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Teaching Statistics with Current and Historical Events: An Analysis of Survivor Data From the Sinking of the HMT Birkenhead, the RMS Titanic, and the Korean Ferry MV Sewol

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Abstract

Statistical examples can feel remote to students, especially if the variables under consideration are ambiguous. However, life or death is not ambiguous but very concrete. Three different historical shipwrecks offer an abundance of ways to demonstrate the relevance and importance of statistics. Here, we discuss statistical outcomes associated with the loss of three ships: the HMT Birkenhead in 1852, the RMS Titanic in 1912, and the Korean ferry MV Sewol in April 2014. These disasters can serve as examples for demonstrating the relevance of statistics to current events. Statistics in these historical events can help students see that the survival rates of different groups of passengers were very different, with medium to large effect sizes. Even if statistical analyses cannot answer all of the questions about why some passengers had higher survival rates than others, they can lead to further productive qualitative or quantitative research into such questions.

Keywords

research methodology, naval disasters, survival rates, RMS Titanic, HMT Birkenhead, MV Sewol, teaching statistics

Introduction

Shipwrecks are among the disasters that can be analyzed statistically to determine if there were any nonrandom patterns. There are other disasters that can be assessed statistically (e.g., The Challenger Shuttle explosion; the disaster at Pearl Harbor that ignited World War II; both discussed previously in Schumm et al., 2002; more recently by Dean, 2016), but here the focus will be on three shipwrecks, including the RMS Titanic, the HM Troopship Birkenhead, and the Motor Vessel Sewol. The South Korean ferry, Motor Vessel (MV) Sewol sank off South Korea on April 16, 2014 while taking many high school students on a field trip. Each of these naval disasters involved, to the statistical "eye," some nonrandom associations that may either help explain some of what happened or at least raise more questions that might be worth investigating. More information will be presented later on each shipwreck.

The Three Shipwrecks

HMT Birkenhead

Originally commissioned in 1845 as a British frigate, the Birkenhead was converted to a troop ship in 1851. While carrying British troops to the war in South Africa, along with a few civilians, the Birkenhead hit uncharted rocks off Danger Point on the coast of South Africa and sank on February 26, 1852. When the Birkenhead sank, it was about two miles offshore. Some men tried to swim to shore, while others were picked up by lifeboats or other naval vessels. Some men clung to some of the

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Birkenhead's masts that remained above water. Many men drowned; many were taken by sharks, later known as "Tommy sharks" for having killed so many British soldiers and sailors. At least five of the eight or nine horses on the ship made it safely to the shore. The "Birkenhead Drill" in which the soldiers stayed on the ship until it sank to allow greater safety for the women and children in their lifeboats was one of the first such incidents, later repeated with the RMS Titanic sinking where chivalry deemed that priority for lifeboats be given to women and children (Phillips, 2002).

RMS Titanic

The RMS Titanic, a British passenger liner, was one of the largest ships in the world when it was launched in May 1911. It featured a number of technological innovations for the time, including wireless communication, watertight compartments, and watertight doors that could be activated remotely. However, on its maiden voyage, the Titanic hit an iceberg in the north Atlantic on April 15, 1912 and sank, with much loss of life because there were too few available lifeboats. More than 1,500 passengers and crew perished in the calm but cold waters. Popular media have conveyed the idea that wealthier passengers had a higher survival rate than less wealthy passengers due to the privileges of social class. A number of improvements were made to maritime safety requirements as a result of lessons learned from the loss of the Titanic (Butler, 1998).

MV Sewol

A South Korean ferry, MV Sewol, was carrying 476 passengers and crew from Incheon, South Korea, to Jeju, on Jindo Island, South Korea on the morning of April 16, 2014. Many of the passengers were high school students on a school-sponsored field trip from Danwon High School in Ansan City, South Korea. The ferry was operated by 33 crew members, including the captain, Lee Joon-seok. The ferry could legally carry up to 956 persons, including the crew members. The Sewol made the trip from Incheon to Jeju three times per week, a trip that was approximately 250 miles and took over 13 hours. The ferry was also carrying over 175 cars and trucks and over 1,100 tons of cargo that day. Due to a combination of circumstances, including having been loaded with three times the legal limit of cargo and less than a third of the required ballast, the ship capsized after a sharp turn and sank after more than 2 hours. Many of the passengers had been told to stay in their rooms despite the critical nature of the situation, while many of the crew and some other passengers abandoned the ferry. The Korean Coast Guard was notified and sent rescue vessels to the scene. Numerous rescue vessels and aircraft, as well as divers, were sent to the scene. Some of the rescue personnel died during their operations. Within 2 weeks, the prime minister of South Korea resigned over the incident, amid great political furor over the tragic loss of so many young lives. The captain and many of the crew abandoned the vessel before they had saved as many passengers as possible and some have been criminally prosecuted with punishments meted out ranging as high as life in prison. Other crew who remained on the vessel lost their lives while trying to help others escape.

Method

When ships are lost at sea, passenger losses are often not random, even though one might think that the chaos of the situation would lend itself to a random survival rate. Indeed, the most basic hypothesis is whether survival rates are randomly distributed across all classes of passengers or not. Any analysis of shipwreck survival rates will be limited by the variables measured and the quality of the available data. For example, when a ship sinks, it is possible that the total listing of passengers may be lost; sometimes, passengers gained access to the vessel without proper authorization and may not be recorded on ticket lists or other passenger manifests.

HMT Birkenhead

Two primary sources of data were used (Addison & Matthews, 1906; Phillips, 2002). Phillips (2002, pp. 65–79) provided a list, by name and rank or status, of 556 passengers. However, the ship reportedly carried approximately 640 passengers (pp. 19, 22). Some soldiers, women, and children disembarked at Simon's Bay before the ship headed east around the Cape. Other passengers joined the ship immediately before the wreck. Among the 25 women who initially sailed with the Birkenhead, 4 died en route (3 from childbirth and 1 from consumption) and 14 disembarked before the wreck, leaving only 7 on board at the time of the wreck. A total of 31 children initially departed England on the ship, but 3 babies were born along the way. However, 21 children disembarked before the wreck, leaving 13 children on the ship at the time of the wreck. While the seven women were listed by name by Phillips (2002), the names do not always match those given by Addison and Matthews (1906). None of the 13 children were included in Phillips's listing of 556 passengers. Two of the children, Richard and Henry, belonged to Mrs. Nesbitt, wife of Captain Nesbitt of the 12th Regiment. Captain Nesbitt was the quartermaster of that regiment, but he was not on the ship at the time of the wreck.

Addison and Matthews (1906) tried to list each passenger and whether they were saved by reaching the shore alive or by being picked up at sea by other vessels.

The lists provided by Phillips and by Addison and Matthews were compared and adjusted to capture names not found in both lists.

Most of our results conform within one or two cases to the traditional number of men from each unit, the greatest outlier being the men from the 45th Regiment, for which 1 officer, 1 sergeant, and 13 enlisted men are unaccounted for in both Phillips (2002) and in Addison and Matthews (1906). Most likely those unaccounted for disembarked at Simon's Bay because of illness. Addison and Matthews listed M. Hartey as a soldier from the 6th Regiment who swam safely to shore, but Michael Hearty was counted as actually belonging to the 12th Regiment, as listed by Phillips (2002). Addison and Matthews did not distinguish members of the 6th Foot Regiment and the 6th Royal Regiment but Phillips did, reporting that all 12 members of the 6th Foot Regiment survived. Addison and Matthews reported that 87 Navy personnel perished but only named 11 of them, as did Phillips; the remaining 76 Navy losses were not named by either author and were included in our database as anonymous sailors. Other discrepancies between Addison and Matthews versus Phillips are listed in Table 1; Phillips did not report any persons lost who were not reported as lost by Addison and Matthews.

RMS Titanic

En route to New York City from Southampton, England, the British passenger liner RMS Titanic ran into an iceberg in the North Atlantic and sank on April 15, 1912, when it suffered a gash along its side that flooded several of what had been assumed to be waterproof compartments. The Titanic lacked enough lifeboats for all of its passengers; therefore, priority was given to women and children, as had occurred with the Birkenhead. Despite these measures, many women and children did not make it to a lifeboat. Data for the list of surviving and lost passengers and their ticket class were obtained (Butler, 1998; Schumm et al., 2002) as presented in Table 2 but may differ from estimates elsewhere.

MV Sewol

In the case of the Sewol, rates of survival differed: crew (69.7%, 23/33), students (23.1%, 75/325), teachers

Table 1. Survival Rates by Type of Passenger for the HMT Birkenhead.

Type of Passenger or Unit (saved or lost)	Saved per Addison and Matthews (boats, shore)	Saved per Addison and Matthews, not listed by Phillips	Saved per Phillips, not listed by Addison and Matthews
2nd Regiment (18/36)	(11/5)		T. Gleeson, S. Hales
6th Regiment (14/48)	(8/3)	J. Hobdy, John Herrich	
12th Lancers (4/5)	(0/3)	W. Butler	M. Schofield
12th Regiment (16/54)	(8/5)		M. Hearty, C. Kerrigan, G. Walker
43rd Light Infantry Regiment (0/29)	(0/0)		
43rd Foot Regiment (15/0)	(3/8)		M. Horhet, M. Healey, D. Bunker, Pvt. Harrison
45th Regiment (1/3)	(1/0)		
60th Rifles (11/30)	(4/6)		M. Laffey
73rd Regiment (18/56)	(10/5)		D. Maloney, J. Maloney, R. Green
74th Regiment (18/0)	(9/7)		A. Nathaniel, J. Sharp
74th Highlanders (0/51)	(0/0)		
91st Regiment (19/44)	(8/9)	Corporal O'Neil, Pvt. Hudson	Mark Hudson, J. Robinson
Army surgeons (1/2)	(1/0)	Robert Bowen	
Marines (6/0)	(4/2)		
Navy personnel (57/87)	(41/16)	James McNeal, J. Dobson, Edward Grosser, John Haines	
Civilian women (7/0)	(7/0)		
Civilian Men (0/1)	(0/0)		
Children (13/0)	(13/0)		
Totals (218/446 of 664)	(128/69)	10	21

Note. Five soldiers were listed as lost by Addison and Matthew (1906) but were not listed by Phillips (2002): L. Giles (73rd Regiment), William Smith and David Miller (74th Highlanders), and Corporal A. Webber and William Foster (91st Regiment).

Table 2. Survivors and Casualties From the RMS Titanic by Class.

Status	Class	Lost	Survived	Total on Board
Men	First	118	57	175
	Second	154	14	168
	Third	381	75	456
	Crew	674	189	863
Women	First	4	139	143
	Second	15	79	94
	Third	89	76	165
	Crew	3	18	21
Children	First	1	5	6
	Second	0	23	23
	Third	53	26	79

Source: Butler (1998, p. 239).

(21.4%, 3/14), and other adults (68.3%, 71/104) for a total of 172 survivors of a total of 476 persons.

Analyses

The primary statistical question for each of these shipwrecks is whether rates of survival were significantly different from what might be expected by chance, if the null hypothesis of no differences were, in fact, correct. Because of small cell sizes for some of the comparisons, we used two-sided Fisher's Exact Tests (FETs) for pairwise group comparisons, along with odds ratios. For the assessment of survival rates across the four groups of Sewol passengers, we used a chi-squared test with three degrees of freedom. SPSS was used for all statistical calculations (Field, 2005).

Results

HMT Birkenhead

Results for the *Birkenhead* are presented in Table 1. Women, children, and cabin boys (25 of 25 survived) were more likely to have survived the Birkenhead wreck than adult men (30.2%, 193/639), a significant result by a two-sided FET ($p < .001$). Navy personnel, not including the six Marines who survived (37.4%, 52/139), had a significantly higher survival rate than did Army personnel (27.4%, 135/493) by a two-sided FET ($p < .03$), with an odds ratio of 1.59 (95% confidence interval [CI], 1.07 to 2.36, $p < .03$). Comparing the units from Table 1, combining the male and female civilians into one group and not including the 13 children, survival rates differed across the units with χ^2 ($df = 16$) = 186.8, $p < .001$, with some units having 100% survival rates (6th Foot Regiment, 43rd Regiment, 74th Regiment, and the Marines) and other units having zero survival rates (43rd Light Regiment and 74th Highlanders).

Looking at specific ranks, the most notable findings were that none of the field grade officers (Navy Captain, Army Colonel) survived, but 100% of the 22 able seaman survived. Comparing the lowest ranking enlisted (privates, stokers, seaman), elevated enlisted (able seaman), noncommissioned officers, and commissioned officers, rates of survival were 26.2% (147/562), 100% (22/22), 46.2% (12/26), and 44.0% (11/25) with χ^2 ($df = 3$) = 60.6, $p < .001$, respectively. Comparing commissioned and noncommissioned officers together (45.1%, 23/51) versus the lowest ranking enlisted personnel (26.2%, 147/562), the former had a significantly higher survival rate by a two-sided FET ($p = .005$). Among only Navy personnel, the able seaman (100%) had a higher survival rate than did the ordinary seaman and stokers (16.3%, 15/92) with a two-sided FET ($p < .001$) and also had a higher survival rate than the commissioned and noncommissioned Navy officers (58.3%, 14/74) with a two-sided FET ($p = .001$). Comparing survival rates for all officers for the Navy (58.3%) versus all officers of the Army (30.8%, 8/26), the results were marginal with a two-sided FET ($p < .09$) and an odds ratio of 3.15 (95% CI, 0.99 to 10.1, $p < .06$). However, in terms of survival rates of the lowest ranking personnel (privates vs. seaman and stokers), the Army personnel (27.3%, 127/465) had significantly higher survival rates than the Navy personnel (16.3%, 15/92) with a FET ($p < .03$) and an odds ratio (OR) = 1.93 (95% CI, 1.07 to 3.48, $p < .03$).

The high rate of survival for the able seamen seemed unusual so ranks were compared within only Navy personnel comparing those saved by boats and those who swam to shore. The results were significant, χ^2 ($df = 2$) = 10.0, $p = .007$, with a rank breakdown of 56.3% of officers (9/16), 18.8% (3/16) for able seamen, and 25.0% (94/16) for those who made it to shore and of 25.0% (7/28), 67.9% (19/28), and 7.1% (2/28), respectively, for those picked up in boats. Just comparing able seamen with seamen and stokers, the results were significant by a two-sided FET ($p < .03$) with 66.7% (4/6) of seamen who were listed by Addison and Matthews (1906) as surviving saved by swimming to shore compared with only 13.6% (3/22) of the able seamen. The difference between seamen and stokers compared with officers was also significant by a two-sided FET ($p < .02$) with 43.8% (7/16) of officers saved by boats compared with 33.3% (2/6) of the lowest ranking enlisted personnel.

RMS Titanic

Survival data by gender and ticket class are presented in Table 2. Using cross-tabulations evaluated by FETs, a

higher percentage of women and children survived for each class of passenger on the *Titanic*: first class (96.6% vs. 32.6%, $p < .001$), second class (87.2% vs. 8.3%, $p < .001$), and third class (41.8% vs. 16.4%, $p < .001$). Overall, 68.2% of women and children survived versus 18.3% of men ($p < .001$). Overall, social class appeared to be linearly related to survival rates with 62.0% of first class passengers, 40.7% of second class passengers, and 25.3% of third class passengers surviving, with χ^2 ($df = 2$) = 128.7, $p < .001$. However, nonlinear patterns were observed for men: 32.6%, 8.3%, and 16.4%, respectively, for first, second, and third class passengers ($p < .001$) and for children: 83.3%, 100.0%, and 32.9%, respectively ($p < .001$). For women, the pattern showed a greater difference between second and third class survival rates (84.0% vs. 46.1%) than between second class and first class (97.2%). Predicting survival using binary logistic regression yielded a Cox & Snell $R^2 = .300$ and a Nagelkerke $R^2 = .409$. Binary independent variables for female gender (vs. male and child), child (vs. adult), and first class passenger status (vs. second and third class), and second class passenger status (vs. first and third class) were used to predict survival. All independent variables were significantly related to survival ($p < .001$) with the following odds ratios and 95% CIs: gender (12.6, 9.32 to 17.16), age (7.1, 4.52 to 11.05), first class (5.8, 4.12 to 8.16), and second class (2.08, 1.48 to 2.94). For men only, first class predicted survival (2.45, 1.64 to 3.67, $p < .001$), but second class predicted a lower rate of survival (0.46, 0.25 to 0.84, $p = .012$). For women, both first class (40.7, 14.38 to 115.14, $p < .001$) and second class (6.2, 3.28 to 11.59, $p < .001$) predicted survival. For children, a logistic regression model did not seem to work well because of the 100% survival rate of the second class children which led to a huge standard error for the second class variable (8,380 compared with 1.12 for the first class variable).

To assess quadratic nonlinearity, which seemed apparent in the cross-tabulation results when examined in terms of men, women, or children, one-way analysis of variance was used to predict survival from ticket class (first, second, and third) with a test for quadratic trends, all of which were significant: men, $F(1, 796) = 23.06$, $p < .001$, women, $F(1, 399) = 7.69$, $p = .006$, and children, $F(1, 105) = 11.41$, $p = .001$.

MV Sewol

As noted previously, in the case of the Sewol, rates of survival differed: crew (69.7%, 23/33), students (23.1%, 75/325), teachers (21.4%, 3/14), and other adults (68.3%, 71/104) for a total of 172 survivors of a total of 476 persons. A chi-square test assessing independence between survival and type of passenger yielded χ^2 ($df = 3$) = 87.97, $p < .001$, indicating differential rates of survival among the four groups of passenger on the *Sewol*. However, such an overall test does not tell us how the different groups of passengers compared on a pairwise basis; pairwise tests can be conducted with either a 2×2 chi-square test or a FET. Because the chi-square test is an approximation and because the FET provides correct results even with small cell sizes, the FET will be reported here.

In terms of pairwise group comparisons, crew members had a higher survival rate than teachers, 2FET, $p < .005$; OR = 8.43 (95% CI, 1.93 to 36.9), $p = .005$, or students, 2FET, $p < .001$, OR = 7.67 (95% CI, 3.49 to 16.8, $p < .001$. However, crew rates of survival did not differ from the survival rates of other adults, 2FET $p = 1.00$, OR = 1.05 (95% CI = 0.45 to 2.46), $p = .90$. Students did not have a significantly higher survival rate than teachers, 2FET $p = 1.00$, OR = 1.10 (95% CI = 0.30 to 4.05), $p = .89$. Other adults did have a higher survival rate than teachers, 2FET $p < .005$, OR = 7.89 (95% CI, 2.06 to 30.2), $p < .005$, and students, 2FET $p < .001$, OR = 7.17 (95% CI, 4.41 to 11.67), $p < .001$. While many of the crew members were criticized and legally prosecuted for alleged negligence, their survival rate can be compared with the other adults; the difference was minimal, far from being statistically significant, even with a one-sided FET ($p = .53$). A comparison of teacher versus student survival rates also yielded comparable levels of nonsignificance ($p = .59$, one-sided FET). However, comparing survival rates for crew and other adults (68.6%, 94/137 from 23/33 for crew and 71/104 for other adults) versus students and teachers (23.0%, 78/339 from 3/14 for teachers and 75/325 for students) did yield a significant result, $p < .001$ (two-sided FET). Results were also significant ($p = .002$, two-sided FET) comparing survival rates for teachers versus the other adults.

Discussion

Each shipwreck involved different information for predicting survival. For the Titanic, gender, child status, and social class were available. For the Birkenhead, gender, rank, branch of service, type of passenger, the way in which some of the passengers were saved, and type of job were available. For the Sewol, only the type of passengers was available to us. Because survival is usually the key outcome of interest, some types of statistical analysis may be more appropriate than others for shipwreck data, given the binary nature of survival or death. Although we did not do so, instructors might try statistics that we did not use (e.g., differences in proportions, see Brase and Brase, 2015, 503–505) or other nonparametric statistics and discuss any apparent differences obtained from different approaches.

In general, results for the Titanic's passengers indicated that survival chances were better for those with higher social class, women, and children, although some patterns were nonlinear with social class. Results for the Birkenhead indicate that some units had very high survival rates and one might wonder what helped those unit members (presumably) work together to ensure each other's survival. There remains a question as to why able seamen had a much higher survival rate than other ranks in the Navy—were they more fit for swimming to safety? Did they "pull rank" over ordinary seamen to get on the lifeboats? Did they have just the right combination of relative youth, maturity, and seasoned skills that gave them an edge in surviving the ship's sinking? Results for the Sewol indicate that adults had high survival rates, whether crew or passengers, but that teachers and students both had much lower survival rates. Did that occur because of location on the ship when it capsized? Did it occur because of orders for students (and possibly their teachers) to stay put while the ship was going down? Statistics may not be able to tell us what or why things happened, but they show us that even in chaotic disasters such as shipwrecks, outcomes are not always random. But, if outcomes are not random, that opens up questions for further exploration: What could be asked of survivors to get a larger picture of what happened as the ship sank or floundered, for example. Even issues of culpability might be resolved, taking the lead of statistical results. For example, how would the high-ranking officers of each ship explain the nonrandom results reported in this study? How would, for example, the Captain of the MV Sewol explain the much greater losses among teachers and students than among crew and other adults on the Sewol? His explanation might not relieve him of culpability, but it might help explain why civilian adults survived at much higher rates than high school students. History is replete with examples of tragedies that can be examined safely in the classroom but with an eye toward the usefulness of statistics helping us understand future tragedies, possibly even to prevent them (as with the Shuttle Challenger). Though not analyzed statistically here, a major factor in each wreck involved lifeboat launching, either too few lifeboats to accommodate all passengers (Titanic), problems launching lifeboats due to mechanical issues (Birkenhead), or, apparently, a lack of available crew members to try to launch most of the lifeboats that were on board (Sewol).

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