Trends, Causal Analysis, and Recommendations from 14 Years of Ferry Accidents

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Abstract

Ferries and other passenger vessels provide a crucial mode of transportation for many in the developing world, especially in archipelagic nations like Indonesia and in river delta nations like Bangladesh. However, this dependence on passenger vessels coincides with a high rate of accidents and fatalities in many countries, linked to purchase of old, substandard, and/or inappropriate vessels in low-income nations; overcrowding; inadequate training; and sudden hazardous weather. Any serious attempt to decrease the number and fatality count of ferry accidents in the developing world must have a complete record of past incidents on which to draw. This report compiles detailed information on the 232 major accidents that occurred around the world between 2000 and 2014. It assesses the prevalence of various common factors in ferry accidents, including human error, hazardous weather, and overcrowding, and makes recommendations for future research into the prevention of ferry accidents.

Keywords: *Ferry safety, maritime safety, accident causation, fatalities*

Introduction

Although ferries offer a safe and often a discretionary form of transportation in North America and Europe, this is far from the case in the developing world. Many countries in Southeast Asia, the African Great Lakes region, and elsewhere rely on ferries as a primary mode of transportation for people and goods, and accidents are frequent. This high rate of accidents and fatalities is linked to a number of causes, including substandard vessels, overcrowding, and a lack of training for emergency scenarios, as well as to more systemic issues such as inadequate support and/or corruption in the regulatory process. These failures were highlighted by the 2014 sinking of the MV Sewol off the coast of South Korea, during which the captain and crew abandoned ship while hundreds of students remained aboard and perished (Harlan 2014).

Efforts to monitor, let alone improve, ferry safety in the developing world are handicapped by incomplete recordkeeping in many developing countries and sparse or

non-existent media coverage of accidents by major international news outlets. Reports of ferry accidents often do not include the name of the vessel involved, information on the company or individual that owned the vessel, or data about proximate and root causes of the accident. Often, even the number of passengers on the ferry is unknown, because overcrowding is massive, disturbingly frequent, and unrecorded (Lawson and Weisbrod 2005).

Any serious attempt to decrease the number and fatality count of ferry accidents in the developing world—as Interferry, the International Maritime Organization, and the Worldwide Ferry Safety Association have pledged to do—must have a complete record of past incidents on which to draw. This project works to fill in the gaps of an existing dataset of ferry accidents compiled by Interferry and the Worldwide Ferry Association, spanning 232 accidents in the period between 2000 and 2014. With this information, it is possible to analyze trends and common threads among accidents and make recommendations for future safety efforts.

Methods and Sources

Information in the dataset was drawn from news sources around the world, both local and international; incident investigation reports, where available; and the IMO Global Integrated Shipping Information System (GISIS). Particularly well-represented news sources include the BBC and the English-language version of China's Xinhua News Agency, both of which cover accidents around the world. Only accidents that resulted in the deaths of two or more passengers and/or crewmembers were recorded. Each accident entry includes, where available, number of fatalities compared to total passenger load; date, location, and time of day of the accident; proximate cause and any exacerbating factors; name of vessel(s) involved, with their operators and owners; weather conditions; captain and crew member response; and the timing and effectiveness of search and rescue efforts, if any. In total, 25 data fields were collected across the 232 entries.

In many entries, one or more of the desired metrics is missing, reflecting incomplete media reporting of ferry accidents, complex and multilayered accident causes, and a lack of reliable accident investigation. However, the lack of records about these factors can itself be considered an important data point in the understanding of ferry accidents, since it indicates poor recordkeeping and accident investigation in those countries. Therefore, the existence of a number of incomplete accident records at the conclusion of this project should not be taken as a sign of the project's failure, but as another form of information about ferry safety in the countries studied.

The analysis of accident causes presented below would be much more valuable if we had access to full-length investigation reports for all, or even most, of the cases described here. With detailed reports, we would be able to tease out the interacting technical, organizational, and human factors leading to fatal accidents through a model such as SEMOMAP (SEquential MOdel of the MAritime Process), used by Nurwahyudy (2014) to determine the causes and contributing factors of selected Indonesian ferry

fires. However, in most of the countries in which ferry accidents are rampant, either accident investigations are not carried out or their results are never published.

Analysis

This paper records the details of 232 ferry accidents over the 14-year period from 2000 to 2014. By a conservative tally based on news reports, 21,574 lives were lost, an average of 130 deaths per incident and 1,541 deaths per year. The accidents included occurred in 43 different countries around the world, with three countries—Bangladesh, Indonesia, and the Philippines—responsible for almost 50% of all accidents (Figure 1). Even more striking, the five countries of Bangladesh, Tanzania, Indonesia, Senegal, and the Philippines were responsible for almost two-thirds of all fatalities in the 14-year period (Figure 2). Bangladesh alone had 20% of all accidents in the time period and 23% of all fatalities. Overall, 94% of all accidents and 97% of all fatalities occurred in developing-world countries, using the World Bank's definition of developing-world nations as those with a gross national product per capita of less than $12,736 (World Bank 2015).

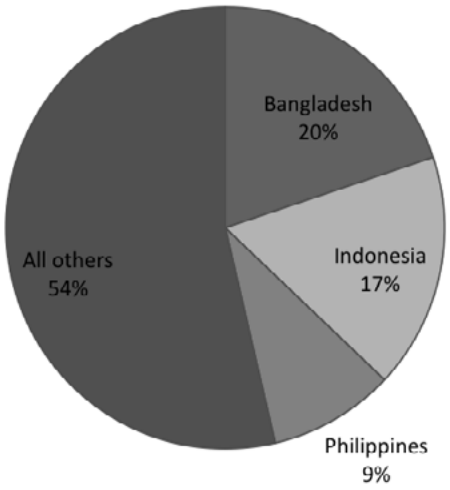

FIGURE 1.
Proportion of ferry accidents occurring in top 3 countries

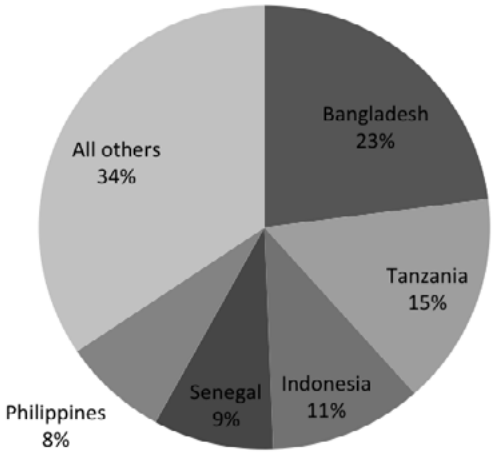

FIGURE 2.
Proportion of ferry fatalities occurring in top 5 countries

Human Error

Human error, also known as operator error, is recognized as a frequent cause of accidents and mishaps across many industries. It can include a variety of faults, including errors of commission, in which an operator performs an act incorrectly; errors of omission, in which the act is forgotten or left out; errors of timing, in which the act is performed too early or too late; and errors of sequence, in which acts are performed in the wrong order (Latino 2007). Conventional wisdom, cited by many authors, holds

that some form of human error causes about 80% of maritime vessel accidents, but this number has not been put to the test of a rigorous quantitative analysis, especially for passenger vessels (Rothblum 2000). The 14-year dataset compiled for this paper provided the opportunity to run an analysis of the role of human error across more than 200 ferry accidents around the world.

One challenge to this study was the concern that human error can be difficult to define and recognize after the fact, especially when using sparse news reports written by non-technical personnel who may not have had access to the scene of an accident. To address this issue, two analyses have been run on all accidents in the dataset, one defined by conservative parameters and one by liberal parameters for what may constitute human error. For each analysis, we determined the percentage of all accidents attributable to human error and the percentage of all fatalities attributable to human error.

Under conservative parameters, human error includes only those errors that led directly to the incident in question. Vessel disrepair and misjudgments about the safety of sailing during bad weather would not qualify. Human error that led to increased fatalities, but not the incident itself, would not count (i.e., failure to provide passengers with life vests). Overloading of passengers, unbalanced rolling cargo, and collisions with other vessels are classic examples of human error under these conservative conditions.

Under liberal parameters, criteria are as broad as possible. Factors such as misjudgment of the weather and vessel disrepair qualify as human error under this analysis. Human error leading to increased fatalities (as defined above) qualifies. Overloading that is not borne out by hard numbers on the number of passengers versus vessel capacity will count under this analysis but not the conservative one.

In both scenarios, we have disregarded incidents caused by malicious damage, most notably the 2004 SuperFerry bombing by an Islamist terrorist group in the Philippines. Cases in which human error on the part of passengers, rather than crew, caused accidents also were included under both conservative and liberal parameters; this includes incidents such as the sinking of the Acita 03 in Indonesia in 2007, which was precipitated by passengers climbing onto the roof of the vessel to get a stronger cellphone signal (Mandari 2007). Cases for which the cause of the accident is unknown have not been included in either analysis; these accounted for 14% of the total dataset.

This analysis demonstrated that 53% of all accidents in the dataset were caused by human error under conservative parameters, and 74% were caused by human error under liberal parameters. However, when accidents possessing incomplete causal data were removed from the analysis, it was found that a higher proportion of accidents were related to human error—62% under conservative measures and 86% under liberal measures. Of the dataset's 21,574 fatalities, 70% were related to human error under our conservative criteria, and under liberal criteria, 86% of the lives lost were linked to human error. When accidents with incomplete causal data were ignored, 75% of fatalities were found to be caused by human error under conservative criteria, and an overwhelming 92% could be linked to human error under liberal criteria.

Table 1 is a summary of results of the accident analysis of 147 ferry accidents worldwide to determine what proportion of accidents are caused by human error (HE). "Total cases" refers to all cases included in the dataset, including those in which no cause could be assigned. "Total known" refers to only those cases in which a cause (human error/no human error) was assigned.

TABLE 1.
Summary of Results of Human Error Ferry Accident Analysis

	Conservative	Liberal
Number of Accidents		
% HE* by total known cases	61	85
% HE by total cases, known and unknown	53	73
% unknown	14	14
Fatalities (dead and missing)		
# fatalities caused by HE	15,156	18,595
% fatalities caused by HE by total known cases	75	92
% fatalities caused by HE by total cases, known and unknown	70	86

**HE = human error*

Weather

Hazardous weather conditions are a major cause of fatalities and vessel loss while at sea. High winds together with rough seas and high waves have caused vessels that had previously been traveling safely and stably to become destabilized and capsize. Numerous ferry fatalities have been associated with sudden hazardous weather, as have the loss of fishing vessels and their crew, cargo vessels, and even the largest military ships, known as super carriers (Lehner and Rosenthal 2006). Of the 232 accidents covered by this study, 50% were at least partially caused by hazardous weather, unsafe wave conditions, monsoon-related flooding, or unusually strong currents.

One example is the Philippines ferry Princess of the Stars, which set sail on June 28, 2008, as Typhoon Fengshen was making landfall in the eastern Philippines. The vessel was allowed to sail because its route would take it only through the projected periphery of the Category 3 storm, and the Princess of the Stars was considered large enough to remain afloat under those conditions. However, Typhoon Fengshen unexpectedly changed course on June 21, placing the ferry directly in its path (Yahoo! News 2008). The vessel capsized in the midst of the storm off the coast of Romblon Island at around midday on June 21, leading to a final death toll of 814 dead and missing with only 56 known survivors. Rescue vessels did not reach the wreck until 24 hours after the accident, since the area was surrounded by "gigantic waves, pounding rain, and gusty winds" (Guinto 2008).

Overcrowding and Overloading

Many ferry operators, constrained by artificially low ticket prices imposed by government regulation (Lawson and Weisbrod 2005), deliberately overload vessels with passengers and cargo to cover their costs and turn a profit. Often, operators do not record the names of passengers who embark after a vessel's capacity has been reached, making it difficult to gauge the total number of dead and missing and to

identify individuals who are lost. Overcrowding can precipitate accidents, especially when passengers group themselves on the upper levels of a ferry or rush to one side when they anticipate danger. Heavy cargo loads can become destabilized if they are not stowed properly and can pose even more immediate risks if a vessel is carrying dangerous or flammable substances. In all, overloading and overcrowding played a role in about a third (29%) of the accidents collected in this database, although they rarely caused accidents alone without the influence of other factors.

Other Causes

Collisions and other navigational problems, including abrupt turns and groundings, were implicated in 22% of all accidents. Fires and engine trouble were at least the partial cause of 26 accidents, or 11% of the total dataset. Recent studies have shown that truck ferry fires are becoming a serious issue worldwide because of certain vessel design features of RO-RO truck ferries (Nurwahyudy 2014, Moretti 2015). Of the accidents for which data on the time of day could be collected, 60% occurred during the night or at dawn, when visibility is low and crewmember alertness suffers. However, this temporal information was available for less than half of all the accidents in the dataset, so this result should not be assumed to be conclusive.

Discussion and Recommendations

The concentration of accidents in the Southeast Asian nations of Bangladesh, Indonesia, and the Philippines suggests that research and advocacy efforts should be focused in these three countries and the surrounding region. Bangladesh, in particular, with its high accident rate and even higher proportion of fatalities, should be considered a "hot spot" for ferry accidents and receive aid proportionate to its need. These three countries and their neighbors all experience the challenge of a regular monsoon or rainy season that creates dangerous conditions in waterways and puts stress on maritime infrastructure. In addition, they all score below the 50th percentile for control of corruption in the World Bank's Worldwide Governance Indicator tool, a dataset used to summarize the quality of governance provided in countries around the world (World Bank 2014). New research and new ideas are urgently needed to combat these risk factors; nearly 9,000 lives have already been lost to accidents in those three countries alone.

Human Error

The widespread occurrence of human error—a factor in more than 70% of accidents, by the liberal criteria described above—highlights the need for better and more intensive training programs for captains and crew, along with intuitive, low-cost technologies to help crew members monitor and control hazardous conditions. Cases in which error occurred at the hands of passengers, such as the Acita 03 disaster mentioned previously, show that safety training must extend to passengers as well, following the model of the airplane safety instructions currently given at the beginning of every flight. More broadly, the safety culture of countries and companies—defined most simply as the basic assumptions of an organization about how safety issues should be treated (Guldenmund 2000)—must be strengthened. Although government agencies can have a role in defining and changing an industry's safety culture from the top down,

individual companies, ferry operators, and trade associations are powerfully placed to improve their organizations' safety standards on their own. Operators also have the most to lose from poor safety standards, since it is their passengers, crew, vessels, and company reputation that are most at risk. They also have the most to gain from improved standards, since passengers with higher confidence in the industry will take more trips and spend more money on travel.

Weather

Encountering storms and unsafe weather conditions will always pose an unavoidable risk when traveling by water. That said, simultaneously improving weather information systems and making them more affordable for small business owners in the ferry industry could prevent accidents and save thousands of lives. The Princess of the Stars' tragic encounter with Typhoon Fengshen in the Philippines clearly illustrates this need for better information systems, but greater changes also must happen. A culture of caution, strong maritime regulation, and concern for safety rather than profits would have prevented the sailing of the Princess of the Stars entirely; this decision would have saved the lives of the 800 men, women, and children trapped on board. A Board of Marine Inquiry convened after the accident found Sulpicio Lines, owner of the Princess of the Stars, liable for negligence in the accident and recommended that its license be suspended (Cebu Daily News 2008). But within a year, the company resumed operations under the name Philippine Span Asia Carrier Corporation, and its vessels have since been involved in other deadly accidents (Quiano and Hackney 2013). Only regulatory changes can prevent deaths in weather-related accidents as long as companies such as Sulpicio Lines push their crewmembers to maximize profits by sailing in marginal conditions.

Along with regulatory changes, a number of technological fixes that change the way weather information is disseminated could have a profound impact on ferry passengers' safety from adverse weather. Many parts of the world, especially those in which ferries are most vulnerable to sudden weather-related hazards, lack an affordable, real-time weather alert system for vessels that have already left port. One solution is the use of SMS technology to push storm alerts from a central source to crew member cellphones, a solution that already has been developed to aid fishermen in the African Great Lakes region (Luganda 2012) and Bangladesh (UNDP 2015). If expanded to include ferry operators and crews, these programs could provide great benefits to passenger ferry systems. However, even if SMS-based alert programs were initiated in the nations that need them most, the detailed and up-to-date weather data they would require could be prohibitively expensive for developing countries to obtain. In these countries, deploying a nation-wide network of the 3D-printed weather monitors currently being developed by USAID and NOAA (Freitag 2015) could alleviate some of the cost and difficulty associated with gathering data on which to base forecasts.

Finally, the prevalence of sudden hazardous weather conditions means that hyperlocal, up-to-the-minute weather data and forecasts should be a critical priority. NOAA's mobile-based weather data crowdsourcing application, called mPING (Meteorological Phenomena Identification Near the Ground), could help weather services in

infrastructure-poor countries supplement their existing monitoring systems to capture hyperlocal data.

Overloading and Overcrowding

Overloading and overcrowding will continue to pose a persistent problem as long as some regulators enforce low ticket prices and fail to prevent operators from packing passengers onto their vessels. However, several factors could help mitigate this problem even without more consistent regulation and the intensive enforcement it would require. Several technologies exist to count individuals as they pass an entry point and alert staff members after capacity has been reached, although these systems cannot always take into account the extra weight of infants and hand-held baggage. A weight-sensing system of the kind used in elevators could overcome this hurdle, and an accompanying alarm that is triggered when weight limits are reached could prevent ships from sailing until the extra load is removed (Rahman and Rosli 2014).

Another unexplored factor is the role of passengers in controlling and preventing the overloading of the vessels they use. Passengers often crowd onto a vessel that is already past capacity, fearful of missing an infrequent passage to their destination but unknowingly contributing to the instability the vessel. But passengers in dangerously overcrowded situations have also been known to act collectively to avoid accidents. In May 2013, passengers on a Hong Kong ferry prevented the vessel's departure when they noticed that unsecured cargo was blocking the ferry's exits and stairway (Ngo 2013). The ferry was on the same route and belonged to the same company as another vessel that had sunk a year previously, killing 39 passengers. It is unlikely that the Hong Kong passengers would have been so active in their own defense without the example of the previous year's accident, but their reaction shows what passengers can accomplish when they act collectively.

Search and Rescue

Following the compilation of the data presented here, the U.K.-based International Maritime Rescue Federation (IMRF) performed a follow-up research project analyzing the search and rescue (SAR) response in 160 of the above accidents. For each of those accidents, the IMRF's project collected data on SAR response times, the resources available to SAR services in each case, rates of rescue, and challenges during the rescue process. With these data, IMRF researcher Kiersten Reid Sander identified SAR challenges and initiatives unique to each country represented in the dataset. The five most fatality-prone countries in the world as described above—Bangladesh, Tanzania, Indonesia, Senegal, and the Philippines—have several challenges in common. They have large rescue areas but inadequate rescue and salvage equipment, which, combined with dangerous weather and sea state conditions, can cost SAR services hours of delay in reaching accident sites. In these countries, passenger vessels often fail to complete their passenger manifests, making it difficult for SAR services to gauge the time and resources they will need for a rescue. Many vessels do not carry communications devices, meaning SAR coordinators may not receive distress signals in time for their efforts to be effective (Reid Sander 2015). These challenges are systematic, and some, such as large rescue areas and poor weather, are unavoidable. But updating high-risk nations' rescue equipment,

incentivizing operators to keep accurate passenger manifests, and supplying all vessels with basic distress beacons are a set of quick fixes that could have tangible impacts for the ferry passengers caught in deadly accidents.

Implications

The development of this dataset has already had real-world implications for ferry safety efforts. As mentioned, the IMRF contributed a follow-up project based on this work that explicated the failures and needs of SAR services in developing countries. In addition, on learning that hazardous weather played a role in 50% of accidents, the Worldwide Ferry Safety Association (WFSA) recalibrated its programming to reflect the importance of weather and included a panel on cutting-edge weather information technology at the first annual WFSA conference in 2015. This panel led to a conversation among international weather experts that resulted in the technological recommendations described in the discussion above. In 2016, WFSA will follow up with a second annual conference that will continue to draw on this dataset to direct the conference's programming.

Conclusion

None of the causes and contributing factors of ferry accidents described are insoluble problems. Developing new rigorous but affordable training and qualification programs can address the problem of human error, and improved weather information systems can help vessels avoid storm systems, high sea state conditions, and other inclement weather. The practice of collecting passenger lists is already designed to prevent overcrowding, and new technology could help enforce caps on the number of passengers a vessel can carry. Finally, passengers can be empowered to make safe, informed decisions about their travel, enforcing safety regulations from the bottom as well as from above. Across the board, the question continues to be, not how to develop solutions to worldwide safety problems, but how to make those solutions available to ferry operators and to passengers in the countries that need them the most.

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