Data Analysis - Gender Pay Gap Claims by Female Doctors at Houston College of Medicine

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Abstract

Background Women doctors at Houston College of Medicine filed a case at the U.S District Court of Houston, claiming that women in the College were victims of gender discrimination associated with salaries and promotions.

Objectives To evaluate the claims made by the plaintiffs v and to quantify associations, if any, between salaries and gender as well as any other covariates included in the data.

Methods Data was obtained from plaintiff's case submission, consisting of 261 subjects. Variables of particular interest included annual salary in 1994 and 1995, gender, and faculty rank. Other recorded variables were department affiliation, clinical focus, board certification, publication rate, and experience. Model estimated average annual salary with gender as main predictor, interacted with experience, and adjusted for department affiliation, clinical focus, faculty rank, and board certification.

Results There is a significant association between gender and average annual salary with men employees at Houston College of Medicine earning about 10% higher average annual salary compared to women, on average, after controlling for department affiliation, clinical focus, experience, board certification, and faculty rank. However, this difference shrinks by 0.97% for each year of experience accumulated.

Conclusions Female employees in the same department and clinical focus were paid 10% less on average given the same faculty rank and board certification status. Therefore, the data supported the claims made by the plaintiffs.

Introduction

Under Title VII of the Civil Rights Act of 1964 as it appears in volume 42 of the United States Code, any discrimination based on race, color, religion, sex and national origin for employment is prohibited[1]. However, more than fifty years since the implementation of Title VII, the gender pay gap remains an issue, as evident from numerous reports and articles that still continue to surface arguing for or against the issue[4, 5, 7, 8].

A study found that men typically earn 20-30% more than women in medicine[3] while another found significant differences in salary based on gender after accounting for "age, experience, specialty, faculty rank, and measures of research productivity as well as clinical revenue" in the medical field[6]. Conversely, there are arguments that these studies of gender pay gap did not take into account "a whole host of factors" and "ignores the fact" that Bureau of Labor Statistics found that in 2017, "men worked an average of 8.05 hours in an average day compared to 7.24 hours for women"[9].

As part of exploring this issue, the authors were interested to investigate a case that occurred a few years ago in the United States District Court of Houston involving female doctors at Houston College of Medicine who claimed that *the College has engaged in a pattern and practice of discrimination against women in giving promotions and setting salaries*. Data was presented by the plaintiffs to show these differences. Authors aimed to assess the association between salaries and gender from the data and thereby evaluate whether or not the claim is supported by the data.

Methods

Data Source

Data contained information on 261 employees of the Houston College of Medicine with their 1994 & 1995 annual salaries, gender, department assignments, clinical focus (clinical vs. research), board certification (certified vs. not certified), experience (years since obtaining MD degree), faculty rank (assistant, associate, or full), and publication rate. There were six departments; Biochemistry/Molecular Biology, Physiology, Genetics, Pediatrics, Medicine, and Surgery. Publication rate is the ratio of number of publications on CV to the number of years between MD certification and CV.

Study Population Characteristics

Average annual salary from 1994 to 1995 was selected *a priori* as our primary outcome of interest; obtained by averaging the annual salary in 1994 and 1995. Unadjusted comparisons of the characteristics of men and women in our data were evaluated using Kruskal-Wallis and Chi-squared tests for continuous and categorical variables, respectively.

Data is complete without missing data points. It consisted of 261 employees of the Houston College of Medicine, of which 106 were females (40.61%). Table 1 summarizes the unadjusted characteristics of the employees. There is a statistically significant difference (p < 0.001) between the distribution of men and/or women based on department affiliation. Full professors accounted for

Figure 1. Distribution of salary before and after ln-transformation
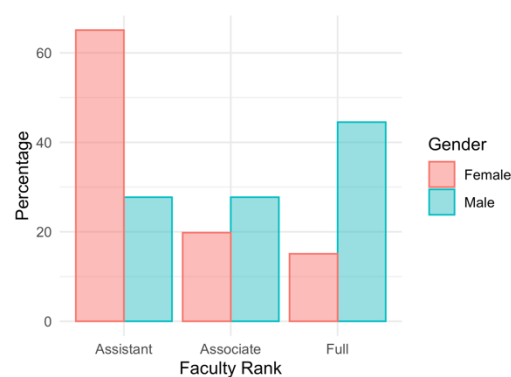
Figure 2. Percentage of men and women by faculty rank

45% of men as compared to 15% of women, which were significantly different (p < 0.001). Conversely, 65% of assistant professors were females compared to 28% of males; suggestive that women were more likely to be assistant professors (Figure 2). Median was used for publication rate, experience, and salaries since data suggested right-skew (Appendix A, Figure 3). Women had higher median publication rate of 5.25 than men at 4.00 (p < 0.05) while they have less median experience at 7 years compared to men at 10 years (p < 0.001). Unadjusted average annual salary showed a

significant difference between genders with men earning a median of $162,990 compared to women earning a median of $130,880 (p < 0.001). To normalize the right-skew in salary, a log transformation was applied to the salary variables (Figure 1). Distributions of board certification and clinical focus were not significantly different.

Table 1: Characteristics of the study population (n = 261)

	Female (n = 106)	Male (n = 155)	Total (n = 261)
Department Affiliation (n %) *			
Biochemistry / Molecular Biology	20 (18.9%)	30 (19.4%)	50 (19.2%)
Physiology	20 (18.9%)	20 (12.9%)	40 (15.3%)
Genetics	11 (10.4%)	10 (6.5%)	21 (8.0%)
Pediatrics	20 (18.9%)	10 (6.5%)	30 (11.5%)
Medicine	30 (28.3%)	50 (32.3%)	80 (30.7%)
Surgery	5 (4.7%)	35 (22.6%)	40 (15.3%)
Clinical Focus (n %)			
Research	46 (43.4%)	55 (35.5%)	101 (38.7%)
Clinical	60 (56.6%)	100 (64.5%)	160 (61.3%)
Certification Status (n %)			
Not Certified	36 (34.0%)	37 (23.9%)	73 (28.0%)
Board Certified	70 (66.0%)	118 (76.1%)	188 (72.0%)
Faculty Rank (n %) *			
Assistant Professor	69 (65.1%)	43 (27.7%)	112 (42.9%)
Associate Professor	21 (19.8%)	43 (27.7%)	64 (24.5%)
Full Professor	16 (15.1%)	69 (44.5%)	85 (32.6%)
Publication Rate *			
Mean (SD)	5.35 (1.89)	4.65 (1.94)	4.93 (1.94)
Median (Q1, Q3)	5.25 (3.73, 7.27)	4.00 (3.10, 6.70)	4.40 (3.20, 6.90)
Min - Max	2.40 - 8.70	1.30 - 8.60	1.30 - 8.70
Experience (# of years since obtaining M.D. degree) *			
Mean (SD)	7.49 (4.17)	12.10 (6.70)	10.23 (6.23)
Median (Q1, Q3)	7.00 (5.00, 10.00)	10.00 (7.00, 15.00)	9.00 (6.00, 14.00)
Min - Max	1.00 - 23.00	2.00 - 37.00	1.00 - 37.00
1994 Salary ($ in Thousands) *			
Mean (SD)	118.87 (56.17)	177.34 (85.93)	153.59 (80.47)
Median (Q1, Q3)	108.46 (75.77, 143.10)	155.01 (109.69, 231.50)	133.28 (90.77, 200.54)
Min - Max	34.51 - 308.08	52.58 - 428.88	34.51 - 428.88
1995 Salary ($ in Thousands) *			
Mean (SD)	130.88 (62.03)	194.91 (94.90)	168.91 (88.78)
Median (Q1, Q3)	119.13 (82.35, 154.17)	170.97 (119.95, 257.16)	148.12 (99.97, 218.96)
Min - Max	38.67 - 339.66	58.92 - 472.59	38.67 - 472.59
Mean Annual Salary ($ in Thousands) * †**			
Mean (SD)	124.87 (59.09)	186.13 (90.40)	161.25 (84.61)
Median (Q1, Q3)	113.71 (79.06, 148.40)	162.99 (114.61, 244.33)	141.63 (95.18, 210.01)
Min - Max	36.59 - 323.87	55.75 - 445.86	36.59 - 445.86

* p-value < 0.05 for the difference in the publication rate between male and female or within the respective gender in *the College*.
*** p-value < 0.001 for the difference in proportion of the variables between male and female or within the respective gender.
† Data included for the sake of completeness. Obtained by averaging the annual salary in 1994 and 1995 i.e. average = (1994 salary + 1995 salary) / 2.
Proportion outcomes were evaluated with Chi-squared tests while continuous outcomes were evaluated with Kruskal-Wallis test.

Confounder Selection

Our first model estimated the log-transformed average annual salary as a function of gender, adjusted for department, clinical focus, board certification, faculty rank, and years of experience. Model coefficients were used to select confounders and covariates were considered a confounder when the difference between unadjusted and adjusted-for-single-covariate gender coefficient is greater than 10%. The test found that every covariate was a confounder except for faculty rank (% difference = -9.34; Appendix B, Table 3) but rank was kept in the model based on article reviews[2, 6]. Our adjusted model was then assessed for multicollinearity by evaluating its VIF. Publication rate was highly collinear (VIF = 16.6; Appendix B, Table 4) and therefore removed from the model.

Interaction Selection

Interaction between gender and other covariates was first evaluated by graphical methods (Appendix A, Figure 4). Rank and experience were found to potentially interact with gender. We then compared the significance of the interaction with models with gender interacting with either rank or experience, adjusted for department, clinical focus, board certification, and years of experience or faculty rank. Results suggest that experience is a significant interaction term ($p < 0.01$; Appendix B, Table 5) and included in our model.

Model Diagnostics

Error assumptions were checked by evaluated residual vs. fitted plot and QQ plot, which was found to be mostly retained (Appendix A, Figure 5). Outlier check found ID #184 to be highly concerning (DFFITS = 1.97, Cook's d = 0.24; data not shown) and was removed from the data.

Final Model and Stratification

Our final model (Table 2) is a multiple linear regression model of log-transformed average annual salary as a function of gender (interacted with experience), adjusted for department affiliation, clinical focus, faculty rank, and board certification with exclusion of outlier (ID #184). Model was then evaluated further with stratification by experience divided into low (< 9 years) vs. high (≥ 9 years) experiences. Significance of each coefficient in MLR (df = 247), low-experience (df = 110), and high-experience (df = 129) models were evaluated by two-sided t-test. Calculations done using RStudio 1.2.1335 (see Appendix C for packages used).

Table 2: Final model coefficients and p-values

Terms	Coefficient Estimate†	Standard Error	Statistic (t-test)	p-value
(Intercept)	3.9933990	0.0314093	127.140543	0.0000000
Male	0.0980362	0.0335580	2.921398	0.0038073
Experience (years)	0.0265793	0.0032029	8.298410	0.0000000
Department: Physiology	-0.1724555	0.0259669	-6.641360	0.0000000
Department: Genetics	0.1839449	0.0323392	5.687983	0.0000000
Department: Pediatrics	0.1993257	0.0319941	6.230079	0.0000000
Department: Medicine	0.5197882	0.0264503	19.651510	0.0000000
Department: Surgery	0.9224977	0.0315828	29.208882	0.0000000
Clinical Focus: Clinical	0.2260865	0.0195177	11.583676	0.0000000
Certification: Board Certified	0.1990218	0.0190522	10.446141	0.0000000
Faculty Rank: Associate	0.1316143	0.0214132	6.146415	0.0000000
Faculty Rank: Full Professor	0.2165458	0.0235904	9.179409	0.0000000
Male interacted with experience	-0.0096760	0.0032422	-2.984415	0.0031263

† Estimates are changes relative to the reference factor; gender = female, department = biochemistry/molecular bio, clinical focus = research, certification = not certified, faculty rank = assistant.

Results

Final Model

The model accounted for 94.5% of the variability in the average annual salaries (adjusted R^2 = 0.946) and suggests that at 0 years of experience, men earned about 10% more than women on average (p = 0.0038), adjusted for all other statistically significant covariates. This difference decreased with each year of experience by about 0.97%. This is all in consideration of an outlier that was removed yielding a dataset of 260 subjects.

Stratified Model by Experience

Interaction between gender and experience was explored through stratification of experience. Experience was divided into low (< 9 years) vs. high (≥ 9 years) experiences. In the low-experience model, men were estimated to earn about 5.8% more than women on average ($p < 0.01$), adjusted for all other statistically significant covariates. Men earned more in the high-experience model but the difference was not significant (1.9%; p = 0.543).

Discussions

Findings suggested that differences in salaries in Houston College of Medicine was significantly associated with gender with females earning roughly 10% less than male employees after controlling for board certification, department affiliation, clinical focus, and faculty rank. Stratified model by experience revealed that there is a significant difference in pay when employees have less than 9 years of experience. However, as they pass the 9-years mark, the difference became non-significant. This association suggests that seniority or age might actually play a role rather than gender.

There are limitations to our model in that conclusions made from this work are only generalizable to salaries in Houston College of Medicine. Further analysis might be warranted given the high level of social interest on the topic at hand, and given its complexity. To address the claim at its best, other potential covariates might need to be addressed, with a wider time range of study, given the variability in times of promotion or hire schedules. Having information on part-time and full-time work would help clarify the nature of salary differences. Moreover, different combinations of existing datasets could be evaluated and checked for differences in outcomes.

Conclusion

There is statistically significant evidence suggesting that gender pay gap remains between female and male counterparts based on the data provided by the plaintiffs with women earning roughly 10% less than men on average after adjusting for board certification, department affiliation, clinical focus, and faculty rank. This finding supported claims made by plaintiffs regarding gender pay gap.

References

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Appendix
Appendix A – Other Figures

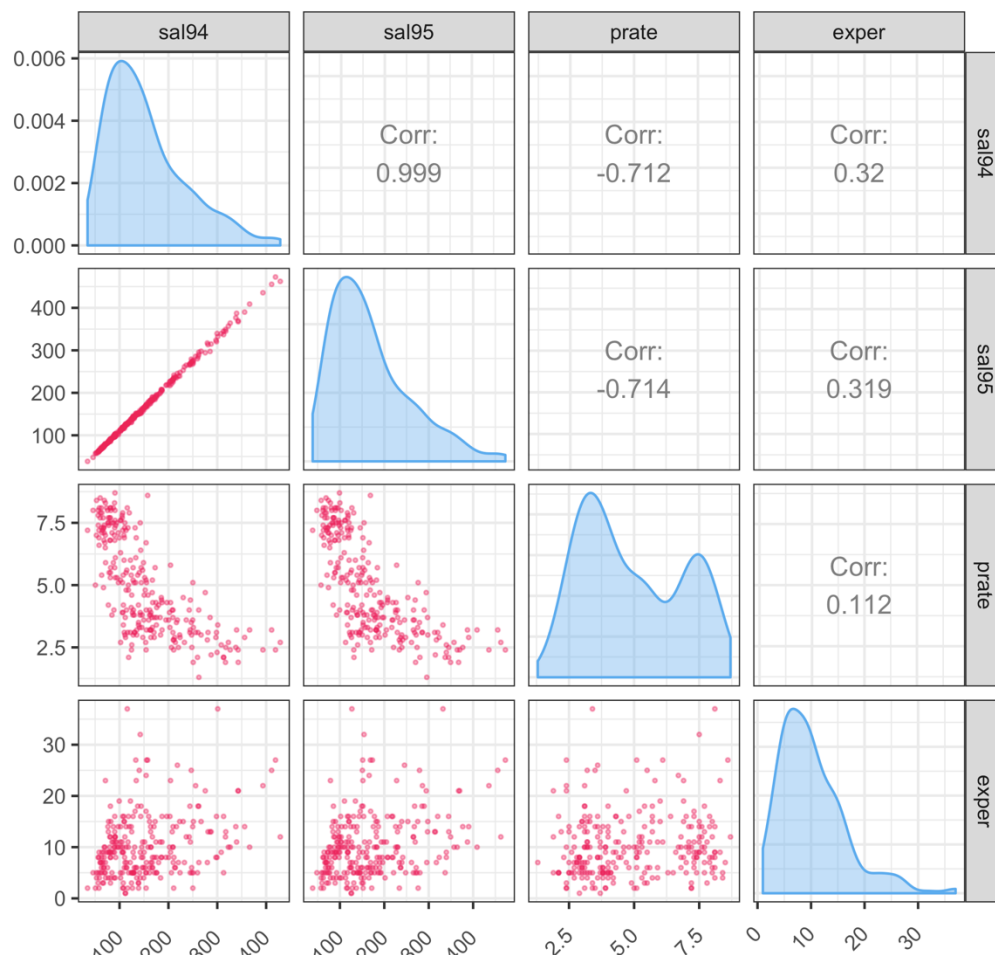Figure 3. Scatterplot and density curve for each continuous variable.

Figure 3. A correlation matrix showing correlations along with the distribution curve of each continuous variables

Figure 4. Plots to Investigate Interaction

Figure 4.A: Departments

Figure 4.B: Board Certification

Figure 4.C: Clinical Focus

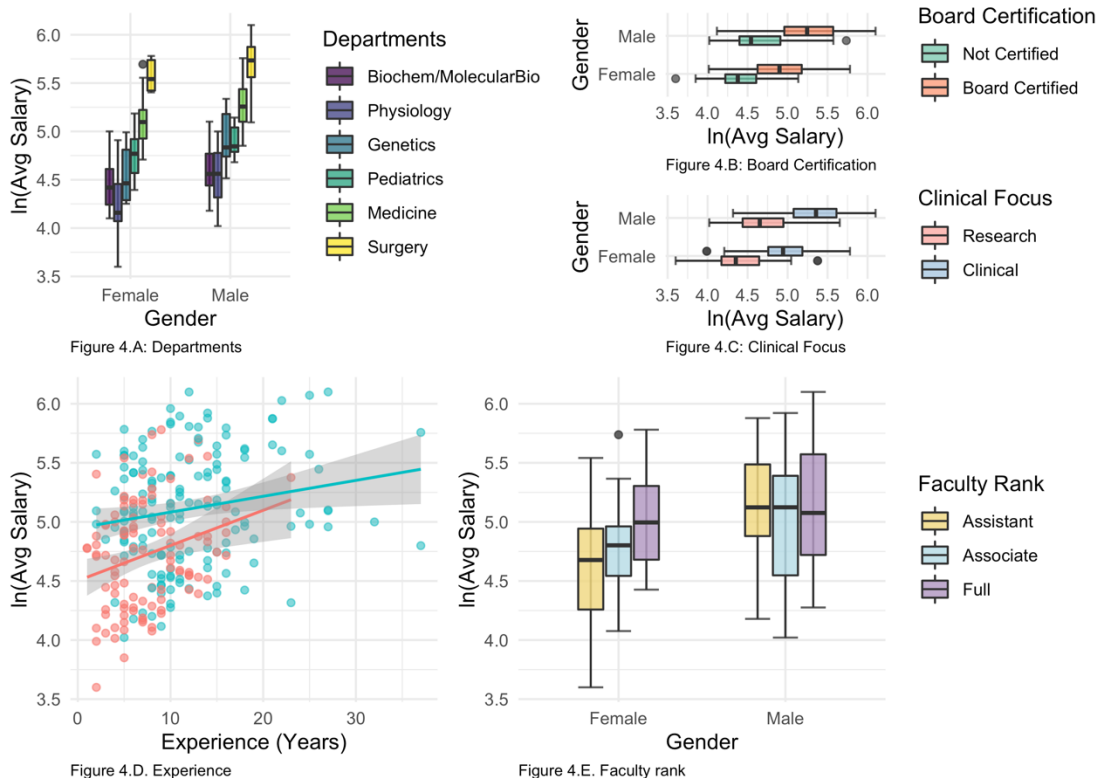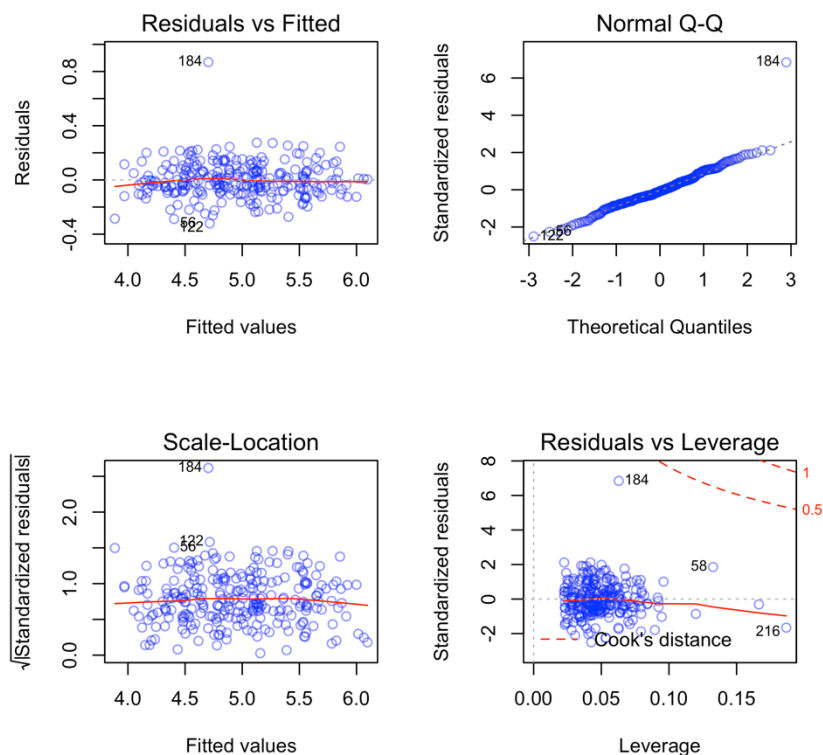Figure 4.D. Experience

Figure 4.E. Faculty rank

Figure 4. Graphs to test interaction between gender and department (4.A), board certification (4.B), clinical focus (4.C), experience (4.D), and faculty rank (4.E),

Figure 5. Model Diagnostics for our interaction and adjusted model

Appendix B – Descriptive Statistic Results

Table 3: Differences in Gender Coefficients to Test Confounders

Regression Model	Gender Coefficients	Difference	Percent Difference
Gender only	0.385	0.000	0.000
Gender adjusted for			
Department	0.205	-0.180	-46.716
Clinical Focus	0.337	-0.048	-12.458
Board Certification	0.333	-0.052	-13.496
Publication Rate	0.252	-0.133	-34.518
Experience (years)	0.308	-0.077	-19.984
Faculty Rank	0.349	-0.036	-9.343

Table 4: Evaluation of Multicollinearity with

	VIF	Degrees of Freedom	GVIF^(1/(2*Df))
Gender	1.443762	1	1.201567
Department	9.088387	5	1.246949
Clinical Focus	5.877635	1	2.424383
Board Certification	1.329952	1	1.153236
Publication Rate	16.626048	1	4.077505
Experience (years)	1.884661	1	1.372830
Faculty Rank	1.956945	2	1.182755

Table 5: Interaction of Gender with Experience vs. Faculty Rank

Terms	Coefficients	Standard Error	Test statistic (t-test)	p value
Interaction with Experience†				
(Intercept)	3.9955695	0.0348047	114.799678	0.0000000
Male	0.1289315	0.0369123	3.492917	0.0005656
Experience (years)	0.0277735	0.0035450	7.834479	0.0000000
Faculty Rank: Associate	0.1182307	0.0236483	4.999550	0.0000011
Faculty Rank: Full Professor	0.2080364	0.0261120	7.967070	0.0000000
Male interacted with Experience	-0.0117282	0.0035803	-3.275776	0.0012042
Interaction with Faculty Rank†				
(Intercept)	4.0515796	0.0279356	145.032839	0.0000000
Male	0.0744792	0.0275681	2.701648	0.0073777
Experience (years)	0.0181712	0.0018056	10.063791	0.0000000
Faculty Rank: Associate	0.1731415	0.0339042	5.106786	0.0000007
Faculty Rank: Full Professor	0.2822813	0.0395941	7.129384	0.0000000
Male interacted with Faculty Rank: Associate *	-0.0829432	0.0447499	-1.853484	0.0650054
Male interacted with Faculty Rank: Full Professor	-0.1052708	0.0466541	-2.256413	0.0249196

* p-value > 0.05. Variable is considered not significant for interaction.
† Irrelevant coefficients are removed as this table focuses on interaction terms. They include department, clinical focus, and board certification. These were verified beforehand to retain p-value < 0.001

Appendix C – Rstudio Packages used

- tidyverse: Essential package for data wrangling
- arsenal: Package for summary tables
- readxl: Used to read in provided data
- patchwork: Facilitate flexible plot arrangement
- GGally: Allows variable-to-variable comparisons efficiently
- car: Utilized the VIF function from this package
- ghibli: extra color palette set for ggplot2