Potentials of Data Mining and Cloud Computing in The Fish Poisoning and Relevant Economic Contexts: A Conceptual Review

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Abstract— **Fish poisoning can be life threatening and it is important to detect the causes of fish poisoning, and the type of fish poisoning, reliably and accurately. However, the existing research on fish poisoning has generally focused on statistical methods and specific areas within the fish poisoning field. This review based research also highlights the possibilities of data mining in this area, especially by reflecting how the different data mining methods may address different issues of uncertainty linked to fish poisoning. The article also discusses the possibility of cloud computing in this context and the economic benefit that may be brought forth by using a data mining based system within cloud computing architecture. Additionally it demonstrates an example of utilizing data mining in the fish poisoning research area. The work is expected to guide empirical research, especially for the Fijian context.**

Keywords- Data mining, Fish poisoning, Economy, Cloud Computing

I. INTRODUCTION

Fishery is a primary industry in Fiji, especially with the involvement of local and international stakeholders (Fuata, 2015). Fish in varied cooked forms not only constitute a special delicacy for the Fijian population, fish is also an important attraction behind the Fijian tourism and foreign investment potentials (Fiji, 2016). Further, the source of livelihood of many Fijians is the fisheries industry. Considering these, fisheries form an important part of Fijian economy and social life. However, a major concern for the sector is the growing rate of fish poisoning, which a non-infectious yet serious ailment is caused by consuming contaminated fish.

Fish poisoning can be of varied types including ciguatera fish poisoning, scombroid fish poisoning, rudderfish/escolar diarrhoea and shellfish poisoning (Government of South Australia, 2015; Davis &Shiel, 2015). Ciguatera fish poisoning occurs due to consuming larger fish residing near the reef where ciguatoxin or maitotoxin may be present, while scombroid fish poisoning occurs due to eating decayed fish; rudderfish/escolar diarrheais is caused by consuming fish that contains high quantity of wax ester, and shellfish poisoning may stem from eating shellfish which contains toxin. (MedlinePlus, 2015; Olander, 2015).

A specific issue of concern is the uncertainty about identifying whether a particular fish is poisonous (Smith and Zeller, 2016; Dolan et al. 2016;Fuchsman,2016).For example, a ciguatoxic fish appears, smells and tastes similar to non-poisonous fish; and processing, including freezing , cooking, smoking and drying, are unable to counteract the toxin present in the fish (IAMAT, 2015). Kits are available that allow testing for ciguatoxin, but these kits are not very accurate and also expensive. Thus, there is an opportunity to use data mining methods for accurate prediction of fish disease, especially since data mining methods can address such levels of uncertainty. This paper presents a review on fish diseases in the Fijian context, and suggests data mining approaches that may be applicable in this area.

The paper is organized as follows: Section II and III describes the related literature on fish poison and indicates the issues that exist in this area. Section IV provides some details on data mining techniques. Section V conceptually suggests show data mining may be applied in this area, Section VI demonstrates cloud computing on data mining area, while Section VII define rules, finally VIII concludes the paper with recommendation for future research directions.

II. FISH POISONING

Fish poisoning is a common food poisoning that may occur from eating contaminated fish, where the fish is poisonous by its species characteristics or where the fish as become poisonous due to its environment (Norušis, 2012;Johns Hopkins Medicine, 2016). While most people are aware about fish species designated as poisonous, fish that has become contaminated due to environment are hard to identify and differentiate from non-contaminated fish from the same species. Thus, research potentials exist in this respect and such potentials should be explored to help the

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populace and also to help the Government in terms of minimizing economic loss.

Indeed, fish poisoning has drawn attention of literature, especially concerning the different causes of fish contamination. Natural events (cyclones, tidal waves or heavy rainfall), human induced disturbances (coastal constructions, reef dredging or blasting) may damage or kill coral, and lead to the growth of deadly algae; and these algae, when consumed by fish and consequently by humans in the ecosystem, may lead to fish poisoning (Wikipedia, 2016).Literature also relates fish poisoning in the pacific island nations to the rise in sea temperature (Government Agency, 2015;Science Alert, 2012). Heavy metals combined with climate change, industrial toxic wastes, nutrient run-off from the land and overfishing and shipwrecks may also contaminate fish and cause fish poisoning (Gil & Gil, 2015; Science Alert, 2012; Soloway, 2009). Overall, the causes of fish poisoning are not very clear. The following subsections briefly discuss the different types of poisoning.

Ciguatera Fish Poisoning

Ciguatera fish poisoning is the most common ailment, affecting many people globally (Marcus, 2016; Lewis & Sellin, 1993; McIntosh, 2015). According to the literature, ciguatera fish poisoning has one of the highest reported incidences in the world and has scary symptoms (Dickey & Plakas, 2009,Wongetal. 2005; Wong etal. 2014;Mendoza etal. 2013; Olander, 2015). Media, for example, reports a case of fish poisoning where the patient suffered for over 18 months after eating contaminated fish in Fiji (Ihaka, 2012). Ciguatera outbreak has also been reported in in New York, with 28 patients admitted in the hospital due to the food poisoning (Poison, 2013). There has been claim that the reason this type of fish poisoning is on the rise is due to climate change (Olander, 2015; Larsen, 2015). Ciguatera fish poisoning starts from small fish that may have eaten the poisonous algae and algae-like organisms; and the poisoning transfer to human when larger fish, that have consumed these poisonous small fishes, are eaten by men (MedlinePlus, 2015; McIntosh, 2015; McNeil, 2015).An issue with this type of poisoning is, even after being processed and cooked, the poison may still impact the person consuming the fish (MedlinePlus, 2015; McIntosh, 2015; McNeil, 2015).

Scombroid Fish Poisoning

Scombroid fish poisoning, also known as histamine poisoning, occurs due to eating fish that has not been properly refrigerated or stored, especially since bacteria may contaminate dead fish and release histamine harmful to human health (Nordt and Pomeranz, 2016; MedlinePlus, 2015; Soloway, 2009;Feng, 2016). According to Canadian Food Inspection Agency (2012) a small dose of histamine is necessary for proper human body functions; however an overdose may trigger symptoms including vomiting, itchiness, rash, dizziness and diarrhoea. Thus, an issue in scombroid fish poisoning is preventing the occurrence of the disease and identifying the symptoms when the poisoning occurs (Mead 2014; Canadian Food Inspection Agency, 2012). Additionally, as Mead (2014) notes, the presence of histamine in the dead fish is difficult to identify.

Shellfish Poisoning

Shellfish poisoning occurs when humans consume the shellfish contaminated by eating harmful algae; and constitutes four major types of ailments - paralytic, neurotoxic, amnesic and diarrheic shellfish poisoning (Trevino, 1998). Paralytic shellfish poisoning is rated as the most dangerous, and can cause people to remain ill for days (Trevino, 1998; Tan & Lee 1988; Soto-Liebe etal, 2013). It is mostly triggered by ingesting contaminated shellfish species, especially mussels, clams, oysters, and scallops (MedlinePlus, 2015;Davis and Balentine, 2015; Ahmed, 1991; Ansdell, 2015; Fleming,2016; ABC, 2015; Andrews, 2014).The neurotoxic shellfish poisoning occurs by consuming shellfish contaminated with brevetoxins and the symptoms include: slurred speech, nausea, vomiting, gastroenteritis, broncho constriction, temporary respiratory discomfort, diarrhoea, numbness, tingling in your mouth, headache, dizziness, and hot and cold temperature reversal (Davis & Shiel, 2015; MedlinePlus, 2015; Ahmed, 1991; Ansdell, 2015).Amnesic Shellfish Poisoning is caused by shellfish that has consumed domoic acid, and which, when eaten by human, leads to symptoms including: vomiting, diarrhea, abdominal cramps, memory loss, brain damage, and even death (Davis & Shiel, 2015; MedlinePlus, 2015; Ahmed, 1991; Ansdell, 2015; Washington State Department of Health, 2016).Diarrhetic Shellfish Poisoning is mostly caused by eating oysters, clams, scallops, and mussels that may have been contaminated through feeding on varied species of *Dinophysis* and polyether molecules; and the symptoms include diarrhoea, nausea, vomiting, abdominal pain, and chills (Davis & Shiel, 2015; Ahmed, 1991; Ansdell, 2015). Overall, the issue with shellfish poisoning is the inability of cooking to remove the toxins and the difficulty in treatment, especially when a proper anti-toxin is lacking (Poisoning, 2016).

Rudderfish/Escolar Diarrhoea

Escolar diarrhea is caused by consuming the escolar fish, rudderfish and the blue marlin fish, and symptoms, which may occur within two hours, include watery and oily diarrhoea, abdominal cramps, nausea, vomiting, malaise, extensive respiratory distress, muscle weakness, and mental impairment (Government of South Australia, 2015; Vilar, Santos, & Carvalho, 2012; Yohannes etal. 2002).A specific issue regarding this ailment includes proper identification of species susceptible to the poisoning.

Other Fish Poisoning

Other than the discussed four fish poisoning types, other types include Fugu fish poisoning, caused by consuming poisonous puffer fish of puffer fish and symptoms include perioral paraesthesia, nausea, vomiting, dizziness, abdominal pain, numbness and paralysis (Islam, et al., 2013; Johns Hopkins Medicine, 2015).Another disease is the Minamata disease, which occurs in humans consuming shellfish contaminated by industrial waste water and symptoms include sensory disturbances, ataxia, dysarthria, and tremor (Harada, 1995).

III. FISH POISONING RESEARCH

Research on fish poisoning has been varied in terms of focus and context. Llewellyn (2010), for instance, investigated the association between sea surface temperature and the epidemiology of fish poisoning in the South Pacific, and confirmed the link between ciguatera and climate change. Malmet. al. (1997) studied the influence of gold mining, especially through impacting the mercury levels in fish, human hair and urine, at the Madeira and Tapajós basins in Brazil. Weis (2004) undertook statistical analysis to relate mercury concentrations to the size of fish for species in the Canadian Great Lakes areas. Loon and Beamish (1977) also employed statistical analysis to relate heavy-metal concentration in water to fish contamination in the FlinFlon area in Canada, and suggested that fish in those areas were well tolerant to zinc. Bessa, et al (2016) similarly employed statistical model to characterize the biomarker toxicity caused by drainages from uranium mines. Cheng and Sun (2016) noted Partial Least Squares Regression (PLSR) as an approach to reliably predict chemical characteristics of fish muscle. Mataba et al (2016) assessed the distribution of trace elements in fish tissues in Tanzania and the risks to human health through correlation analysis, and highlighted that frequent comsumption of fish from the sampled area can be harmful. Fuchsman et al (2016) employed a case study approach and descriptive statistical methods to evaluate the mercury toxicity measures employed in fish poisoning context, and called for more research in better understanding the research issue. Tong et al (2015)suggested that mercury linked contamination can also be due to factors other than fish, and the role of fish in such poisoning may be overplayed with mercury poisoning from rice consumption being a notable factor. Torkar and Zwitter (2015) linked mercury mining to fish poisoning in the Idrijca River Basin, Slovenia. Koki et al (2015) reviewed the risk caused by heavy metals to human, especially when contaminating fish, air and water.

There has also been works covering areas linked to fishery and data mining (details of data mining are discussed subsequently). Muttil and Chau (2007), for instance, used artificial neural networks (ANN) and genetic programming (GP) to identify factors significant towards the dynamics of algal blooms. Elkadiri et al (2016) developed ANN, multivariate regression and hybrid data-driven models to investigate the probabilities of algal bloom at Kuwait Bay from remote sensing datasets. The model used in the research was noted to provide improved performance over conventionally employed techniques. Verma and Singh. (2012) use data mining to predict toxic substance level in water and which in turn may impact the fish. However, as the above discussions show, concerns about causes of fish poisoning, classifications of poisonous fish, intelligent identifications of symptoms for fish poisoning, and intelligent assessment of risk factors for fish poisoning are areas where data mining may be applicable, yet such works are lacking. This work hence contributes by assessing the relevant possibilities.

IV. DATA MINING

Data Mining is a knowledge discovery process to identify interesting patterns from varied volumes of data, and has found applications in wide areas like marketing, surveillance, fraud detection, and medicine (Han & Kamber, 2006). It has also been shown as potential in varied disease detection tasks including cancer and heart disease (Nahar et al. 2009; Nahar et al. 2013).However, fish poisoning is a particular area where data mining holds potentials, yet have not been extensively applied.

Notably, data mining can be expressed through two functionalities: descriptive data mining and predictive data mining, where descriptive methods target identifying human-interpretable patterns to conceptualize the data, while the predictive methods infer on existing data to predict outcomes (Han & Kamber, 2006). The predictive methods or tasks for data mining include:

Classification –Classification is a key data mining approach, the purpose of which is to accurately predict the target class from test patterns (Orecle, 2016; Breiman et al., 1984).There are different classification algorithms including Decision Tree, Nearest Neighbour, Naive Bayesian, Artificial Neural Network and Support Vector Machine (Kaper et al., 2004; Schlögl et al., 2005; Lotte et al., 2007; Han &Kamber, 2006;Cios et al., 2007).

Regression –Regression constitutes identifying a model that captures the relationship between independent and dependent variables (Cios et al., 2007).

Association rule learning –Association Rule Mining (ARM) entails finding highly correlated attributes shared within large database, and thereby identifying interesting rules easily interpretable by human (Han & Kamber, 2006).

Clustering –Clustering is a data mining task that groups data with similar items, and has found applications in different fields including multimedia and biology (Cios et al., 2007).

V. POSSIBILITIES OF DATA MINING IN FISH POISONING AREA

It is very hard to detect which fish is poisonous simply by observation. It is also difficult to how adverse the effects of different fish poisoning are, especially when originating from different fishes. Further, treatment for different types of fish poisoning can be varying and a wrong treatment may lead to fatal consequences. At the moment, there is no such system in place that is able to detect poison in a fish and to prevent it from being sold. Data mining can hence aid fish poisoning research in varied ways. This section discusses the feasibilities.

Association rule mining may extract useful information from fish databases. For instance, ARM may reveal the patterns associated with fish poisoning symptoms and then relate these to the type of fish. ARM may further help deducing meaningful associations among the factors to reflect how the symptoms interact towards causing fish poisoning. Support, confidence, and lift (Han & Kamber, 2006), calculated from the association rules, can be used to evaluate the strength of these rules. In addition, ARM may also aid ranking the effects of fish poisoning to understand the level of risk such poisoning poses to a person.

A classification approach that may aid in fish poisoning area is the SVM. In the case of SVM, it may help in labeling and identifying fish poisoning incidents. It may also help us in determining the type of fish poisoning. Additionally, SVM may aid in identifying genes that are linked to the cause of poisoning in fish and that linked to the occurrence of fish poisoning in human. In addition, SVM may also be used in assessing literatures and documents on fish poisoning, and thereby contribute to enacting appropriate bio-security policies.

Clustering is another data mining technique that has potentials. Using its unsupervised learning nature (i.e., where the target labels are not given during training), clustering may aid in grouping the fish poisoning incidents and risk factors. This may further allow the identification of fish poisoning, not previously encountered. Additionally, clustering may allow better conceptualization of the spread and origins of the particular diseases. Clustering can further be used to group identical fish with and without fish poisoning influenced by factors like location (shallow waters, deep sea and so on), size of fish, and the type of fish. Indeed, as discussed earlier, many fish poisoning types show similar symptoms and remain undetected through observations or remain existent even after processing during cooking. Thus, by adopting the different data mining techniques, a holistic disease prevention system and identification system may be developed. The use of the system may aid health practitioners in treating the ailments. This system will also detect whether a fish is safe to consume or not. This will save the government large amount of money spent on medication for patients with fish poisoning. Additionally, the policy makers will be better informed in forming policies towards the prevention.

VI. CLOUD COMPUTING WITH FISH POISONING

Cloud Computing is a ubiquitous computing environment that allows on-demand access to shared computing resources and services through varied deployment models (Cios et al., 2007). A particular specialty of cloud computing is to facilitate high computing processing power at less implementation costs, have noted applications in areas including application hosting, backups, e-commerce and search engines (Hurwitz et al. 2010; Cios et al., 2007; Jämsä-Jounela, 2013).

Cloud computing also has potentials, along with data mining, in the area of fish poisoning. For instance, a number of cases of fish poisoning are reported in Fiji on a regular basis. The hospitals of Fiji generally deal with the cases in isolation, and the details on the incidents are recorded and archived by the respective hospital administration. A cloud computing platform, especially through the SaS architecture (Hurwitz et al. 2010; Jämsä-Jounela, 2013), can link the records of all the hospitals in Fiji to create a central database for fish poisoning. This database can then be processed through clustering, classification and ARM to develop a holistic fish poisoning detection and prevention system. Further, with a cloud infrastructure integrating the public health systems of Fiji, while ensuring proper privacy measures, the government will be provided with up-to-date information that may facilitate decisions at a national level. Such decisions may prevent people from consuming specific fish species until any incidental food poisoning issues have been addressed. It will also have economic impact both due to the influence of cloud computing and data mining perspectives.

From cloud computing perspective, a central architecture to process the medical information and to deliver the case study information to the doctors will save costs linked to the deployment of prevention systems and database systems at each individual medical facility. From the data mining perspective, the cloud architecture will both allow access to sufficient volumes of data for accurate training by the data mining models; and allow design of hybrid expert systems towards better prediction and identification. The overall impact will be saving of public money through reduced procurement of medication and labour. The economic benefits will also be enjoyed by the private sector of Fiji as they will be able to avid prolonged sick leave payment for staffs, especially with the data mining based system being able to detect the fish poisoning cases early. Economic benefits also come from reduced time and money spent on computational analysis, especially since the data gathered from the public sector will be large in volume and potentially infeasible to process stand-alone. Overall, the combination of cloud computing and data mining in fish poisoning also has potentials from health economics area, especially with the better allocation of public funding in medical facilitation and the possibility of redirecting the saved funding towards other public services.

VII. EXPERIMENT OUTCOME

As an example of employing computational intelligence, this section provides the outcome of running Apriori, a rule mining approach, on a fish poisoning dataset developed from existing literature. More precisely, the research reviewed different literature on the fish poisoning; and developed a dataset containing the different fish type, the symptoms and circumstances notable for cases of fish poisoning and the type of fish poisoning. WEKA (Witten and Frank, 2005) has been used as the computational intelligence platform for this experiment. The dataset was designed in the format required by WEKA. Table 1 shows the outcome of running Apriori.

From the experiment, a total of 28 rules with a support between 1.0 and 0.1 were found. The top nine rules in terms of support and confidence are shown in Table 1. As evident from the rules showing the highest support (0.48) and confidence (1), consumption of Tuna is well linked to fish poisoning. This supports the fact, especially since it is a big fish and research notes that fish poisoning very often occurs from taking bigger rather than smaller fish. The other top support rule suggests consumption of Mackerel, which is a deep-sea fish, may also be linked notably to fish poisoning, especially if exposures to chemicals have occurred. In a similar way, the other rules indicate the symptoms, the environmental contexts, the area, and the general time to the development of symptoms linked to the different fish poisoning for the different species of fish. Notably, the outcomes shown here is part of a pilot project, and a detailed and more through experiment will be undertaken as a future work. Also, even though a cloud computing architecture has not been used in the experiment, the Apriori algorithm employed can be extended to such architecture. Overall, the outcomes illustrate that Apriori is effective in gaining valuable information regarding fish poisoning. And this, in turn, empirically suggests the applicability of data mining (and potentially, cloud computing) in the fish poisoning area.

Table 1. Rule mining for risk factors and symptoms of Fish poisoning. Here, '∩' symbol implies 'and' in the rules, while the '=>' symbol indicates 'implication'

Extracted rules for Fish poisoning

<u>Support: lower support 0.1, upper support 1.0</u>

Rule: {Tuna _fish } => **Fish poison 1** (support 0.48, conf-1);
Rule:{Mackerel ∩ 15_miutes ∩ Deep sea ∩ USA_Hawai ∩ Exposure_to_chemicals ∩ Nausea ∩ Vomiting ∩ Diarreha}=>**Fish poison 1** (support 0.48, conf-1);
Rule: {Bluefish ∩ USA ∩10_15_minutes ∩ High_level histamine ∩ Severe_ allergic reaction ∩ Palpitations ∩ Itching∩ Blurred_ vision ∩ Abdominal_ cramps ∩ Diarrhea} =>**Fish Poison 2** (support 0.39, conf-1);
Rule: {Barracuda ∩ Coral_reef_damage ∩10_15_minutes ∩ USA ∩ Muscle_ weakness ∩ Joint _aches ∩ Headache ∩ Dizziness ∩ Pacific_ and_ Indian_ Oceans ∩ Low_ blood _pressure } =>**Fish poison 2** (support 0.36, conf-1);
Rule: {Coral ∩ Coral_ loss_ and_ algae ∩ Yellowfin_ grouper ∩ Australia ∩ 15_min_24_hours ∩ Warm_tropical_water ∩ Headache ∩ Blurred_ vision} => **Fish poison 3** (support 0.30, conf-1);
Rule: {Moray eel ∩ The_western_ Gulf_ of_ Mexico ∩ Coral_ reef_ damage ∩ 20_2_hours ∩ Tingling ∩ Abdominal_ pain ∩ Burning_ sensation} => **Fish poison 3** (support 0.28, conf-1);
Rule: {Red snapper ∩ Cold_ allodynia ∩ Hawaii ∩ 2_24_hours ∩ Spread_ of_toxic_ algal_ blooms ∩ Sensation_ that_ the_ teeth_ loose ∩ Itching ∩ Metallic taste ∩ Blurred_ vision }=> **Fish poison 3** (support 0.22, conf-1);
Rule: {Mussels ∩ California ∩ Drowsiness ∩ Mollusks_consumed_toxigenic_ dinoflagellates ∩ Dry_ throat _and _skin_ incoherence ∩ Rash_and _fever∩ } => **Fish poison 4** (support 0.20, conf-1);
Rule: {Coral trout ∩ 2_3_hours ∩ July ∩ Tingling∩ Sensation_ numb ∩ Shivering ∩ Vomiting ∩ Diarrhea ∩ Exposure_to_chemicals } => **Fish poison 4** (support 0.17, conf-1)

VIII. CONCLUSIONS

This research surveys varied fish poisoning and their symptoms, along with reviews on varied data mining techniques, to highlight the possibility of both data mining and cloud computing in the fish poisoning area. It also indicates outcomes of a pilot experiment to justify the use of data mining in this research area. As discussed, fish poisoning is difficult to detect by observation and difficult to alleviate by processing. Thus, this research reflects some of the measures that could be used to prevent poisoning, while encouraging people to consume fish. A data mining based approach, deployed on cloud architecture, may lead to better diagnostics of fish poisoning cases, and inform people on fish consumption safety and contribute towards developing a general guideline for fish consumption to reduce fish poisoning. Additionally, it may aid in forming national policy on risks linked to fish poisoning, while also saving public funding. In a next stage of this research, data will be collected from different areas in Fiji to identify the different classes of fish poisoning and rules regarding different fish poisoning for the disease detection.

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