstrate that non-Hispanic blacks have the highest rates of self-reported obesity followed by Hispanics and non-Hispanic whites.[15] Our study finds that Hispanics, non-Hispanic Blacks, and non-Hispanic whites who are current smokers have higher odds of getting risk- OSA except the 'other' race category. Hispanics and non-Hispanic Blacks who were former smokers have higher odds of having high-risk OSA. This agrees with Wetter et al which reports current smoking as an established risk factor for OSA with current smokers at a higher risk of developing OSA than non-smokers and heavy smokers are more likely to develop OSA than former smokers.[19] An individual's sex elevates the odds of high-risk OSA for non- Hispanics white males, while statistically significant differences were not detected for the other races. Our result was in agreement with Lyons et al which states that males have an increased risk of OSA as compared to females and that the gender difference was consistent across all countries in the study.[20]

We found that non-Hispanic whites had the highest frequency of individuals suffering from high-risk OSA based on the STOP questionnaire and also constituted the highest percentage of individuals that were diagnosed by healthcare professionals with OSA. An interesting finding of our study was that the frequency of high–risk OSA (based on the 4 questions from the STOP questionnaire) was 3 times greater than for individuals who were ever told by a health professional that they have a sleep disorder, with the result consistent across race/ ethnicities. This indicates that nearly two-thirds of the population are underdiagnosed or undiagnosed. The STOP questionnaire is a concise and simple self-administered screening tool for OSA that includes four (yes/no) questions, with high

sensitivity, especially for patients with moderate to severe OSA. An easy-to-administer questionnaire like this may have the ability to identify many of these individuals for additional OSA screening. Also, Non- Hispanic whites had the highest frequency of population suffering from high-risk –OSA and were diagnosed by healthcare professionals with OSA. One of the reasons for the higher diagnosis rate is better access to healthcare among non-Hispanic whites.[29]

Strengths and Limitations

One of the strengths of our study is that we used the NHANES dataset for this analysis. NHANES is a major program of NCHS (National Center for Health Statistics) which combines interviews and physical examinations of many individuals. [7] It is the only survey to conduct oral health examinations for a representative sample of the US population.[6] The large sample size obtained from the NHANES allowed us to analyze many potential confounding variables in a multivariable model that allowed us to reflect the experience of the US population. Finally, trained healthcare professionals collected the dental data and did not rely on an individual's self-report which makes the data more reliable and valid for the study and reduces the self-desirability bias.

A limitation of this study is that the association between tooth loss and the OSA relationship is based on the NHANES data (2005-2008) provided in the dataset. Since the NHANES survey is a snapshot of data collected at a single point in time, it does not let us measure the relationship between tooth loss and OSA over a period of time, so we cannot

be sure if OSA occurred before the tooth loss. A longitudinal study will be helpful to examine the development of OSA symptoms over time. Another limitation of this study is that there is a limited availability of sleep questionnaires in the NHANES cycles had these surveys, (NHANES 2005-2006, 2007-2008), so additional datasets could not be included for analysis. Also, our categorization of the Hispanic population included both Mexican Americans and other Hispanic populations hence these populations were not analyzed individually. It may be that combining Hispanics into one group may dilute a stronger relationship.

CONCLUSION

Hispanics demonstrated 3% lower odds of getting OSA with each additional tooth retained with a similar trend seen for the number of posterior teeth. Sleep disorder symptoms are highly underdiagnosed. OSA is underdiagnosed in the US population, and in a consistent manner across various race categories. Dentists should consider identifying individuals who are currently underdiagnosed or undiagnosed and refer them to a specialist. They can help to bring up the diagnosis rate by targeting Hispanics since they have the lowest diagnosis rate. The effects of tooth loss on OSA are stronger for Hispanics than for other races. The dentist should consider extra outreach for Hispanics especially. Utilizing the STOP questionnaire, we might identify more of these people. Identifying individuals with OSA may potentially diminish the effects of this disease such as traffic collisions, chronic debilitating diseases such as cardiovascular diseases (atrial fibrillation, hypertension, coronary artery disease), and chronic kidney diseases.

Hispanics have a significantly lower risk but clinically it is a modest protective effect. Although the risk is lower, looking at the underdiagnosis it is better to increase the diagnosis rate. Also, Healthy People 2030 [27] goals aim to reduce the proportion of individuals aged 45 years and older who have lost all their teeth.[4] More research is needed to see if there are differences among Hispanic ethnicities (i.e., Mexican Americans and other Hispanics) to identify potential differences as suggested by clinical research across various race/ethnicities.

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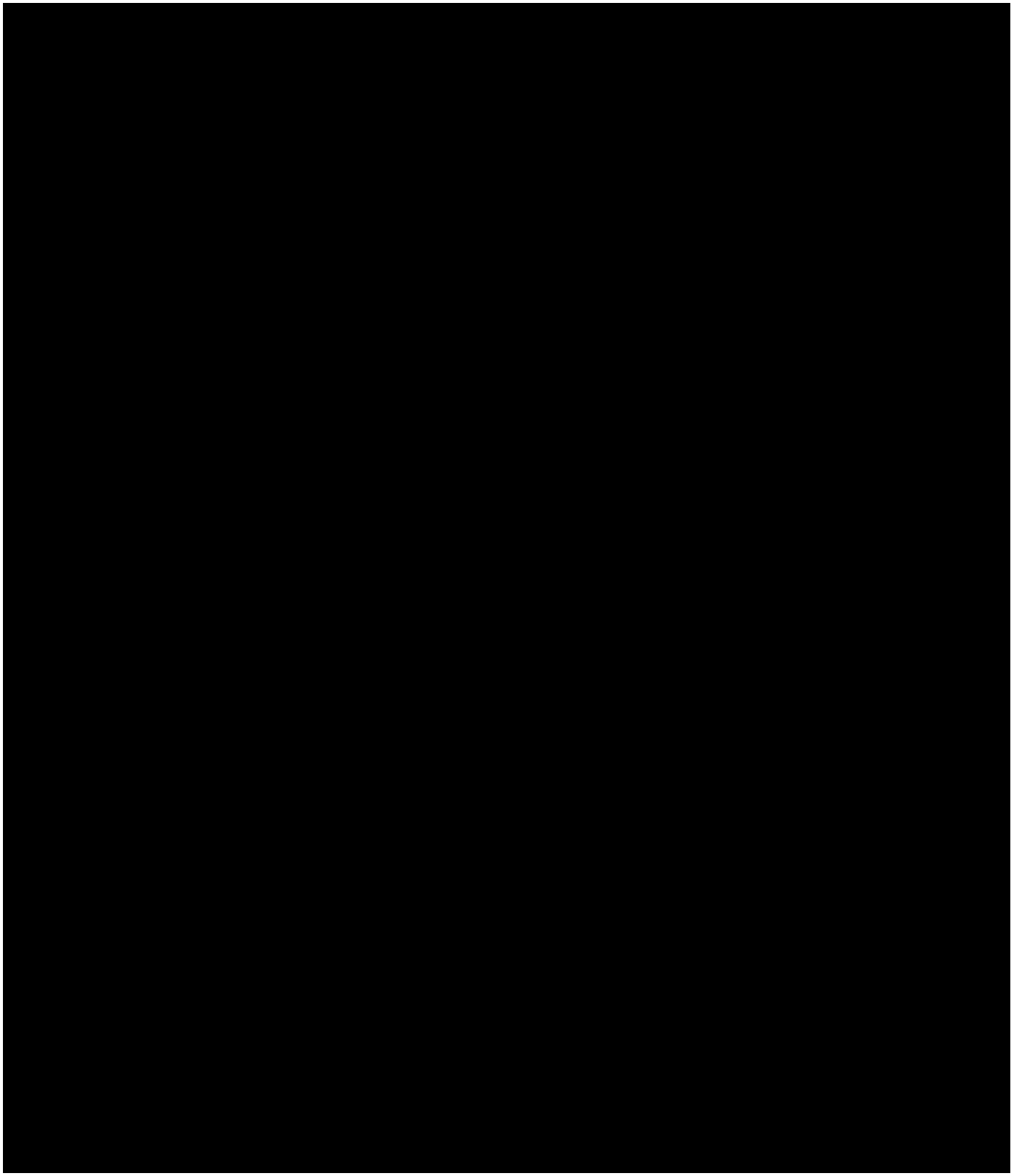
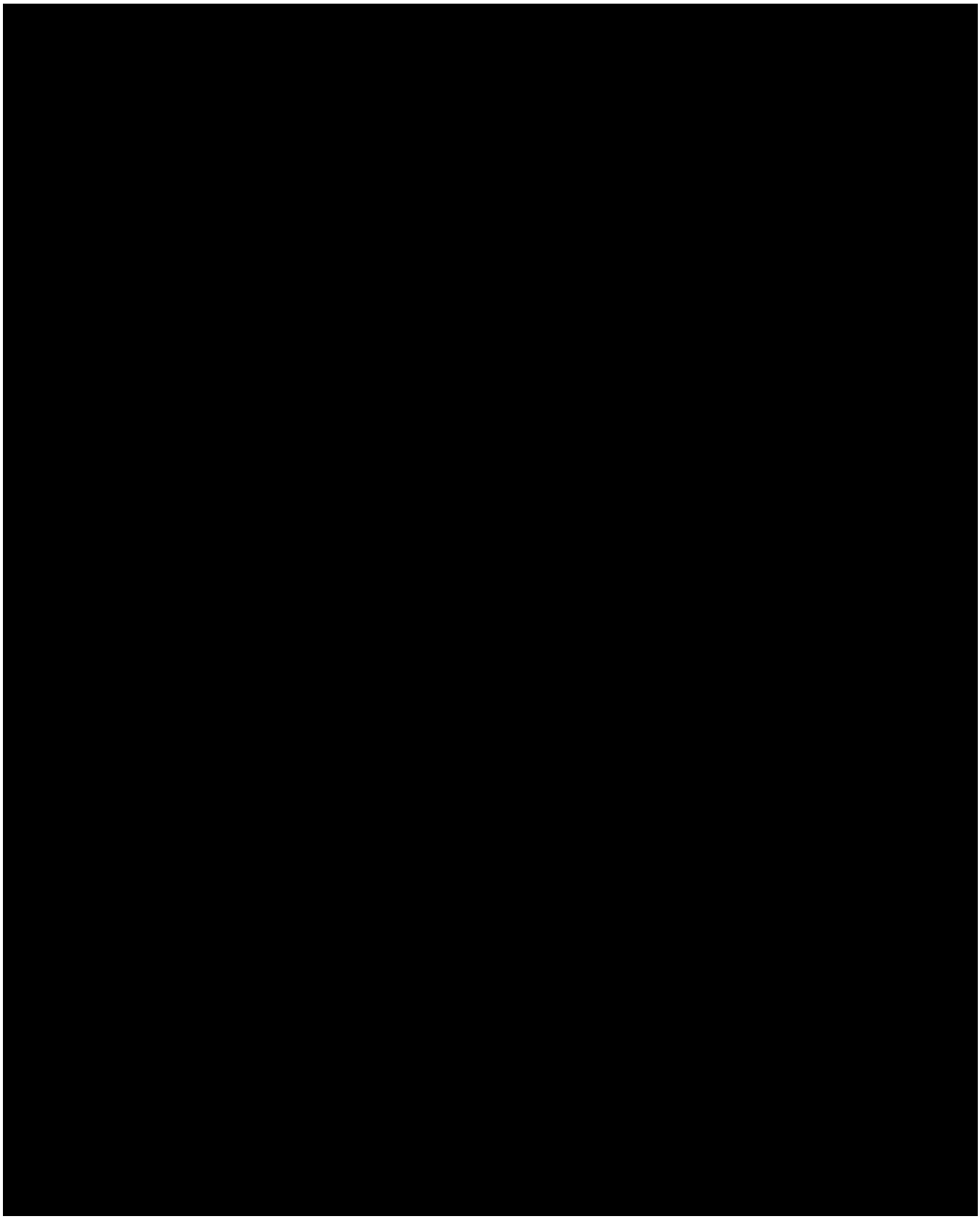
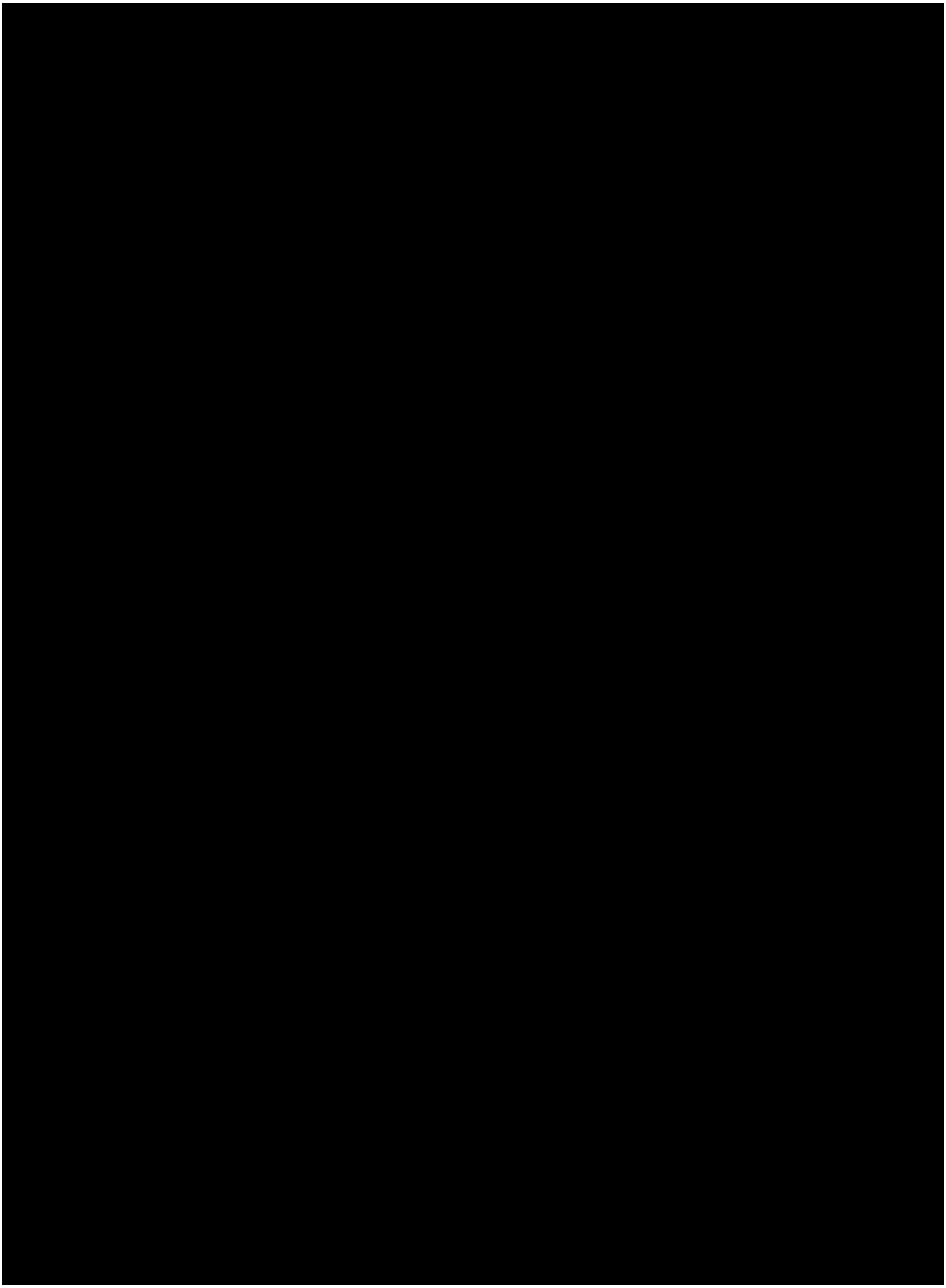
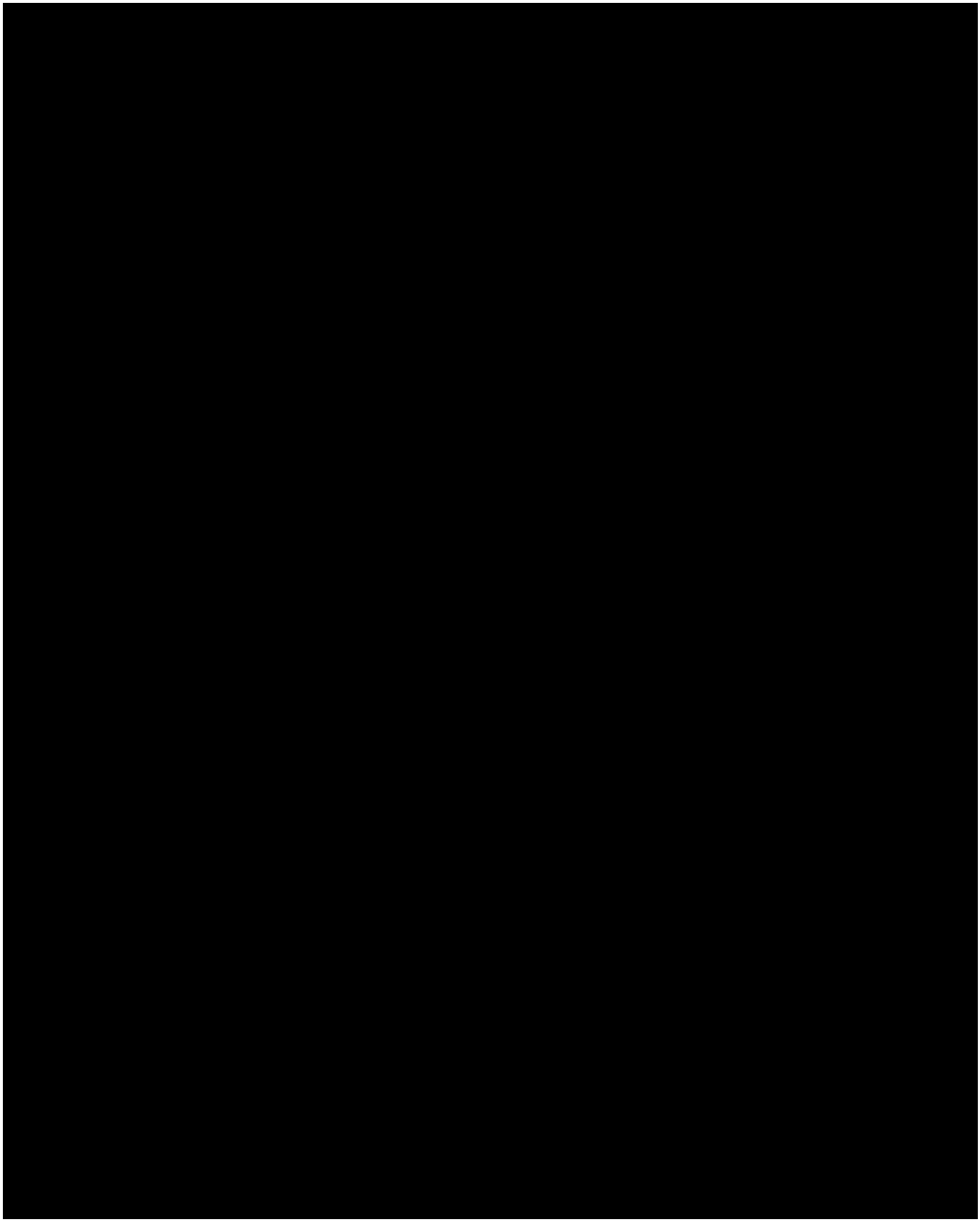
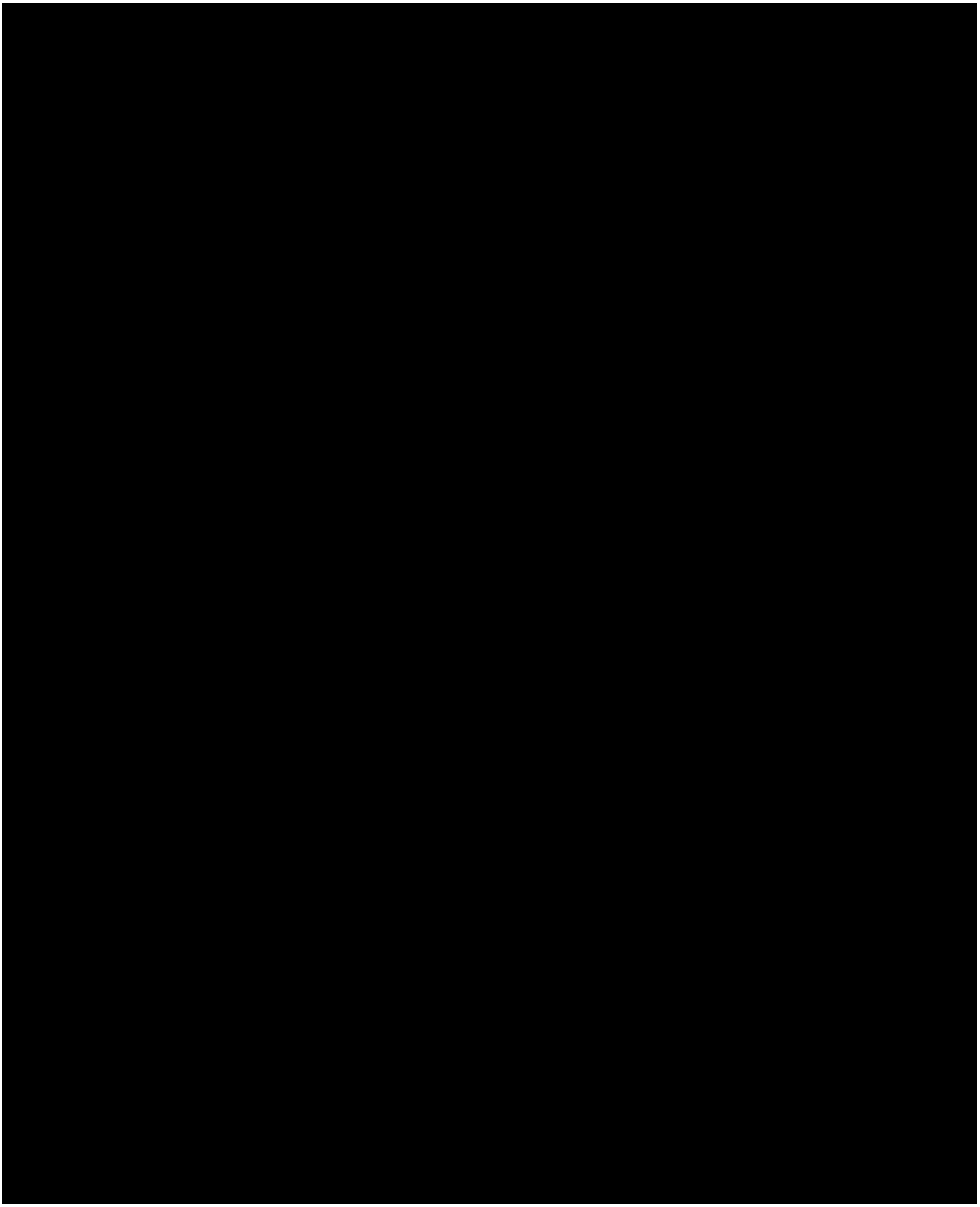
CURRICULUM VITAE

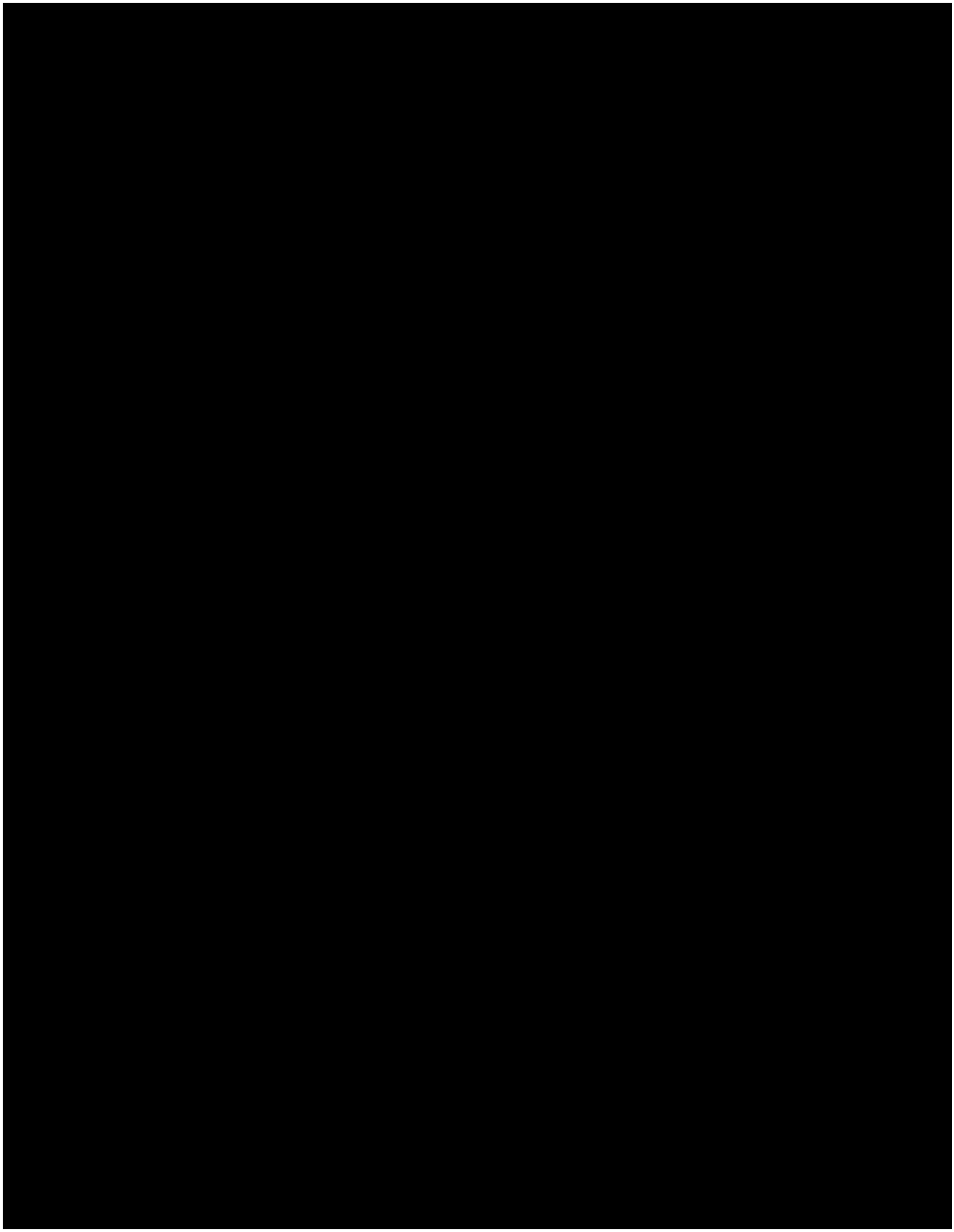


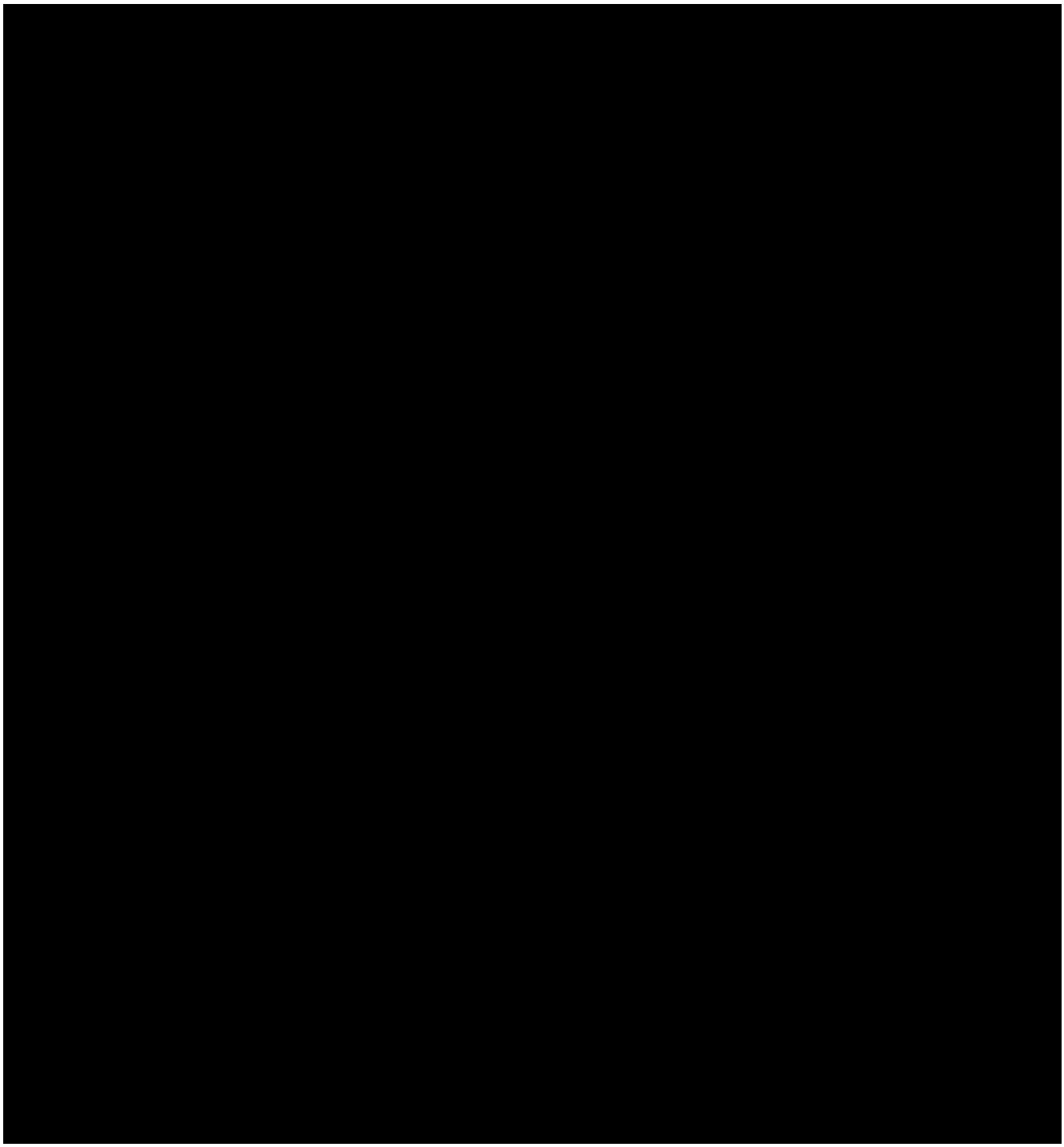












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