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Does the National Hockey League (NHL) have a case of the "Vegas Flu"? - A statistical examination of the Vegas Golden Knights' inaugural 2017-18 season

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Abstract

Following the Vegas Golden Knights' inaugural 2017-18 season in the National Hockey League (NHL), numerous media outlets warranted the team's success to a prevailing home ice advantage due to the team's location in Las Vegas. Given that the city of Las Vegas is synonymous with its casinos and night life, the colloquial phenomenon termed the "Vegas Flu" has been used by the media to headline the Golden Knights' success. This paper offers a statistical analysis that examines the efficacy of this notion. Specifically, the current study utilizes a binary logistic regression model to predict game outcomes (i.e., wins and losses) and quantifies the "Vegas Flu" phenomenon through the number of visits made by an opposing team. Controlling for a series of variables (e.g., opposing team quality, point in season, game duration, attendance, opposing team location, and opposing time zone), findings from the logistic regression analysis using Firth's penalized-likelihood correction did not support any significant effect of the "Vegas Flu." Ultimately, limitations and routes for further research are presented.

Subject Classification: *(2010) 62-07, 62J02, 62P25, 90B90.*

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1. Introduction

Historically, expansion teams in the "Big Four" North American professional sports leagues (i.e., Major League Baseball [MLB], National Basketball Association [NBA], National Football League [NFL], and National Hockey League [NHL]) have not fared well during their first season of play. However, this is to be expected. New teams beginning in a professional sports league often face various managerial and operational challenges, such as cultivating a new fan base, developing team chemistry amongst players, coaches, and other personnel, negotiating stadium arrangements and television deals, along with other issues (Sutton, McDonald, Milne, & Cimperman, 1997). As a result, even the most mediocre season (e.g., one where the team achieves a .500 winning percentage) can be considered a productive campaign (Crepeau, 1992; Zygmont & Leadley, 2005).

For instance, expansion teams across the "Big Four" professional sports leagues have finished with a mean winning percentage of .323 in their first seasons of play. Prior to the introduction of the Golden Knights and dating back to 1924, expansion teams in professional ice hockey have completed their season with a .360 winning (points) percentage on average (North Star Hockey, 2011). For a full summary of these records, Table 1 provides the winning percentages by league. In the case of the NHL's Vegas Golden Knights, however, the team vastly surpassed expectations by finishing first in their division, accumulating the fifth most points in the NHL with 109, and posting a 51-24-7 regular season record (i.e., a .665 points percentage; Hockey-Reference, 2018). During their first season, the Golden Knights went on to win the Western Conference and finished as runner-up in the Stanley Cup Final. Individuals in the media, such as Paine (2018), a writer at *FiveThirtyEight*, a popular data-focused site covering politics, sports, science, health, economics, and cultural phenomena, have argued that the Golden Knights' first season may have been the best in the history of expansion teams.

With the recent success of the Vegas Golden Knights of the NHL, many parties in the media have attributed their superior performance on the ice to a rapidly spreading phenomenon, known as the "Vegas Flu." A variety of sports outlets have defined this as the effect of the stereotypical Las Vegas culture involving late nights at casinos, parties, and clubs, among other night-time activities (Curtis, 2018; Granger, 2017; Wyshynski, 2017) on the players' preparation for impending games and overall condition. Thus, with the Golden Knights seemingly improbable run of success,

Table 1

Expansion Team Average Winning Percentage in First Season by Professional Sports League

League	Average Winning Percentage	Included Expansion Teams
NBA[1*]	.264 (.130)	8
NFL[2†]	.165 (.160)	6
NHL[3‡]	.360 (.119)	24
MLB[4]	.376 (.051)	14

Note : Standard deviations for winning percentage are noted using parentheses. [1]Basketball-Reference (2018). [2]D'Andrea (2018). [3]North Star Hockey (2011). [4]Brisbee (2018). [*]As a result of the NBA and American Basketball Association (ABA) merger prior to the 1976-77 season, teams formed after this event are considered. [†]Due to the conclusion of the merger between the NFL and American Football League (AFL) teams in 1970, only teams formed after the merger are included in this calculation. [‡]Due to the use of overtime losses in the NHL, points percentage is used as a measure of winning percentage.

various media channels have speculated that the team's early success may actually be due to their location as opposed to solely their level of play. In other words, the team may hold an inimitable home team advantage in comparison to other franchises. Consequently, the current study intends to examine a range of factors that may have impacted the Golden Knights' first season. Primarily, the aim of this paper is to determine whether or not the team's success during the regular season could be attributed to a case of the "Vegas Flu."

1.1 *Home Advantage*

In sports, the home team advantage has been a widely-studied concept. Numerous factors have been distinguished in affecting this occurrence, ranging from referee bias (Boyko, Boyko, & Boyko, 2007) and crowd effects (Agnew & Carron, 1994; Nevill & Holder, 1999) to winning possession coin tosses (Morley & Thomas, 2005) and minor contributions of travel fatigue (Pollard, 1986), along with many more. Despite this, the home advantage may not occur equally across all sports. Early work by Schwartz and Barsky (1977) discriminated the effects of home advantages, observing that indoor sports (e.g., ice hockey) tend to receive greater benefits from playing at home compared to outdoor sports (e.g., baseball and American football).

More recently, however, there has been much debate regarding the role of how such factors influence the home advantage. For instance, Johnston (2008) challenged the notions put forth by Boyko et al. (2007) and found no

supporting evidence for the effects of referee biases and attendance. While there has been no overarching consensus in the literature, such factors could still potentially play a part in certain sports. In addition, differences in home advantages between sports have been more carefully inspected in recent years. For example, more current research by Jones (2018) has inspected the variations between the five major professional sports (e.g., American football, baseball, basketball, ice hockey, and soccer). As determined by the effect size measure, Cohen's *h*, Jones notes that the data illustrates a robust, but small impact of home advantages in certain sports (e.g., $h = .16$ for the proportion of wins for games between home and away teams in soccer and baseball). Most notably, ice hockey seemed to have one of the lowest home advantages.

In a focused analysis of the home advantage in ice hockey, Hoffman, Loughead, Dixon, and Crozier (2017) examined its impact on the duration of games (i.e., regulation, overtime, and shootout). The researchers found that teams of higher quality, or those with a more balanced level of play at home and on the road, tended to win more regulation games compared to when games went into overtime. Hoffman et al. also observed that the chances of home teams winning in a shootout decreased in comparison to overtime. Thus, while game duration was shown to affect the outcome, team quality also seemed to play a role in this relationship. As a result, factors like this and those mentioned previously may be useful to regulate when determining the effects of novel phenomena, such as the "Vegas Flu."

Taking this into account, the purpose of the current research is to pinpoint the presence of the "Vegas Flu." This paper aims to answer the following research question: *During their first regular season of play, did the Vegas Golden Knights have a competitive edge that superseded even the standard home ice advantage?* To accomplish this, the present study will use a series of regulatory variables to separate their effects from the main concept of interest (i.e., the "Vegas Flu). The current work serves as an extension to that by Hoffman et al. (2017) and to our knowledge, offers the first scholarly examination of the Vegas Golden Knights' inaugural season.

2. Materials and Methods

2.1 *Sample*

Data from the 2017-18 NHL season were obtained from the online hockey statistical database, Hockey-Reference (https://www.hockey-reference.com/). Team statistics for all home games of the Vegas Golden

Knights were collected for the present study. In all, a total of 41 games were included in the analysis. Specifically, we compiled a matrix containing *game outcomes* (wins or losses), *number of visits to Las Vegas by the opponent*, *point in the season* (before or after the All-Star Game), *duration of the game* (regulation, overtime, shootout), attendance, length of game (hours), *home ice location* (domestic or international), and *time zone* (hours). The number of opponent visits served as the primary indicator of the "Vegas Flu."

The logic behind the selection of opponent visits as a proxy for the "Vegas Flu" is that if the phenomenon is present, then teams who visit Las Vegas initially may be at a greater disadvantage than those who make additional visits. Although stated in the context of baseball, prior work by Smith, Ciacciarelli, Serzan, and Lambert (2000) has noted that any possibility for the effects of travel on home advantage could be diminished by teams playing multiple games against one other. While teams in baseball play a series of games against the same opponent consecutively (i.e., usually three or four games), there could potentially be an effect of acclimation to the novel area (Jamieson, 2010). In addition, research by Lopez, Matthews, and Baumer (2017) has speculated that home teams can become accustomed to playing conditions, such as high altitude in cities like Denver, Colorado or Salt Lake City, Utah. This could potentially also influence away teams making multiple visits to an opponent's home arena. Collectively, such research may suggest that teams making additional visits to Las Vegas could develop a proverbial "immunity" to the "Vegas Flu" over the course of a season.

2.2 *Descriptive Statistics*

During the 2017-18 NHL season at home, the Golden Knights won 29 games and lost 10 games in regulation and 2 games in overtime. Of these home games, the team played 33 games in regulation (80.49%), 6 games in overtime (14%), and 2 games (4.90%) in a shootout. On average, the games lasted 2 hours 31 minutes (SD = 6 minutes 51 seconds). In their inaugural season, the Golden Knights' average attendance was 18,135 (SD = 882), which is slightly higher than the reported 17,500-person capacity of the team's home ice, T-Mobile Arena (2018). A summary of these statistics is provided in Table 2.

Table 2

Team Statistics Included in the Present Study

Date	Opponent	Outcome	HTQ	ATQ	DTQ	Visit	Point in Season	Duration	Attendance	Length of Game	Location	Time Zone
10/10/17	Arizona Coyotes	W	.21	.39	–.19	1	Before ASG	REG	18,351	2:30	D	+1
10/13/17	Detroit Red Wings	L	.79	.56	.23	1	Before ASG	REG	17,150	2:32	D	+3
10/15/17	Boston Bruins	W	.25	.56	–.30	1	Before ASG	REG	19,092	2:28	D	+2
10/17/17	Buffalo Sabres	W	.17	.34	–.17	1	Before ASG	OT	17,468	2:31	D	+1
10/21/17	St. Louis Blues	W	.83	.53	.30	1	Before ASG	OT	15,303	2:26	D	+0
10/24/17	Chicago Blackhawks	W	.79	.50	.29	1	Before ASG	REG	18,231	2:35	D	+1
10/27/17	Colorado Avalanche	W	.70	.42	.28	1	Before ASG	REG	18,184	2:25	D	+1
11/10/17	Winnipeg Jets	W	.54	.61	–.07	1	Before ASG	REG	19,289	2:24	I	+0
11/19/17	Los Angeles Kings	W	.61	.69	–.08	1	Before ASG	REG	15,321	2:41	D	+0
11/24/17	San Jose Sharks	W	.47	.71	–.24	1	Before ASG	OT	19,057	2:27	D	+3
11/28/17	Dallas Stars	L	.77	.24	.53	1	Before ASG	REG	18,506	2:21	D	+3

Contd...

Date	Opponent	Outcome	HTQ	ATQ	DTQ	Visit	Point in Season	Duration	Attendance	Length of Game	Location	Time Zone
12/3/17	Arizona Coyotes	W	.35	.33	.02	2	Before ASG	OT	18,644	2:32	D	+2
12/5/17	Anaheim Ducks	W	.45	.42	.03	1	Before ASG	SO	17,562	2:35	D	+3
12/12/17	Carolina Hurricanes	L*	.46	.42	.05	1	Before ASG	SO	18,220	2:32	D	+3
12/14/17	Pittsburgh Penguins	W	.61	.31	.30	1	Before ASG	REG	18,085	2:30	D	+3
12/17/17	Florida Panthers	W	.45	.38	.07	1	Before ASG	REG	18,030	2:29	D	+0
12/19/17	Tampa Bay Lightning	W	.71	.68	.03	1	Before ASG	REG	18,122	2:26	D	+2
12/23/17	Washington Capitals	W	.68	.42	.26	1	Before ASG	REG	18,267	2:35	D	+1
12/31/17	Toronto Maple Leafs	W	.59	.57	.01	1	Before ASG	REG	18,014	2:44	I	+3
1/2/18	Nashville Predators	W	.59	.57	.01	1	Before ASG	REG	18,207	2:24	D	+0
1/7/18	New York Rangers	W	.61	.45	.16	1	Before ASG	REG	18,230	2:37	D	+1

Contd...

Date	Opponent	Outcome	HTQ	ATQ	DTQ	Visit	Point in Season	Duration	Attendance	Length of Game	Location	Time Zone
1/13/18	Edmonton Oilers	L	.37	.48	–.11	1	Before ASG	OT	18,328	2:44	I	+0
1/23/18	Columbus Blue Jackets	W	.55	.43	.12	1	Before ASG	REG	18,269	2:30	D	+3
1/25/18	New York Islanders	L	.51	.44	.07	1	Before ASG	REG	16,514	2:31	D	+2
2/11/18	Philadelphia Flyers	L	.51	.49	.01	1	After ASG	REG	17,402	2:35	D	+3
2/13/18	Chicago Blackhawks	W	.54	.44	.10	2	After ASG	REG	19,515	2:19	D	+3
2/15/18	Edmonton Oilers	W	.40	.45	–.05	2	After ASG	REG	19,070	2:41	I	+3
2/17/18	Montreal Canadiens	W	.51	.29	.21	1	After ASG	REG	19,723	2:28	I	+3
2/19/18	Anaheim Ducks	L	.52	.47	.05	2	After ASG	REG	18,420	2:32	D	+2
2/21/18	Calgary Flames	W	.43	.55	–.12	1	After ASG	REG	18,295	2:25	I	+3
2/23/18	Vancouver Canucks	W	.40	.42	–.02	1	After ASG	REG	18,075	2:28	I	+3

Contd...

Date	Opponent	Outcome	HTQ	ATQ	DTQ	Visit	Point in Season	Duration	Attendance	Length of Game	Location	Time Zone
2/27/18	Los Angeles Kings	L	.58	.55	.03	2	After ASG	REG	18,214	2:26	D	+0
3/2/18	Ottawa Senators	L	.44	.30	.14	1	After ASG	REG	17,562	2:29	I	+2
3/14/18	New Jersey Devils	L	.51	.47	.05	1	After ASG	REG	18,042	2:38	D	+2
3/16/18	Minnesota Wild	L	.68	.39	.30	1	After ASG	REG	18,326	2:27	D	+0
3/18/18	Calgary Flames	W	.42	.53	–.11	2	After ASG	REG	18,121	2:28	I	+3
3/20/18	Vancouver Canucks	W	.39	.38	.01	2	After ASG	REG	18,191	2:30	I	+2
3/26/18	Colorado Avalanche	W	.67	.42	.25	2	After ASG	REG	18,458	2:38	D	+3
3/28/18	Arizona Coyotes	L	.41	.36	.05	3	After ASG	REG	18,865	2:51	D	+0
3/30/18	St. Louis Blues	W	.57	.50	.07	2	After ASG	OT	18,347	2:20	D	+1
3/31/18	San Jose Sharks	W	.64	.48	.16	2	After ASG	REG	18,458	2:38	D	+1

Note : *Indicates overtime loss. For *Outcome*, W = Win (1), L = Loss (0). HTQ = Home Team Quality. ATQ = Away Team Quality. DTQ = Difference Team Quality. For *Point in Season*, ASG = All-Star Game, Before (1), After (2). For *Duration*, REG = Regulation (1), OT = Overtime (2), SO = Shootout (3). For *Location*, D = Domestic (1), I = International (2). Parentheses refer to coding in dataset.

2.2.1 Opposing Team Quality

The quality of the opposing team was measured using a modified version of James (1980) Pythagorean Method, developed by Cochran and Blackstock (2009). Originally applied in the context of the MLB, James posited that a team's winning percentage, or team quality, could be determined using the following formula that simply uses runs scored and runs allowed.

$$\text{Winning Percentage} = \frac{\text{Runs Scored}^2}{(\text{Runs Scored}^2 - \text{Runs Allowed}^2)}$$

Suitably, Cochran and Blackstock (2009) adjusted this metric for the NHL using goals for and goals away. In the manner of Hoffman et al. (2017), we conceptualized opponent team quality by producing Pythagorean scores for the opponents both away and at home at the *n*th game played prior to visiting the Vegas Golden Knights. The difference of these scores was then taken to determine the opponent's overall quality. Higher scores indicated that the opponent performed better at home, while negative scores illustrated that the opponent played at a higher level on the road. The identical formula and procedure were utilized to calculate the difference team quality statistic (see Table 3). Figure 1 offers a visual presentation of the descriptive statistics of opponent team quality over the sampled season.

3. Results

3.1 *Data Analysis*

Due to the limited sample size of games from only one season of play coupled with issues in quasi-complete data separation, Firth's

Table 3

Difference Team Quality Procedure

Step	Statistic	Formula
Step 1	Home Team Quality	$\frac{\text{Home Goals For}^{1.927}}{(\text{Home Goals For}^{1.927} - \text{Home Goals Allowed}^{1.927})}$
Step 2	Away Team Quality	$\frac{\text{Away Goals For}^{1.927}}{(\text{Away Goals For}^{1.927} - \text{Away Goals Allowed}^{1.927})}$
Step 3	Difference Team Quality	(Home Team Quality–Away Team Quality)×100

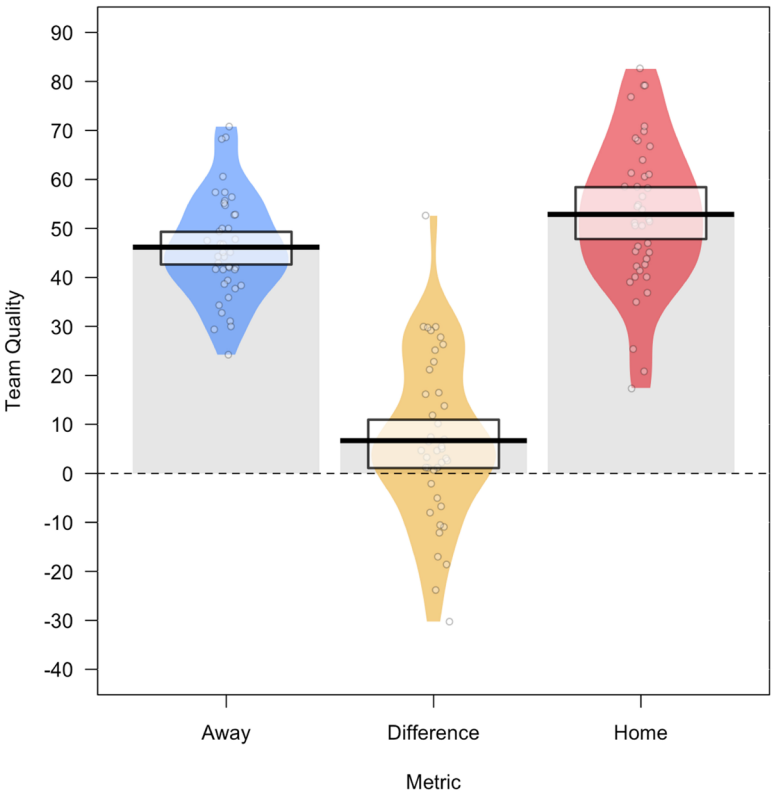


Figure 1

Pirateplot of the Vegas Golden Knights' opponent team quality over the 2017-18 NHL season. The vertical bars show average scores, light grey points represent raw data, rectangle displays Bayesian 95% Highest Density Intervals (HDI; Kruschke, 2010), and coloured "beans" represent smoothed density (Kampstra, 2008). Team quality metrics are multiplied by 100 for ease of viewing.

penalized-likelihood logistic regression was performed (Firth, 1993). Ordinary maximum-likelihood logistic regression techniques assume that sample sizes are large. However, with limited sample size, bias can be introduced to such binary logistic regression models due to standard maximum-likelihood procedures assuming that sample size converges infinitely (Rasch & Waibel, 2015). Wang (2014) notes that Firth's correction remediates such issues by reducing bias in cases of small sample size, while also accounting for complete or quasi-complete separation (i.e., one

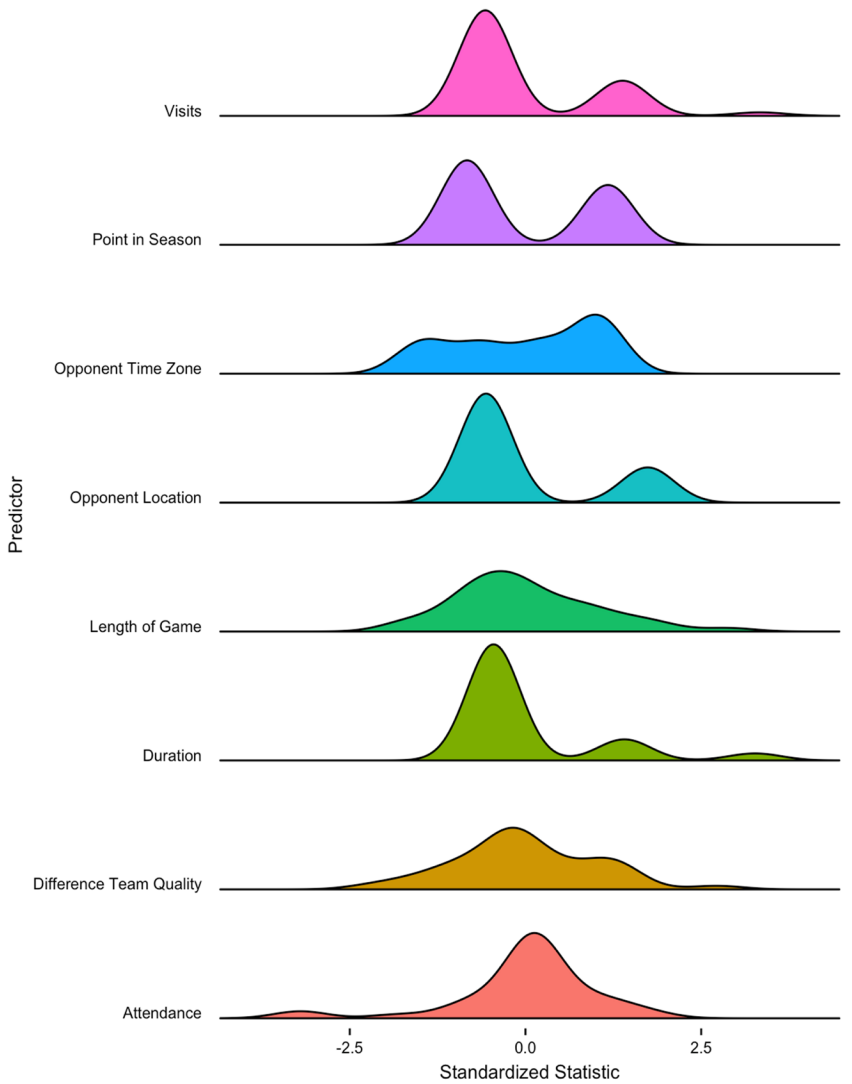


Figure 2

Distribution of standardized predictor scores.

specific outcome [e.g., a win] being associated with only a certain level of a predictor). Thus, Firth's correction penalizes the log-likelihood based on Jeffreys invariant prior (Jeffreys, 1946).

Firth logistic regression has been widely applied and validated in the context of medical research (Fischer, Sipe, Rogers, Cook, Robb,

Vuppalanchi, & Rex, 2015; Ma, Blackwell, Boehnke, & Scott, 2013; Puhr, Heinze, Nold, Lusa, & Geroldinger, 2017). All statistical analyses were conducted using R Studio (Version 1.0.44; RStudio, Inc. 2009-2016; R Version 3.3.2) for macOS. The R package, logistf (Heinze, Ploner, Dunkler, & Southworth, 2016), was utilized to perform Firth's logistic regression. Prior to modelling, all predictors were standardized to *z*-scores (see Figure 2).

3.1.1 Initial Analysis

As a measure of reliability, Pearson's product-moment correlation coefficients were computed to examine the use of the modified Pythagorean Method scores (Cochran & Blackstock, 2009) as an indicator of team quality. Similar to Hoffman et al. (2017), we computed correlation coefficients between the opponent's actual winning percentage at the *n*th game and their predicted team quality calculated by the modified Pythagorean Method. This test revealed that team quality was a robust indicator for both home, $r(39) = .90$, $p < .001$, and away team quality, $r(39) = .86$, $p < .001$. Figure 3 provides an illustration of this analysis.

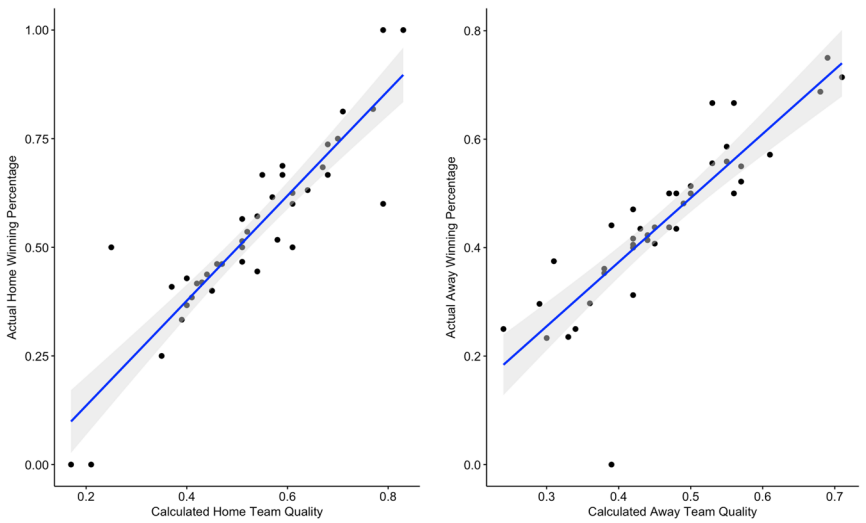


Figure 3

Scatterplots displaying the relationships between calculated team quality and actual winning percentage (home and away). The solid blue lines represent the best-fit lines. The grey-shaded regions illustrate the 95% confidence intervals.

Table 4

Firth's Penalized-Likelihood Logistic Regression for Game Outcome

Predictor	B	SE	95% CI (B)	OR	95% CI (OR)	$\chi 2$	p
(Intercept)	0.84	0.37	0.20, 1.58	2.33	1.22, 4.86	6.79	.01
Visits	0.54	0.53	–0.36, 1.65	1.72	0.70, 5.23	1.35	.25
Covariates							
Difference Team Quality	0.20	0.41	–0.53, 1.00	1.22	0.59, 2.73	0.29	.59
Point in Season	–1.05	0.56	–2.26, –0.09	0.35	0.10, 0.91	4.65	.03
Duration	–0.20	0.38	–0.87, 0.50	0.82	0.42, 1.65	0.33	.56
Attendance	0.15	0.41	–0.62, 0.89	1.16	0.54, 2.45	0.15	.69
Length of Game	–0.52	0.41	–1.33, 0.19	0.60	0.26, 1.21	2.05	.15
Location	0.47	0.44	–0.28, 1.41	1.61	0.76, 4.11	1.46	.23
Time Zone	0.17	0.43	–0.64, 0.99	1.19	0.53, 2.70	0.18	.67

3.1.2 Testing the Vegas Flu

Firth's penalized-likelihood logistic regression was performed to examine the effects of the number of opponent visits to Las Vegas on game outcome (win or loss) using the difference in team quality, point in season, duration, attendance, length of game, opponent's home ice location, and opponent's home time zone as control variables. For the purposes of the analysis, overtime losses were equated to losses. The model revealed no significant effect of the standardized number of visits on game outcome ($p = .25$). In addition, all other standardized covariates had no meaningful effect on wins and losses (p's $> .05$), with the exception of point in the season, wherein the Vegas Golden Knights were more likely to win home games that were played prior to the All-Star break ($p = .03$). The results of this analysis are provided in Table 4.

4. Discussion

In summary, the present study sought to examine the effects of a superseding competitive advantage held by the NHL's Vegas Golden Knights, namely the "Vegas Flu." The results of our logistic regression model do not support this notion. Controlling for opponent team quality, point in the season, duration, attendance, length of the game, opponent home ice location, and opponent time zone, the analysis did not yield any

meaningful effect of the number of visits to Las Vegas. Thus, the Golden Knights' chances of winning may not be significantly affected by the team's location according to the current model. As concisely contended by Swartz and Arce (2014) in respect to environmental effects on teams, the Golden Knights do not appear to have an "extraordinary home team advantage" (p. 15).

4.1 *Limitations and Future Directions*

Considering these findings, however, the current study was limited by a series of variables. Namely, the analysis was restricted by a small sample size due to the examination of only 41 home games from merely one regular season. While this limitation was accounted for by using Firth's correction, future research could benefit from using a compilation of supplementary seasons. Although the use of other variables could enhance future inquiries into this matter, the consideration of a multitude of variables may overdetermine statistical models. Thus, it may be appropriate to create a harmonized index of such factors to assess the home team advantage for the Vegas Golden Knights more accurately. In addition, future work should consider developing stepwise models employing a variety of variables (e.g., the effect of fatigue through back-to-back games) and comparison with teams in other large markets with seemingly alluring night life activities (e.g., cities like Boston, Chicago, Los Angeles, New York City, and the like). Ultimately, the literature could further advance from the examination of such variables and potential competitive advantages in the context of the playoffs and post-season. Such studies may also better inform managers of professional expansion franchises on the effects of the locality on performance. Although not in the scope of the present research, studies can consider other performance metrics (e.g., goals scored, goals allowed, goalie save percentage, takeaways, giveaways, penalty minutes, and others) when evaluating players and potential competitive advantages.

These considerations may better disentangle the influence of the stereotypical Las Vegas culture on not only NHL teams, but also teams like the Women's National Basketball Association's (WNBA) Las Vegas Aces and other franchises expecting to play in the notorious "Sin City" in the coming seasons. For example, with the NFL's Raiders impending move to Las Vegas scheduled for the 2020 season (Disis & Byers, 2017), other teams may look to research on NHL franchises to identify factors that could influence their performance. Findings from such prospective

studies could inform managers of these sports organizations on how to cope with visits to Las Vegas for games. While the current study did not find ample evidence for the "Vegas Flu," this paper does shed light upon utilizing data-driven support to manage distractions created by the media. Accordingly, while the underlying characteristics of visiting a city could be a crucial factor, there are surely a plethora of other elements that teams must manage in order to maintain superior performance.

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