

Acknowledgments

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**Soccer Substitution Patterns:
Analysis of the 2022 FIFA World Cup**

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Abstract

Substitutes have a key role in professional soccer in their ability to impact the outcome of a game. Substitution decisions are also one of the few opportunities a manager has to influence a game. Despite the value that substitutions hold and the increasing use of analytics in improving a team's chance of success, limited research has been done on optimal substitution methods.

The 2022 FIFA World Cup was the first World Cup that implemented the International Football Association Board's Substitution Procedure allowing for up to five substitutions rather than the maximum of three. An exploratory analysis took place to consider the effect of this new rule and timing of substitutions depending on the multitude of game situations a manager faced. Substitution patterns of teams in the 2022 World Cup indicate that making substitutions earlier in the game was of benefit to a team, however, this depends on the situation. Also teams of similar quality chose to make their substitutions around the time in only limitation scenarios.

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Introduction

Importance of Substitutions

Soccer fanatics have a particular fondness for the phrase “super sub.” This is a player who is substituted into a game off the bench and has a clear impact on the game upon their entrance. One of the best known super subs is Mario Götze. A German striker who played against Argentina in the 2014 World Cup Final. It was an enthralling goalless battle with Argentina scoring an offside goal that would not count and Germany hitting the post. At the very end of regulation, Götze subbed into the game at the 88th minute mark. The game went into extra time and would continue on to a penalty kick shootout in order to crown the world champion if it was still scoreless after an additional 30 minutes of play. During extra time, there would be chances on goal by both teams but neither team could seem to score. However, in the 113th minute, Germany had an attack down the left flank. The ball was served in, Götze controlled it off his chest, and volleyed it past the keeper into the back of the net. Germany were World Cup winners, and they had the super sub abilities of Götze to thank for it.

Whether a team is winning and needs to conserve the lead, is losing and seeks to score a goal, or is level with their opponent but desperately wants to win, a substitute – like Götze – has the unique ability to impact the outcome of a game. A substitute has the opportunity to observe what is happening in the game, including the opponent’s points of weakness as well as the successes of his own team, prior to stepping onto the field. Furthermore, the energy level of a substitute will be higher than any of the starters who have been competing for a considerable amount of time. In addition, most substitutes most likely have a sense of fight due to the fact that

they did not start the game. These factors could potentially give a substitute player an advantage over his teammates who started the game.

Furthermore, substitutions are a key aspect of the role managers have during a game. Prior to a game, the coach designs training sessions, analyzes game footage, and provides direct instructions to players whenever he desires. However, once the whistle blows on game day, a coach has a limited influence on the game itself. The game is in the hands of the players on the field. Yet, ultimately it is in the power of a head coach in determining what players are given the chance to affect the game. Thus substitutions are a deliberate method for managers to impact the course of a soccer game.

Being that a substitute is a unique opportunity and can be an influential aspect of a soccer match, substitutions should be a strategic decision. Yet, little research has been done to find the optimal approach to substituting.

Background on the FIFA World Cup

In July of 2022, there was an official change to the substitution rule in professional soccer that allowed for a maximum of five substitutions. FIFA, the international governing body of association football, made a request, stating, “in May 2020 to protect player welfare during the global pandemic, The IFAB (International Football Association Board) introduced a temporary amendment giving top domestic and international competitions the option of allowing teams to use up to five substitutes; this provision was extended several times” (“All you need to know about squad lists and substitutions”, 2022). The IFAB, previously limited teams to three

substitutions. The 2022 FIFA World Cup was the first World Cup where the five player substitution rule was implemented.

Structure. The FIFA World Cup is a month-long tournament consisting of 32 teams that takes place every four years. It is the only source for this study since it includes the best teams internationally, all of which express a must-win mentality through the duration of the tournament. There are neither outside factors such as home and away advantages, nor a need to worry about the longevity of a regular club season that could typically impact how a game is approached. Teams are doing everything in their power to win – including (hopefully) substituting players in ways that lead to success.

The FIFA World Cup is made up of group stage and knockout stage games. “Each match shall last 90 minutes, comprising two periods of 45 minutes, with a half-time interval of 15 minutes” (“Regulations FIFA World Cup 2022”, 2022). The group stage, which is the initial stage of the competition, is composed of eight groups with four teams in each group. Each team plays one game against the three other teams in its’ respective group. A team aims to continue onto the knockout stage based on the points earned throughout the opening three games. A win earns a team three points; a tie is one point; and a loss is zero points. The two teams with the most points in each group move onto the knockout stage.

The knockout stage subsequently includes the round of 16, quarter-finals and semi-finals, and the final (as well as a consolation match for third place). Starting with the round of 16 matches, there must be a winner of each individual game. Games can still end after the 90 minutes of regular time, although “in the knockout stages, if a match is level at the end of normal playing time, extra time shall be played. Extra time shall consist of two 15-minute periods, with an interval not exceeding five minutes before the first period of extra time begins and a short

drinks break (interval) not exceeding one minute at halftime.” (“Regulations FIFA World Cup 2022”, 2022, p. 22). This period of extra time is not sudden death or, golden goal. If a team does score a goal to go ahead of their opponent during extra time, the time remaining must be played. In the 2022 World Cup, five of the sixteen knockout stage games went to extra time. Interestingly, the score was tied at the end of the extra time in all five of these matches. “If the score is still level at the end of extra time, kicks from the penalty mark shall be taken to determine the winner” (“Regulations FIFA World Cup 2022”, 2022, p. 22).

Substitution Law. A substitution can be made in any minute of a professional soccer match. Although there are specific guidelines that must be followed in order to substitute a player. The IFAB outlines the Substitution Procedure in Law 3.3 (IFAB, 2022-23):

The names of the substitutes must be given to the referee before the start of the match.

Any substitute not named by this time may not take part in the match.

To replace a player with a substitute, the following must be observed:

- the referee must be informed before any substitution is made
- the player being substituted:
 - receives the referee’s permission to leave the field of play, unless already off the field, and must leave by the nearest point on the boundary line unless the referee indicates that the player may leave directly and immediately at the halfway line or another point (e.g. for safety/security or injury)
 - must go immediately to the technical area or dressing room and takes no

further part in the match, except where return substitutions are permitted

- if a player who is to be substituted refuses to leave, play continues

The substitute only enters:

- during a stoppage in play
- at the halfway line
- after the player being replaced has left
- after receiving a signal from the referee

In accordance with the Law 3: The Players, it is also stated that: “international teams where competition rules permit a maximum of five substitutes to be used, each team:

- has a maximum of three substitution opportunities*
- may additionally make substitutions at half-time

*Where both teams make a substitution at the same time, this will count as a used substitution opportunity for both teams. Multiple substitutions (and requests) by a team during the same stoppage in play count as one used substitution opportunity.

Substitution Opportunity. A substitution opportunity is essentially the moment in which a team uses a substitution. Historically, setting a maximum number of substitution opportunities was irrelevant since, prior to the change in the substitution law, the three substitutions occurred in three substitution opportunities as most substitutions were a one-for-one replacement. Teams could substitute multiple players into the game at the same time but there were not that many

personnel changes occurring in order to have rules about a limited number of opportunities. In order to avoid time wasting (since the clock is always running in a soccer match), the law was set up such that the five substitutions must take place within three opportunities. The switch to five substitutes per team requires teams to substitute multiple players at the same opportunity if they do want to use all five of their available players. Although, as noted in the bullet points above, the substitutions that occur during the natural stoppage of play at halftime are not included in the number of substitution opportunities used by a team.

Furthermore, teams gain one additional substitution when a knockout stage game goes into extra time, “regardless of whether or not the team has already used the full number of permitted substitutes before extra time” (“Regulations FIFA World Cup 2022”, 2022, p. 45). Law 3.2 of the IFAB states that “substitutions may also be made in the period between full-time and the start of extra time, and at half-time in extra time – these do not count as used substitution opportunities.”

Literature Review

Most of the research that has been completed on substitutions is based on games with the three substitution rules or fails to provide a tangible strategy for making substitutions. Work by Corral et al. looks at the Spanish league for the first substitution a team makes and gives insight on factors, aside from timing, that do influence the substitution patterns, such as score of the game at the time of the substitution, whether the game was being played home or away, as well as the defensive or offensive position of the player being substituted (2008). Myers conducted a study that determined the minute in which a team should make their first, second and third

substitutions depending on whether the team was winning, losing, or tied at the time in which they made the substitution (2012). It is stated that when losing, a team should make the first substitution prior to the 58th minute, the second substitution prior to the 73rd minute, and the third substitution prior to the 79th minute (Myers, 2012). According to Myers, the timing of substitutions do not impact the result of the game if the team is tied or winning (2012). These results are known as the Myers' Decision Rule. There were some limitations to the Myers' Decision Rule therefore Silva and Swartz provided an exploration of Myers' work and shared an alternative analysis (2016). In conclusion, Silva and Swartz essentially state that there is no best time in a soccer game to make a substitution (2016).

Uniquely, Myers does provide somewhat of a strategy with his proposed Decision Rule. Although the Decision Rule is limited to only providing a solution based on the minute of the game and moments in which a team is losing. It could be valuable to have insight on substitutions patterns when a team is winning and tied as well. Furthermore, previous work on substitutions in soccer is inadequate and outdated due to the new substitution guideline that allows for five substitutions.

Methods

The data for this research was self-collected from the FIFA's official Scores & Fixtures page ("Scores & Fixtures"). The website includes details about each match that occurred in the 2022 FIFA World Cup from November 20th to December 18th 2022. The timeline of events for each match was scraped for valuable information. Each row in the dataset was an individual substitution. The minute the player entered the game was the primary variable of interest. The

minute of substitution variable ranges from one to 45 for the first half and 46 to 90 for the second half with substitutions that occurred at halftime noted as the 46 minute mark. The clock is always running in professional soccer games therefore at the end of a half the referee adds on time that was wasted. There were numerous substitutions in the 2022 FIFA World Cup that occurred in minutes added on to the first half, but the time of these substitutions were rounded down to the 45th minute for a more accurate analysis. Substitutions that occurred in the minutes added on at the end of a regular time match were rounded down to the 90 minute mark. For knockout stage games that went into extra time, the minute of substitution variable also includes 91 to 105 for the first half of extra time and 106 to 120 for the second half of extra time with the 106th minute marking the break between periods where substitutions can occur. Substitutions that occurred in the minutes added on during the extra time period were also rounded down to either the 106th or 120th minute mark, respectively.

This exploratory analysis is focused on the timing of substitutions as they relate to the other factors, such as if the team was winning when the substitution was made or if they won the game itself.¹ The total number of goals scored and conceded in the game by the team making the substitution was collected as well as the game outcome (win, tie, loss). In addition, the number of goals scored and conceded prior to the minute the substitute entered the game as well as the game state (winning, tied, losing) at the time of the substitution was gathered.

The number of the substitution, is whether the player was the first, second, third, fourth, or fifth (or, in extra time knockout stage scenarios, sixth) player to enter the game for a team. The substitution opportunity (substitution moment) for which the substitution took place was also collected for the analysis.

¹ Most analyses are performed on games in which teams made a total of five substitutions. This is due to an interest in the fact that five substitutions were first allowed in the 2022 FIFA World Cup and, as will be mentioned later, that the majority of both group and knockout stage matches used five substitutions.

Other variables were gathered on a team basis as they related to the individual substitution, such as the total number of substitutions used by the team and the total number of substitutions opportunities used by the team. These variables provide novel insights being that the 2022 World Cup was the first World Cup in which a maximum of five substitutions (six in extra time knockout stage games) was allowed and substitution opportunities were in existence.

The team making the substitution and the nation of their opponent were also collected from the FIFA website. An analysis based on the specific attributes of the team occurred so additional sources were referenced for information on the quality of the team and their opponent. The position of the team in the group stage as well as how far in the tournament the team made it before being knocked out was gathered from a phone app called FotMob. In addition, FIFA ranking, which is an official ranking of every international team (despite their inclusion, or lack thereof, in the 2022 FIFA World Cup) by the official governing body of soccer was included.

The type of game (group, knockout) as well as duration of the game (regular, extra time) was also taken into account. Throughout this study the results are split based on the game type variable, which consists of either a group stage game or a knockout stage game. The methodology employed to analyze these two types of games differs. A group stage game can end in a tie but a knockout stage game continues into extra time or a penalty kick shootout if the game is tied at the end. Teams most likely have a different strategy in the group stage games compared to in the knockout stage when they potentially have to play additional 30 minutes via two 15-minute periods directly after a 90 minute battle. A head coach might be more conservative with the substitutions in this case. Furthermore, as mentioned previously, teams competing in knockout stage games that go to extra time also gain an additional substitution, which fundamentally shifts the substitution strategy for a manager.

Similar to Myers' research, this study does not include team formation as a variable. This is due to it being challenging to track and somewhat subjective. (Myers, 2012) In addition, "a team could start in one formation, then evolve into at least one other during the course of the match" (Myers, 2012, p. 3). Furthermore, this analysis is only concerned with field players. Although the position (e.g., defense, midfield, attack) of the player entering the game, as well as the player being replaced, was not collected due to the complexity of positions in the modern game of soccer. Tactics of professional soccer are advancing such that the field position of a player is extremely fluid in the type of runs and responsibilities of the player. It is also not uncommon for a player to change their position throughout the course of the game, which would affect the outcome of the data if this were to be analyzed. Although it was not included as a variable, position was referenced early on to ensure that no substitutions relating to a goalkeeper were included. Goalkeeper substitutions are rare and typically are made for different reasons than field player substitutions. There was one goalkeeper substitution made during the 2022 World Cup that was excluded from this study.

After excluding irrelevant substitutions this analysis was based on 564 observations gathered from the 2022 FIFA World Cup ("Scores & Fixtures"). The original dataset also included whether or not the substitution was made due to player injury (and/or because of a concussion). As well as whether or not a red card was distributed to a player on the team making the substitution was also included in the analysis. These variables were collected from FotMob (2023). A concussion substitution protocol was introduced for the 2022 World Cup that allotted an extra substitution and substitution moment for a player potentially suffering from a head injury. These substitutions are unrelated to tactics and are a health measure therefore four substitutions were removed from the database. Furthermore, all substitutions that occurred

during games in which a red card influenced the outcome of the game were also excluded. The only game in which both a red card was given and the scoreline changed after a substitution was in the group stage when Wales lost zero to two to Iran. The score was tied at zero to zero when Welsh player Wayne Hennessey received a straight red card in the 86th minute. Wales went on to concede two goals in the time added on at the end of the game. Due to this extreme situation all the Welsh and Iranian substitutions from this game are not included in the overall study.

Lastly, all first half injury substitutions are excluded from the dataset. Typically, few if any substitutions are made in the first half of a soccer game. If there is a first half substitution, it is usually because of an injury, and not an intentional decision by the coaching staff. The 2022 World Cup had eleven substitutions during the first half; nine of which were injury related (non-concussion based). These nine injury based substitutions were excluded. France made two substitutions in the first half of a match that were the only non-injury based substitutions to take place in the entirety of the competition. Second half injury-based substitutions could have also been excluded from this analysis since they are not at the discretion of the head coach. However, due to the change in the substitution rule to allow for more substitutions, teams had more of a chance to make a substitution when a player may have had an injury. The second half injury substitutions were included in this study because it was difficult to differentiate between insincere player injuries and injury substitutions as a precautionary measure.

This study considers the multitude of game situations a manager may face and shares the substitution patterns used based on the tendencies of teams in the 2022 World Cup. After filtering the dataset, the main variables used and that will be discussed in this exploratory analysis are minute of substitution, game type, game outcome, game state, substitution moment, substitution number, substitution team, and FIFA ranking.

Results

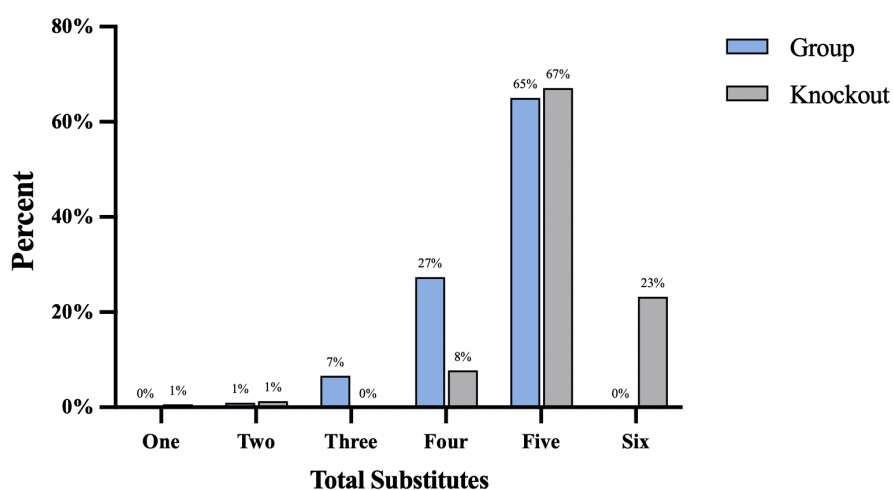
Number of Substitutions

The number of substitutions ranges from zero substitutions to five substitutions in the group stage and regular time knockout stage games. The range is from zero substitutions to six substitutions for knockout stage games that went into extra time since teams have the option to make an additional substitute in these situations.

In the group stage, 65% of teams used all five substitutions. This was followed by 27% of teams using four substitutions. Similarly, in the knockout stage, most of the teams, which was 67%, tended to use all five substitutions. The next highest number of substitutions used was six, which occurred by 23% of teams in the knockout stage matches. Based on the analysis, overall teams in both the group and knockout stages tended to use five substitutions.

Figure 1

Percent of Total Substitutes Used by Teams



Halftime Substitutions

Table 1

Percent of Halftime Substitutions

Game Type	Group	Knockout
	Halftime Substitution	
Yes	33	28
No	67	72
<i>N</i>	94	32

Substitution Moment

Table 2

Count of Substitution Moments Used

Game Type	Group	Knockout
	Substitution Moment(s)	
One	2	1
Two	12	2
Three	61	13
Four	19	15
Five		1
<i>N</i>	94	32

Game Outcome

One-Way ANOVA for Group Stage. A series of one-way analysis of variance (ANOVA) tests were conducted to determine, among games in which teams made a total of five substitutions, were there statistically significant differences in the average time that a substitution occurred depending on the game outcome (win, tie, loss). Taking a look at the outcome of the game is worthwhile since it could depict any common approaches of substitutions teams may have had in order to get the match result that they did. Predominantly, this analysis seeks to discover if there are any similarities and significance of the timing a substitution occurred when teams won instead of lost the game. Note that the confidence interval (CI) is stated in the results to share the range of time that substitutions occurred rather than a single minute of the average time of substitutions via the mean.

The results of a one-way ANOVA indicated that, among games in the group stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the second substitution occurred depending on the game outcome (win, tie, loss), $F(2,51) = 7.15, p = 0.002$. Teams that lost (95% CI (55.08, 62.12)) made their second substitution statistically significantly earlier, on average than those who won (95% CI (62.28, 69.63)) or tied (95% CI (64.14, 78.53)). There were no statistically significant differences in the timing of the second substitution in the group stage when teams won compared to tied the game.

In addition, the results of a one-way ANOVA indicated that, among games in the group stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the third substitution occurred depending on the game outcome (win, tie, loss), $F(2,51) = 3.59, p = 0.035$. Teams that lost (95% CI (63.70, 70.47)) made

their third substitution statistically significantly earlier, on average than those who won (95% CI (69.65, 76.70)). There were no statistically significant differences in the timing of the third substitution in the group stage when teams lost compared to tied the game nor teams that won compared to tied.

Overall, the results of various one-way ANOVAs indicated that, among games in the group stage in which teams made a total of five substitutions, there were no significant differences in the average time that the first, fourth and fifth substitution occurred depending on the game outcome (win, tie, loss).

When analyzing the results for group stage matchups with a game outcome of a win compared to a loss, it seems that teams that waited later in the game to make their second and third substitutions tended to win the game. Teams that waited to make their second substitution also tended to tie rather than lose the game.

One-Way ANOVA for Knockout Stage. On the other hand, in the knockout stage, the results of a one-way ANOVA indicated that, among games in which teams made a total of five substitutions, there were statistically significant differences in the average time that the second substitution occurred depending on the game outcome (win, tie, loss), $F(2,18) = 3.57$, $p = 0.005$. Teams that lost (95% CI (47.66, 60.54)) made their second substitution statistically significantly earlier, on average than those that won (95% CI (59.01, 74.42)). There were no statistically significant differences in the timing of the second substitution in the group stage when teams lost compared to tied the game nor teams that won compared to tied.

The results of a one-way ANOVA also indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the third substitution occurred depending on the game outcome (win, tie,

loss), $F(2,18) = 6.21, p = 0.009$. Teams that lost (95% CI (55.55, 69.05)) made their third substitution statistically significantly earlier, on average than those who won (95% CI (65.50, 81.64)) or tied (95% CI (71.58, 92.92)). There were no statistically significant differences in the timing of the third substitution in the knockout stage when teams won compared to tied the game.

The results of another one-way ANOVA indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the fourth substitution occurred depending on the game outcome (win, tie, loss), $F(2,18) = 12.43, p < 0.001$. Teams that lost (95% CI (66.16, 77.04)) made their fourth substitution statistically significantly earlier, on average than those who won (95% CI (75.64, 88.64)) or tied (95% CI (86.65, 103.85)). In addition, teams that won (95% CI (75.64, 88.64)) made their fourth substitution statistically significantly earlier, on average than those who tied (95% CI (86.65, 103.85)).

Lastly, the results of a one-way ANOVA indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the fifth substitution occurred depending on the game outcome (win, tie, loss), $F(2,17) = 34.30, p < 0.001$. Teams that tied (95% CI (103.33, 116.17)) made their fifth substitution statistically significantly later, on average than those who won (95% CI (79.01, 88.71)) or lost (95% CI (76.44, 84.56)). There were no statistically significant differences in the timing of the fifth substitution in the knockout stage when teams won compared to lost the game.

Overall, the results of various one-way ANOVAs indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were no significant

differences in the average time that the first substitution occurred depending on the game outcome (win, tie, loss).

When analyzing the results for knockout stage matchups with a game outcome of a win compared to a loss, it seems that teams that waited later in the game to make their second, third, and fourth substitutions tended to win the game. Teams that waited to make their third and fourth substitutions also tended to tie rather than lose the game. However, teams that tended to wait to make their fourth substitution tended to tie rather than win. Lastly, teams that made their fifth substitution later tended to win or lose rather than tie the game.

Game State

One-Way ANOVA for Group Stage. In the group stage, the results of a one-way ANOVA indicated that, among games in which teams made a total of five substitutions, there were statistically significant differences in the average time that the first substitution occurred depending on the game state (winning, tied, losing), $F(2,47) = 3.53, p = 0.037$. Teams that were losing (95% CI (50.11, 58.44)) made their first substitution statistically significantly earlier, on average than those who were winning (95% CI (57.07, 65.64)). Meanwhile teams that were tied (95% CI (49.97, 59.10)) also made their first substitution statistically significantly earlier, on average than those that were winning (95% CI (57.07, 65.64)). There were no statistically significant differences in the timing of the first substitution in the group stage when teams were losing compared to tied at the minute of the substitution.

In addition, the results of a one-way ANOVA indicated that, among games in the group stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the second substitution occurred depending on the game state

(winning, tied, losing), $F(2,51) = 6.29, p = 0.004$. Teams that were losing (95% CI (53.02, 61.68)) made their second substitution statistically significantly earlier, on average than those that were tied (95% CI (59.46, 67.87)) or winning (95% CI (63.75, 71.94)). There were no statistically significant differences in the timing of the second substitution in the group stage when teams were winning compared to tied at the minute of the substitution.

The results of another a one-way ANOVA indicated that, among games in the group stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the third substitution occurred depending on the game state (winning, tied, losing), $F(2,47) = 5.56, p = 0.007$. Teams that were losing (95% CI (62.45, 69.97)) made their third substitution statistically significantly earlier, on average than those who were winning (95% CI (71.24, 78.76)). There were no statistically significant differences in the timing of the third substitution in the group stage when teams were losing compared to tied at the minute of the substitution nor when teams were winning compared to tied at the minute of the substitution.

Lastly, the results of various one-way ANOVAs indicated that, among games in the group stage in which teams made a total of five substitutions, there were no significant differences in the average time that the fourth and fifth substitution occurred depending on the game state (winning, tied, losing).

When analyzing the results for group stage matchups with a game state, teams that were winning rather than losing tended to wait later in the game to make their first, second, and third substitutions. Teams that were tied rather than winning tended to make their first substitution earlier but teams that were tied rather than losing tended to make their second substitution later.

One-Way ANOVA for Knockout Stage. In the knockout stage, the results of a one-way ANOVA indicated that, among games in which teams made a total of five substitutions, there

were statistically significant differences in the average time that the first substitution occurred depending on the game state (winning, tied, losing), $F(2,17) = 5.67, p = 0.013$. Teams that were losing (95% CI (44.29, 54.71)) made their first substitution statistically significantly earlier, on average than those who were tied (95% CI (54.49, 73.51)) or winning (95% CI (53.35, 65.80)). There were no statistically significant differences in the timing of the first substitution in the knockout stage when teams were winning compared to tied at the minute of the substitution.

The results of another one-way ANOVA indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the second substitution occurred depending on the game state (winning, tied, losing), $F(2,18) = 5.85, p = 0.011$. Teams that were losing (95% CI (47.71, 59.02)) made their second substitution statistically significantly earlier, on average than those who were tied (95% CI (55.85, 77.49)) or winning (95% CI (59.63, 73.80)). There were no statistically significant differences in the timing of the second substitution in the knockout stage when teams were winning compared to tied at the minute of the substitution.

In addition, the results of a one-way ANOVA indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the third substitution occurred depending on the game state (winning, tied, losing), $F(2,18) = 10.95, p < 0.001$. Teams that were losing (95% CI (56.83, 68.08)) made their third substitution statistically significantly earlier, on average than those who were tied (95% CI (77.57, 99.10)) or winning (95% CI (66.53, 80.62)). Also, teams that were winning (95% CI (66.53, 80.62)) made their third substitution statistically significantly earlier, on average than those who were tied (95% CI (77.57, 99.10)).

Furthermore, the results of a one-way ANOVA indicated that, among games in the

knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the fourth substitution occurred depending on the game state (winning, tied, losing), $F(2,18) = 21.52, p < 0.001$. Teams that were losing (95% CI (67.84, 76.53)) made their fourth substitution statistically significantly earlier, on average than those who were tied (95% CI (92.68, 109.32)) or winning (95% CI (76.70, 87.59)). Teams that were winning (95% CI (76.70, 87.59)) also made their fourth substitution statistically significantly earlier, on average than those who were tied (95% CI (92.68, 109.32)).

Finally, the results of a one-way ANOVA indicated that, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the fifth substitution occurred depending on the game state (winning, tied, losing), $F(2,18) = 34.30, p < 0.001$. Teams that were tied (95% CI (103.33, 116.17)) made their fifth substitution statistically significantly later, on average than those who were losing (95% CI (76.44, 84.56)) or winning (95% CI (79.01, 88.71)). There were no statistically significant differences in the timing of the fifth substitution in the knockout stage when teams were winning compared to losing at the minute of the substitution.

When analyzing the results for knockout stage matchups with a game state, teams that were winning rather than losing tended to wait later in the game to make their first, second, third, and fourth substitutions. Teams that were tied rather than losing also tended to wait later in the game to make their first, second, third, and fourth substitutions. Teams that were winning rather than tied tended to make their third, fourth, and fifth substitutions earlier. In addition teams that were tied rather than losing also tended to make their fifth substitution later.

FIFA Ranking

According to the results of a Spearman's correlation analysis, among games in the group stage in which teams made a total of five substitutions, there was no relationship between FIFA ranking and the time of any of substitutions. In the knockout stage, according to the results of a Spearman's correlation analysis, among games in which teams made a total of five substitutions, there is a moderate relationship between FIFA ranking and the time of the third substitution, $\rho(N = 21) = -0.40, p = 0.73$. Similarly, according to the results of a Spearman's correlation analysis, among games in the knockout stage in which teams made a total of five substitutions, there is a moderate relationship between FIFA ranking and the time of the fourth substitution, $\rho(N = 21) = -0.30, p = 0.18$.

Discussion

Number of Substitutions

The first variable of interest is the number of substitutions that a team tends to use in a game. With the change in the substitution law, did teams in the 2022 World Cup still use three substitutions like they were previously limited to? Or now that they were given the chance, did teams opt to use more substitutions?

Recall that, in the group stage, 65% of teams used all five substitutions and in the knockout stage 67% of teams tended to use all five substitutions. Games in which five substitutions were made by a team indicate that the team replaced half of their field player starting line up. The reason why most teams opted to use a majority of their available substitutes

is uncertain since coaches do not usually provide an explanation for a substitution. A large number of substitutions may have occurred due to a change in tactics or as replacements for fatigued players. However, the current situation and a teams' desire to win the game might also influence the number of substitutions a team uses as well as the times in which a team chooses to make their substitutions.

Due to the fact that 92% of teams in the group stage used more than three substitutions and 98% of teams in the knockout stage used more than three substitutions, it is clear that a high majority of the coaches felt as though there was an advantage in all game circumstances to use more than three substitutions.

Halftime Substitutions

One question typically asked by soccer pundits is whether a team is going to make substitutions at halftime. Halftime is the only occasion during a regular time soccer game where the clock stops and players are given a break. Naturally, during the first half, a head coach and his staff have two primary objectives: (1) observe their opponent's offensive tendencies and determine if their own tactics and players currently on the field are capable of preventing the opponent from scoring a goal; and (2) observe their opponent's defensive tendencies and brainstorm strategies and personnel needed in order to score a goal (or, if winning, keep the scoreline as it is). The break at halftime allows coaches, their staff, and players to come together to analyze these objectives. A coach can gain his players' perspective on what is and is not working, make any necessary tactical adjustments, and provide direct instruction to the players regarding any changes to tactics. Oftentimes a change in tactics result in a change in the

personnel as well. In group stage games, 33% of substitutions occurred at halftime while in knockout stage games, 28% of substitutions occurred at halftime. Both cases have substantial amounts of halftime substitutions. Substitutions at halftime are probably only slightly less common in the knockout stage compared to the group stage since there could potentially be more available moments to make substitutions in the knockout stage. Knockout stage games that go into extra time increase the number of minutes and moments substitutions could occur.

Substitution Moment

The shift from a maximum of three substitutions to five led to the introduction of substitution opportunities. While there was previously one-for-one substitutions at World Cup competitions, if a team in the 2022 World Cup wanted to use all five substitutions then it had to make multiple substitutions at the same time. Due to this new facet of soccer substitutions, the following analysis took place regarding the number of substitution moments a team chose to make.²

Group Stage. In the group stage, 65% of teams made their substitutions in a total of three moments. Recall that 33% of substitutions in the group stage occurred at halftime therefore if a team made one (or multiple) replacements at halftime, there were only two other occasions for the remainder of substitutions to occur. This is somewhat surprising, as it seems that most teams did not opt to use all three of their available moments during the run of play. Considering the fact that, in the group stage 88.3% of teams used a total of either four or five substitutions indicates

² By FIFA's definition, halftime is not included as a substitution opportunity. This analysis refers to substitution opportunities as "substitution moments" so that the count of occurrences in which substitutions are made can include halftime. For example, if four substitution moments happened in a game this means that the team used their maximum of three opportunities during the run of play as well as halftime.

that teams tended to substitute more than one player into the game at the same minute. Perhaps, making multiple changes at the same minute was somehow useful to a team. One reason for this may be that the coach preferred certain players to play together so he substituted them into the game at the same moment. Alternatively, the use of multiple substitutions at the same time might just be due to the coach wanting to replace the most fatigued players with players that have more speed and energy at the same time to hopefully increase the tempo.

Knockout Stage. In the knockout stage, 41% of teams made their substitutions in a total of three moments while 47% of teams made their substitutions in a total of four moments. The shift towards four substitution moments could indicate that substitutions were made at halftime. Although this would only be the case for knockout stage games that declared a winner after the 90 minutes of regular time. However, use of four substitution moments is probably more due to some of the knockout stage games going to extra time and thus gaining more substitution moments options. These matches allotted a team with more chances to make substitutions since teams gained one additional substitution opportunity during the run of play as well as other chances to make substitutions at the end of regular time or at the break between the two periods of extra time. This could have potentially caused an increase in the number of moments to four. However, the reasons for substitutions are most likely the same in the knockout stage as they were in the group stage. Teams may have wanted to put certain players into the game at the same time or make replacements for fatigued players all at once. Although the substitution strategy in the knockout stage definitely differs from the group stage. For example, when winning the game, teams in the knockout stage may be more inclined to use more substitution moments in order to waste time. A team in extra time may also use up a spare substitution moment towards the end of the game simply because they want to put in a player specifically to take a penalty kick in the

shootout. In knockout stage games that went into extra time, 40% of teams used five substitutions and 60% of teams used six substitutions. Teams in the knockout stage were using more substitutions and therefore probably happened to use more substitution moments.

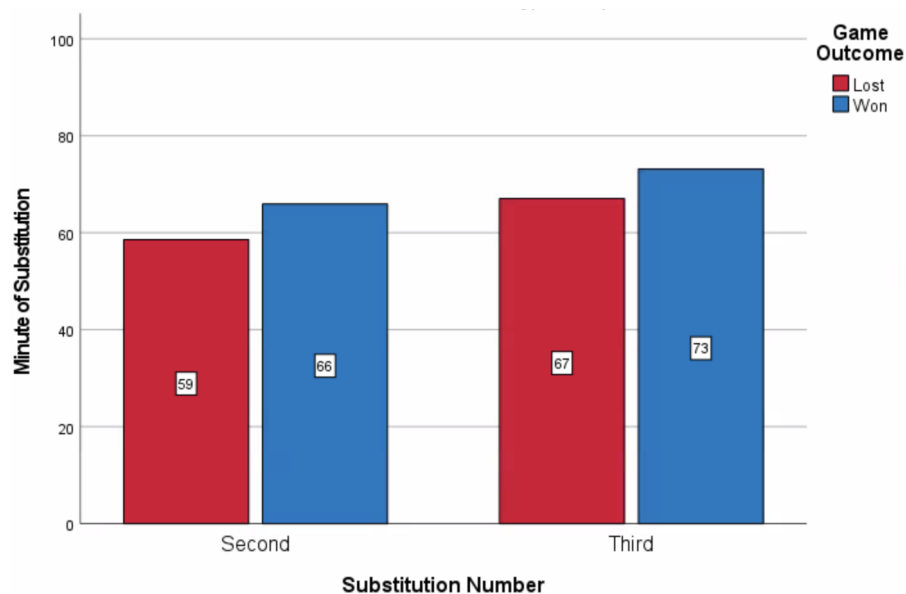
Timing of Substitutions

During the 2022 FIFA World Cup, the minute in which a team made their substitutions does matter – but it depends on the situation. The specific reasons that some of the substitutions were significant depending on timing is not known. But multiple speculations will be discussed.

Analysis of Game Outcome. Game outcome is whether a team won, lost, or tied the game. It was found that in the group stage, when teams made a total of five substitutions they tended to win rather than lose the game when they made their second and third substitutions later in the match.

Figure 2

Average time of Substitutions in the Group Stage depending on Game Outcome



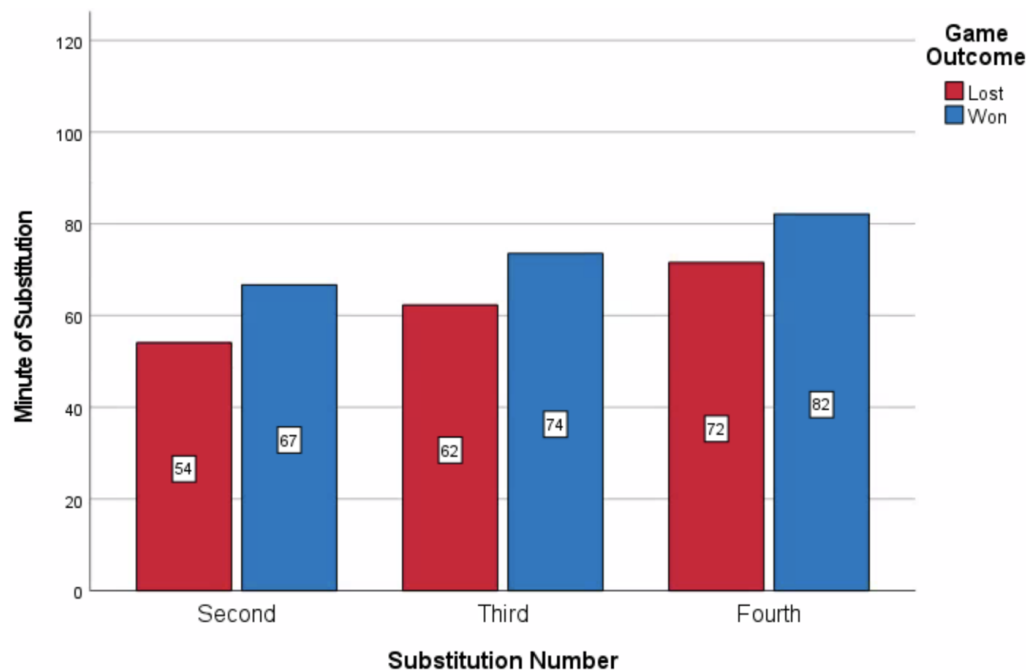
The significance of making these substitutions later in the game may be due to the fact the team had a better sense of their opponent as it became later in the game and could therefore make more informed decisions regarding their substitutions. In addition, when teams made their second substitution later they also tended to tie rather than lose the group stage game. This could also be due to teams having a better understanding of their opponent the longer they waited and thus were able to make educated substitutions that allow them to gain the tie rather than the loss.

There were no statistically significant results for the average time of the first, fourth and fifth substitutions in the group stage when teams made a total of five substitutions. The reason for this is also unknown. Although it is possible that making substitutions too early, such as the timing that is related to the first substitution, is not impactful enough on the game outcome. Meanwhile the latter substitutions occur too late and also do not play a role in whether a team wins, loses or ties.

In the knockout stage, teams that waited later in the game to make their second, third, and fourth substitutions tended to win the game rather than lose it.

Figure 3

Average time of Substitutions in the Knockout Stage depending on Game Outcome



Despite lack of certainty, there is most likely something valuable about the fact that significant results for winning compared to losing only occurred with the middle most substitutions (second, third, and fourth rather than first and fifth). Perhaps the winner of the game was somewhat already determined by the time in the game the fifth substitutions occurred so the minute this player entered the game did not matter. Similar to the group stage, teams in the knockout stage that wait to make a substitution may have a better understanding of the playing style of their opponent, and could therefore make more adequate substitutions that helped them to win the game. In addition, the later it becomes in a game the more fatigued players become.

Waiting to make substitutions might play a role in teams winning their games because there is more of a drastic difference in the fresh energy a substitution brings when they do join.

Substitutes can potentially make more of a difference in the game when the level of energy of the opponent is less than that of their own replacements. Teams that won seemed to have kept their starters in the game longer than teams that lost so potentially teams had their best players involved in the game for longer.

Meanwhile, teams that waited to make their third and fourth substitutions tended to tie rather than lose the game. However, teams that tended to wait to make their fourth substitution also tended to tie rather than win. This indicates that the timing of the fourth substitution in games that teams made a total of five substitutions is most likely quite critical. Recall that according to the one-way ANOVA test results, teams that tied the game tended to make their fourth substitution between the 86.65 and 103.85 minute marks on average. Teams that lost made their fourth substitution between the 66.17 and 77.04 minute marks on average while teams that won made their fourth substitution between the 75.64 and 88.64 minute marks on average in the knockout stage. The timing of the fourth substitution when a team tied tended to be substantially later than games that a team either won or lost. As previously mentioned, there were statistically significant results between the time of the fourth substitution when a team won compared to when they lost so making the fourth substitution between the 75.64 and 88.64 minute marks must have really benefited teams in winning the game. The reason for this is uncertain but potentially, with around 15 minutes left in the game, teams profited by putting in new, fresh energy.

Lastly, teams that made their fifth substitution later tended to win or lose rather than tie the game. The timing of the fifth substitution is most likely due to some of the knockout stage games continuing into extra time. Each of the knockout stage games that went into extra time

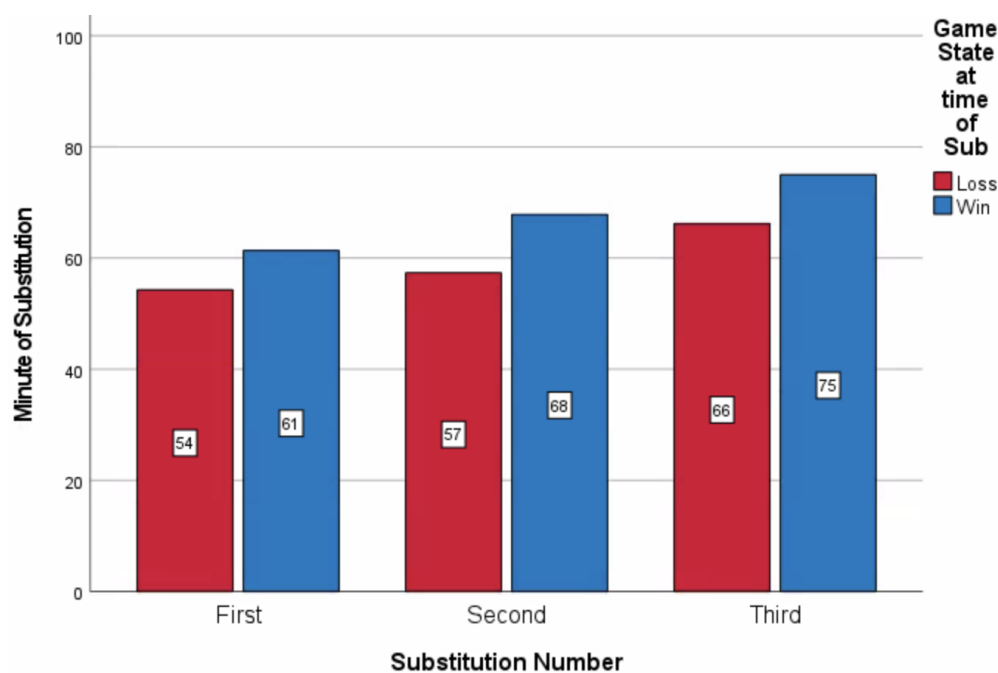
resulted in a tie therefore it makes sense that the final substitution teams made was statistically significantly later for teams that tied the game compared to those who won or lost.

Analysis of Game State. In addition to how the timing of substitutions may have related to the outcome of the game, the state of the game (winning, tied, or losing) at the time in which a substitution occurred may have also played a role. This variable provides hypothetical context to the thought process coaches may have when deciding upon substitutions. For example, it is hypothesized that the time in which a substitution is made when a team is winning is most likely different from the time a substitution is made when a team is losing.

In the group stage, teams that were winning at the time of the substitution tended to make their first, second, and third substitution later in the game compared to teams that were losing at the time of the substitution in the group stage.

Figure 4

Average time of Substitutions in the Group Stage depending on Game State



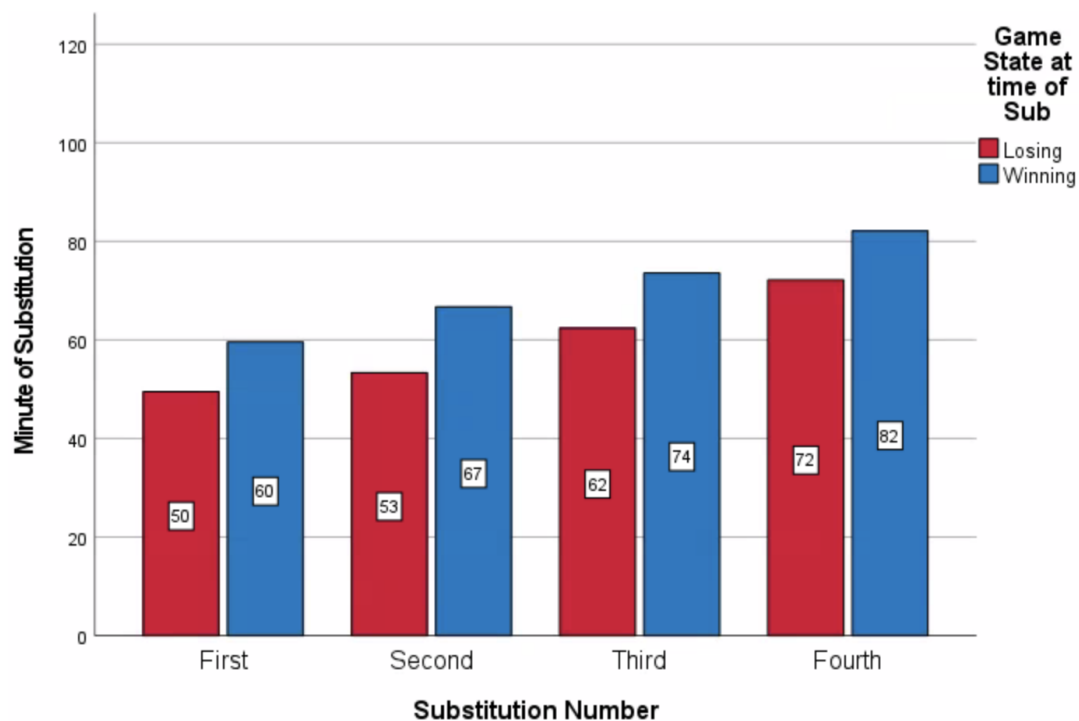
Teams that were winning when making their substitution most likely did not feel the need to make any changes sooner since they were already having success. Meanwhile a team that was losing probably wanted to make their substitutions earlier in order to potentially change the game state from losing to winning. Being that there were no significant results in the timing of the fourth and fifth substitutions in the group stage, it is possible that by the time in which the fourth and fifth substitutions were being made later on in the second half, the scoreline did not reflect the way a coach made his substitutions. It's likely that the state of the game was most likely not going to change depending on the timing of these substitutions.

Also in the group stage, when teams made a total of five substitutions, teams that were tied rather than winning tended to make their first substitution earlier but teams that were tied rather than losing tended to make their second substitution later. The timing of the first substitution occurring earlier when teams were tied rather than winning may be influenced by the number of first substitutions that occurred at or near halftime (46th minute). Sometimes in professional soccer games the score is tied at zero to zero at halftime. It is possible that the second substitution happened later when teams were tied rather than losing because teams were not influenced to make any adjustments to their starting lineup while still being level with their opponent.

In the knockout stage, teams that made five substitutions tended to make their first, second, third, and fourth substitutions later in the game when they were winning rather than losing.

Figure 5

Average time of Substitutions in the Knockout Stage depending on Game State



It may be possible that teams waited to make their substitutions since they were already having success and did not feel obligated to make any changes sooner. Teams that were losing probably felt pressure to make their substitutions earlier in hopes of changing the game state from losing to winning. Teams that were tied rather than losing also tended to wait later in the game to make their first, second, third, and fourth substitutions. A tie is still more favorable than losing so teams most likely tended to keep their starters in the game longer than teams that were losing. However, teams that were winning rather than tied tended to make their third, fourth, and fifth substitutions earlier. These results are probably influenced by the knockout stage games that continued into extra time. Most of the extra time matches remained tied for the duration of the additional 30 minutes so the third, fourth, and fifth substitutions naturally occurred much later

compared to in games when a team was winning. Teams that are winning might also make their fifth and final substitution in order to waste time. In addition, teams that were tied rather than losing also tended to make their fifth substitution later due to the same reason. It is uncertain why more of the individual substitutions showed statistically significant results in the timing of the substitutions in the knockout stage compared to the group. Perhaps, there is a difference in the strategy that is dependent on the timing of substitutions.

FIFA Ranking

The FIFA Ranking variable includes the official ranking of the teams prior to the start of the World Cup on October 6, 2022 (“Men’s Ranking”). The ranking of the teams does not have a role in who a team faces in the competition but rather just gives context to the quality of the team. The official rankings are used in this analysis since they can provide insights on whether the strength of a team was related to the time at which it chose to make a substitution. It could be hypothesized that the “better”, or higher ranked, teams made their substitutions around the same time in games.

Recall that according to the results of a Spearman’s correlation analysis, among games in the group stage in which teams made a total of five substitutions, there was no relationship between FIFA ranking and the time of any of substitutions. Essentially, this indicates that the minute that teams tended to make their substitutions was not based on the quality of the team making the substitution. It is surprising that, in the group stage, the better ranked teams, for example, did not follow a similar pattern for the time in which they made their substitutions. Perhaps, the substitutions a team chose to make in the group stage were more dependent on other

factors, such as the opponent or the scenario occurring in the game itself, such that the ranking of the team was not relevant to the substitution patterns that occurred. Recall that the one-way ANOVA of game state showed that teams that were winning tended to make their first couple of substitutions later in the game. Therefore it might be concluded that teams that were ranked higher would follow similar tendencies to teams that win rather than lose. However, according to the results of Spearman's correlation analysis this was not the case.

In the knockout stage, according to the results of a Spearman's correlation analysis, among games in which teams made a total of five substitutions, there were moderate relationships between FIFA ranking and the time of the third substitution as well as FIFA ranking and the time of the fourth substitution. In the knockout stage, just as in the group stage, the time in which the first and second substitutions were made were not statistically significantly different based on FIFA ranking, which may indicate that the first couple of substitutions that occur earlier on in the second half are not influenced by FIFA ranking. Yet, as the game progresses, teams gain a better understanding of the game and therefore of what they need their substitute to do in order to make an impact. The range of time in the second half when teams were making their third and fourth substitutions in the knockout stage is potentially a more critical period that could influence the outcome of the game. When highly skilled players of higher ranked teams, for example, enter the game around this time then they can have a significant impact. Furthermore, it is possible that by the time the end of the hypothetical critical period happens to be around the time that teams tended to make their fifth substitution. According to Spearman's correlation analysis, among games in the knockout stage in which teams made a total of five substitutions, there was no relationship between FIFA ranking and the time of the fifth substitution. Potentially

there is not enough time left in the game for fifth substitution to make an impact despite the quality of the substituted player based on the side's FIFA ranking.

The results from the Spearman's correlation analysis is also interesting since there are opposing results for the knockout compared to the group stage. This may have occurred since there are somewhat opposing game strategies in the various two stages. For example, by the third, and final, game in the group stage some teams already know whether they are going to move on to the knockout stage or be eliminated while others are still fighting to potentially advantage. Comparatively, in the knockout stage teams may be more likely to have a similar approach to each other as they are all only trying to advance to the next round. The varying strategies that teams had to their games in the knockout and group stages may have caused the timing of substitutions to fail to follow a pattern and be statistically significantly different based on ranking for only the knockout stage.

Lastly, based on the fact that the only substitutions that were statistically significantly different were the third and fourth substitutions in the knockout stage and that these both were only a moderate relationships, rather than strong ones, might indicate that the quality, or rank, of the team does not play that large of a role in the time of which a team chose to make these substitutions.

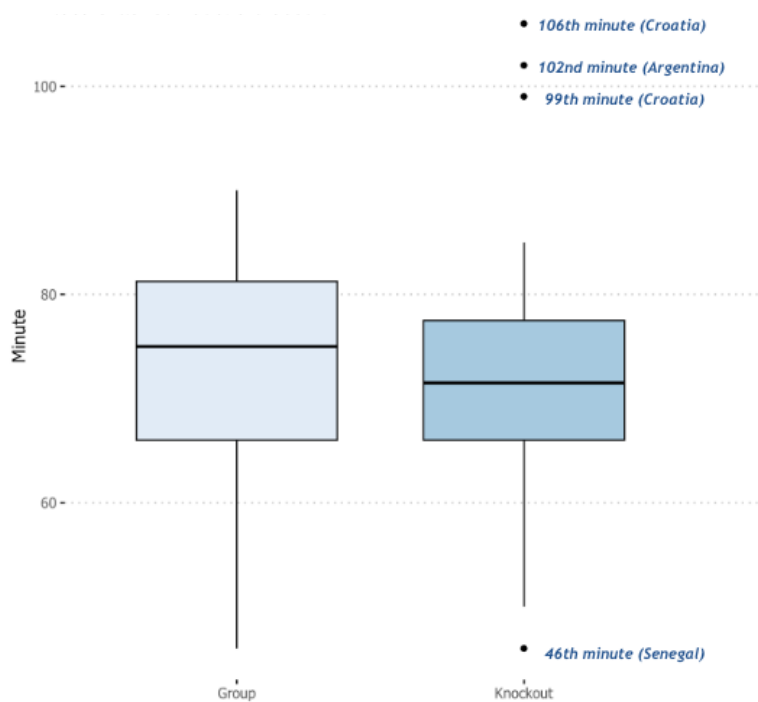
The Third Substitution in the Knockout Stage

There happen to be four outliers that occur based on the timing of the substitution and the number of the substitution for games in which a team made any total number of substitutions. Interestingly, each of the outliers occur at the third substitution during the knockout stage, which

is also when the timing of substitution was statistically significantly different based on the FIFA ranking variable (for games in which a team made a total of five substitutions). This is not to say that one of these variables is the cause of the other but it is interesting to take note of these outliers.

Figure 6

Timing of the Third Substitution in the Group and Knockout Stages



Note. The boxplot of the timing of the third substitutions in the group and knockout stage are based on games in which teams made any total number of substitutions. The team making the substitution corresponds to its respected outlier.

In the knockout stage for the third substitution, one outlier occurs on the earlier side while the remaining three are later. The outliers may occur only for knockout games because the duration of games for the knockout stage are sometimes longer due to the extra time. Also the outliers may only occur for third substitutions because the third substitution falls in the middle of the potential five substitutions a team can make, and therefore a team may be forced to make their third replacement grouped with other substitutions substantially earlier or later. The reason for these outliers cannot be confirmed, although each of these will be described.

Senegal (vs. England). The earliest of the outliers was the substitution made by Senegal (FIFA Ranking = 18th) against England (FIFA Ranking = 5th) in their round of 16 matchup. Senegal was losing zero to two at halftime against England and decided to make three changes at halftime so the outlier occurred at the 46th minute mark. This indicates that it was rare for a team to substitute three players at halftime during knockout stage games. Bukayo Saka scored in the 57th minute to put England up by three goals to nil, which would be the end result of the game. Based on this specific example, it seems that making three substitutions at halftime did not benefit Senegal. Their opponent, England, was also of a higher rank which could have played a factor in Senegal's inability to overcome the deficit of being two goals down when the substitutions occurred. Although credit to Aliou Cisse, the Senegal manager, for trying something different with his substitutions in hopes of having more success in the second half.

Croatia (vs. Japan). The next of the outliers is from Croatia (FIFA Ranking = 12th) in their round of 16 game against Japan (FIFA Ranking = 24th). Croatia made their third substitutions in the 99th minute, which is much later than the range of time the majority of teams made their third substitution. Earlier in this game, Ivan Perisic tied the score at one goal apiece in the 55th minute. The Croatians made their first and second substitutions in the 62nd and 68th

minutes, respectively. The 99th minute outlier occurs when the Croatian side brought in their third and fourth substitutions at the same substitution moment. The interquartile range (IQR) of the time for third substitutions in the knockout stage was 74-65.75. The median was the 71.5 minute mark. The outlier may indicate that teams during the knockout stage tended to prefer to make more changes to their starting lineup earlier in the game. From a Croatian perspective, the substitution pattern that they chose to follow, may not have been the best. As mentioned, they leveled the scoreline prior to making any substitutions and then failed to score again against a team that they were ranked higher than. This game between Croatia and Japan would end in a one to one tie with Croatia advancing to the next round, by winning three to one in a penalty kick shootout. Perhaps Croatia could have saved themselves some energy and stress by not waiting so late in the game to make their third substitution.

Croatia (vs. Brazil). Jumping ahead, it was another Croatian substitute, Lovro Majer, that occurred in the 106th minute as the latest of the third substitution outliers in the matchup quarterfinal match against Brazil (FIFA Ranking = 1st). Croatia (FIFA Ranking = 12th) made their first two substitutions at the same time in the 72nd minute, which is notably later than the majority of knockout stage first and second substitutions were made. The medians are the 62nd and 65th minutes of the game for the first and second substitutions, respectively. The score of this game was zero to zero after regulation. Brazil would score first after 105+1 minutes so it is possible that Croatia made this 106th minute substitution as a reaction to going down a goal and needing to score again to level the game.³ Interestingly, Brazil also made substitutions in the 106th minute of the game, however, these two replacements by Brazil were the last ones they

³ A notation such as 105+1 indicates the referee gave one minute of added time at the end of the game, which was 120 minutes in length. Similarly, for example, if a goal was scored three minutes into added time of the first half it would be written as 45+3.

made via their fourth and fifth substitutions. Croatia made their fourth and fifth substitutions in the 110th and 114th minutes, respectively. The 114th minute entrance of Mislav Orsic had a direct impact as he assisted Bruno Petkovic's 117th minute equalizer that sent the game into a penalty kick shootout. Majer, the outlier substitution, would also play a crucial role. He scored his penalty kick to help the Croatians win four to two in the shootout and move onto the semifinals. In fact, three of the four penalty kick takers for Croatia were players substituted into the game. It is hard to say whether this uncommon approach by the Croatians with their substitutions worked. On one hand, Croatia, who were the lower ranked team, benefited from their starters keeping the game on level terms with Brazil for the majority of the game but their substitutes did contribute to goal and penalty success. Could making changes sooner have allowed Croatia to win the game rather than depending on the "luck" of penalty kicks?

Argentina (vs. France). The remaining outlier was a substitution by Argentina (FIFA Ranking = 4th) in the 102nd minute in the final against France (FIFA Ranking = 3rd). Argentina had been winning two to zero for the majority of the game after scoring twice in the first half. Argentina made their first substitution in the 64th minute. In the 80th and 81st minutes, they conceded two goals, both from Kylian Mbappé. Argentina made their second substitution prior to the start of extra time in the 91st minute, which is somewhat shocking that making their second substitution in the 91st minute was not an outlier since this was definitely a late time to make only a second change to the starting lineup. The Argentine side then made their outlier third substitution along with their fourth substitution in the 102nd minute. Lionel Messi scored his second goal of the game in the 108th minute to put the South American side ahead. Argentina would bring their fifth substitute into the game at the 116th minute mark. Messi's goal wasn't enough to secure the victory as Mbappé converted a penalty kick opportunity during in the 118th

minute of the game to tie the score at three goals apiece and send the game to a penalty shootout to determine the World Cup champion. Prior to the final whistle, Argentina would make their sixth substitution at the 120+1 minute mark. Argentina won four to two in the penalty kick shootout and, similar to the Croatia matchup against Brazil, three of the four Argentine penalty kick takers were players substituted into the game.

Figure 7

Minute of Substitutions in the Knockout Stage for Games with Outliers

Team	First	Second	▲ Third	Fourth	Fifth	Sixth	Ranking
Senegal	46	46	46	72	84		18
Croatia	62	68	99	99	106	106	12
Argentina	64	91	102	102	116	120	3
Croatia	72	72	106	110	114		12

Note. In addition to FIFA Ranking, the table highlights the timing of the other substitutions in the games for which an outlier for the time third substitution occurred.

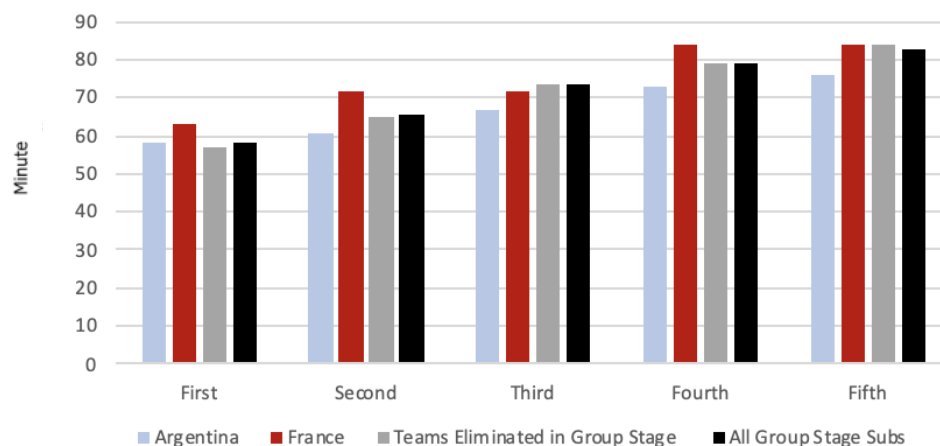
Timing of the Third Substitute. The three outliers that occurred later than the typical range of third substitutions in the World Cup all took place in matches that went to a penalty kick shootout in order to determine the winner. It is not just to assume that the third substitution played any type of role in this happening, although it does raise questions about whether making a third substitution so late in the game was ever of any benefit to the respective teams.

Also, recall that according to results of a one-way ANOVA, among games in the knockout stage in which teams made a total of five substitutions, there were statistically significant differences in the average time that the third substitution occurred depending on the game outcome (win, tie, loss), $F(2,18) = 6.21, p = 0.009$. Teams that lost (95% CI (55.55, 69.05))

made their first substitution statistically significantly earlier, on average than those who won (95% CI (65.50, 81.64)) or tied (95% CI (71.58, 92.92)). Teams in the knockout that waited later to make their third substitution tended to have won rather than lost. It is reasonable to assume that the teams associated with the outliers were doing something different than their opponents with their third substitution in the knockout stage. Although in these special cases, Croatia and Argentina went on to a penalty kick shootout so they did not win the game when substituting later. It is most likely because they waited too late in the game to make their substitutions in order to potentially win the game. However, also note that there are no statistically significant differences between a win and tie for the third substitution among games in the knockout stage in which teams made a total of five substitutions.

Analysis on Argentina's and France's Substitution Patterns

Argentina and France were the two teams in the final of the World Cup. The score of the final was tied three to three after 120 minutes. However, Argentina were crowned winners after beating France four to two in the penalty kick shootout. By making it to the final, it is possible that these two teams had something that set them apart from their competition. Due to their success in the tournament, an analysis was done on their substitution habits in comparison to the other teams in the World Cup.

Figure 8*Average Time of Substitutions in the Group Stage*

Number of Substitutions and Substitution Times in the Group Stage. In their three group stage matches, Argentina made a total of 14 substitutions. Interestingly, they lost their opening match two to one against Saudi Arabia, yet would come back and beat Mexico and Poland their following two group stage games by two goals to nil. In these games, the average time Argentina made a sub was at the 66.29 minute mark. However, the 70.85 minute mark was the average time of all of the substitutions that occurred during the group stage of the World Cup.

France also had an interesting start to their tournament – after winning their first two games against Australia and Denmark, they lost zero to one to Tunisia. However, unlike Argentina, France had already secured a spot in the knockout stage prior to their third group stage game. The French side’s head coach, Didier Deschamps, most likely took on a conservative approach for this match since only two of the Frenchmen who started the game against Denmark also started against Tunisia. Deschamps clearly used this as an opportunity to rest his key players. The French used 13 substitutions in the group stage and the average time these players

entered the game was 75.08 minutes in. This is almost ten minutes later than the average time of Argentine substitutes. The two most successful teams in the tournament definitely seem to oppose one another in terms of average substitutions times in the group stage. There were 64 teams in the World Cup and 32 teams did not move past the group stage. Teams eliminated in the group stage, who are notably less successful than teams such as France and Argentina, made their substitutions at the 70.79 minute mark on average.

Individual Substitution Times in the Group Stage. Similar to the average substitution time for the French being on the later end, they seem to wait longer to make each of their individual substitutions as well. Most notably, the second substitution for the French occurs a lot later than Argentina as well as the overall group average and solely the teams eliminated in the group. The French team waited until the 71.67 minute mark for their second substitution on average during the group stage compared to Argentina who subbed their second player into the game at the 60.33 minute mark on average. Furthermore, Argentina seemed to make their fifth substitution earlier than its competitors. On average, Argentina's fifth substitution occurred at the 76 minute mark. It is important to note that there are only three games in the group stage and Argentina made a fifth substitution in two of their three games. However, the fifth substitution they made occurred in the games that they won and they were already winning the game by the time they made the substitutions as well. Since Argentina was winning they most likely made a fifth substitution in order to waste time.

Substitution Times in the Group Stage compared to the Knockout Stage. On average, group stage substitutions occurred at the 70.85 minute mark while at the 74.97 minute mark in the knockout stage. France made their group and knockout stage substitutions at the 75.08 and 75.92 minute marks, on average, respectively. There is little difference between the time France

makes a substitution depending on the type of game. On the other hand, on average, Argentina made their substitutions at the 66.29 minute mark during the group stage. Yet, they made their substitutions at the 84.18 minute mark on average during knockout stage games. This is a large range compared to France.

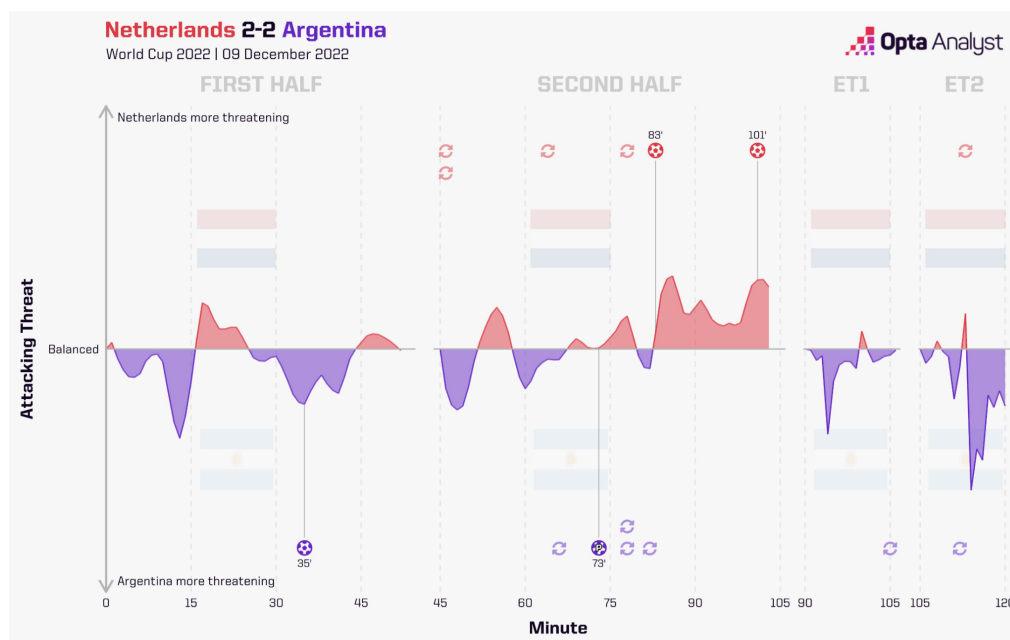
Substitution Times in the Knockout Stage. There seemed to be a trend of teams making each individual substitution later in knockout stage games compared to the group stage games on average. The later substitutions could be due to many factors. One being that some of the knockout stage games continued into extra time which thus extended the duration of the matches for another 30 minutes, and made a larger range for substitutions to occur. Another reason for the later substitution could be that teams wanted to be more conservative with their substitutions in the knockout stage. If the game is close in scoreline, teams may have wanted to wait to make replacements in case the game did become tied and went into extra time. Previously stated data showed that most teams tended to make their substitutions earlier in the game when losing at the time of the substitution compared to when winning or tied at the time of the substitution. So similarly, if the game is close in scoreline, teams that are winning at the time of the substitution will also want to waste time towards the end of the game with intentions of preserving the win.

A closer look at Argentina in the Knockout Stage. However, Argentina, unlike France, did play in one extra time game in the knockout stage prior to going into extra time against France in the final that could impact this result. If the extra time games are excluded, the average time of Argentina's knockout stage substitutions is at the 73.40 minute mark. Meanwhile the 93.17 minute mark is the time in which Argentina made their substitutions for solely matches that went into extra time, on average. Although, after further investigation of Argentina's two to

two draw against Netherlands, it is clear that Argentina did wait longer than their opponents to make substitutions. In this matchup, the Dutch side put in their fourth substitution at the same time the Argentine side put in their second substitution. It was the 78th minute and Argentina was also winning two to zero at this point. They would then concede two late goals and were forced into extra time. Argentina then made substitutions in the 106th and 112th minutes of the game which would extend the average substitution time as previously noted.

Figure 9

Timeline of Events in Netherlands vs Argentina Game



Note. The graph depicts the timeline of events, such as minute substitutions and goals as well as attacking threat via a shaded area, for the Netherlands (top) and Argentina (bottom).

Overview of Argentina and France's Substitution Patterns. Conducting an analysis of the substitution patterns for Argentina and France is fairly logical due to these two teams making it to the final of the 2022 FIFA World Cup. Clearly they had better performance outcomes than the other teams competing in the tournament, however, their substitution preferences did not particularly stand out. Argentina did tend to make their substitutions earlier than France in the group stage but there were not any major talking points for the timing of the substitutions in the knockout stage for these teams. Notably, the two teams certainly did not follow similar substitution patterns in terms of the timing. While both Argentina and France were successful in the World Cup, their accomplishments most likely cannot be attributed to following the same substitution patterns. However, could more knowledge on substitution patterns have benefited other countries in having success?

Future Research

There are multiple directions for which future research could occur related to the timing of substitutions. Ideally, further research could be taken to analyze games to see if there are statistically significant differences in the average time that each of the substitutions occurred depending on both the game outcome (win, tie, loss) and game state (winning, tied, losing). For example, it would be interesting to discover if there is a statistically significant time to make a substitution when a team was winning at the time of the substitution and went on to win the game compared to when teams were winning but lost the game. More data and information is needed to conduct such an analysis.

This project considered whether a team was winning, losing, or tied. To expand from this,

it would be interesting to take a look at the exact number of goals scored or conceded by a team in relation to the timing of substitutions. Further research could take place to determine whether the scoreline played a role in whether or not teams made substitutions at halftime. It's possible that teams that are winning in general, or winning by a certain number of goals, at halftime, may tend not to make any substitutions at that moment in order to continue executing the game plan. However, other teams who are winning at halftime may opt to make a substitution that will enhance their defensive abilities in hopes to avoid conceding a goal.

It is uncertain whether making a substitution at halftime is beneficial to any particular team so further analysis could take place regarding the game state of the match at halftime. As well as the FIFA ranking of the team making the substitution in comparison to their opponent and game state of the match at halftime. It might be logical for higher ranked teams to choose not to substitute at halftime, even when they are not winning. They might have confidence in their ability to break the opponent down eventually using the same game strategy they employed during the first half.

Future research could also occur to determine if the higher ranked teams were the ones who advanced to the knockout stage and therefore less variation in the rank of teams could have contributed to their being a statistically significant difference in the timing of substitutions the knockout stage rather than the group stage based on FIFA ranking. The ranking of the team making the substitution in comparison to the opponent could also be looked at.

Another avenue of future research could take place including the momentum of the game in relation to the substitutions a team made. For example, if a team has a higher xG than their opponent after the first half, this implies that the team had better goal scoring opportunities, and therefore might refrain from making substitutions at halftime because they are already being

successful.⁴ There are certainly a lot of intangibles, such as the momentum of the game, that influence the reasoning behind a substitution that this study was unable to analyze.

In addition, more research could include an analysis of the previous World Cups, such as the 2018 World Cup that had a limit of three substitutions. A similar analysis could also be done based on professional domestic leagues.

Conclusion

Overall, in the 2022 World Cup teams seemed to take advantage of the new substitution law and tended to make a total of five substitutions. It was also common for teams to make substitutions at halftime. This is most likely due to halftime being the only, if not one of the few, times that a game stopped to take a break. In addition, teams tended not to use all of their available substitution moments which indicates that multiple substitutions were made at the same time.

When teams made a total of five substitutions, they tended to win instead of lose when they made their second and third substitutions later in group stage and when they made their first, second, third, and fourth substitutions later in the knockout stage. Meanwhile when teams made a total of five substitutions, they tended to tie instead of lose when they made their second substitution later in group stage as well as their third, fourth, and fifth substitutions later in the knockout stage. Uniquely, in the knockout stage teams tended to make their fifth substitution earlier when they won instead of tied the game. The reasons for these results could be due to a variety of factors but the answer is uncertain.

⁴ “Expected Goals (xG) is a metric designed to measure the probability of a shot resulting in a goal” (StatsBomb, 2023).

If a team was winning when they made their substitution, then a coach tended to wait to make their first, second, and third substitutions than when they were losing in games in which the team made a total of five substitutions. In the knockout stage the first, second, third, and fourth substitutions occurred later in the game when the team was winning compared to when they were losing. For each of these previously mentioned group and knockout substitution numbers, apart from the third substitution in the group stage, teams also tended to make the substitution later when they were tied compared to when they were losing. Uniquely, in the knockout stage teams tended to make their fifth substitution earlier when they were winning instead of tying the game at the time of the substitution. Also the third substitution in the knockout stage tended to take place earlier for teams that were winning compared to when they were tied. The reason for these results cannot be concluded although it does seem that something interesting occurs with the third substitutions in knockout stage games.

The FIFA ranking of the team did not relate to the time substitutions occurred in the group stage. Although it was statistically significant for the timing of the third substitution and fourth substitution in the knockout stage. There were some outliers in the data based on the timing of the substitution. Each of these outliers also occurred with the third substitution in the knockout stage in games in which teams made any total number of substitutions. The outliers indicate that teams had different strategies than their opponents. In these specific cases it seems that teams did not benefit from having a different strategy.

This exploratory analysis was aimed to obtain a better insight to what happened with substitutions in the 2022 FIFA World Cup. The introduction of five substitutions to this tournament added variation and new opportunities to what had previously occurred with substitutions. There are many results in this research that were not statistically significant which

indicates that, in some cases, there simply were not any similarities amongst the substitution patterns of teams. However, novel insights on substitutions were gathered from this research and moving forward there are many areas in which future research on this topic can occur.

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[Image attached] [Tweet]. Twitter.

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