

TOWARDS BEST PRACTICE IN DATA CLEANING: A CASE STUDY OF THE CHICAGO FOOD INSPECTIONS DATASET

**Final Project Report – Fall 2016
Class LIS590: Theory and Practice Data Cleaning**

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I. Introduction

In the age of Big data, data cleaning has become a hot topic nowadays. Data cleaning (or cleansing), according to Rahm and Do (2000), is the activity that improves the data quality when users try to identify and remove errors and inconsistencies from their datasets. However, many research leap in their method section from data collection directly to data analysis, often ignoring the stage where they should handle their data and do data cleaning tasks. Moreover, even if some research did perform data cleaning tasks, the cleaning stages are a linear process. Thus, the aim of this paper is to propose a feasible practice and a general framework for data cleaning.

II. Literature Review and Research Gap

A. Data cleaning in general:

In order to achieve a high-quality dataset, data cleaning is one of the most important but often forgotten tasks during a research process. Osborne(2013) believes that data cleaning is critical in the sense that it will influence the validity of the data. If there are un-handled dirty data, it might affect the quantitative analysis result by violating its hypothesis, or returning the wrong normalization results, which, will eventually lead to potential misunderstanding of the dataset as a whole. Osborne also suggests that each dataset has its uniqueness, so it will take years of experience to truly nature in data cleaning tasks of different kinds of dataset. However, the best that neophyte data cleaners can do is to use our own judgment to identify the unique challenges within each dataset, handling each dataset with different approach best fit for the project.

Many research viewed data cleaning as a linear process, such as in Van den Broeck (2005), where the author identified data cleaning phases into screening, diagnosis, and treatment phases. Furthermore, many research aims at identifying different stages of cleaning tasks thus failed to provide a general guideline for the cleaning tasks. This is where we find the research gap among data cleaning practices: it is our belief that data cleaning is an iterative process which require continuous checks in research process. Researchers should always come back to their dataset to do cleaning and analyzing tasks. For this purpose, we want to propose a feasible data cleaning framework that gives future researchers a general overview of what kind of solutions can be employed upon different types of errors in the dataset.

B. Types of errors:

According to Rahm and Do (2000), data quality problems occur when there are either single-source or multi-source, and there are mainly two levels of data quality problems: schema-level problems which can be addressed at the schema level and instance-level problems which refer to errors and inconsistencies in the actual data contents.

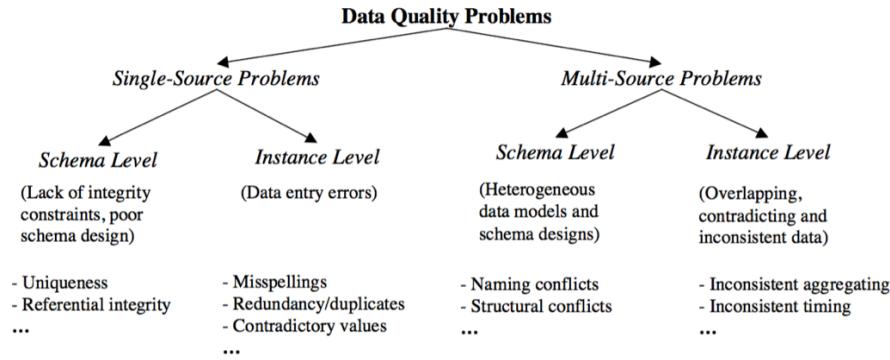


Figure 1. Data Quality Problem graph in Rahm and Do (2000)

Rahm and Do (2000)'s paper emphasized more on the data quality of the dataset per se, mentioning the problems within data entry such as misspellings, redundancy, contradictory values, and so on. Adapting from the classification of data quality problems in Rahm and Do(2000)'s paper and to show a clearer perspective of the type of errors occurring during a cleaning process, we identify three categorizations of errors that could happen within a typical dataset: data format errors, data integrity errors, and also data structure errors. For each of these, we have different subtype of errors as well, and our cleaning solutions are provided in the Data Cleaning Framework section of this paper.

C. Geocoding:

Within our study, we implemented some geocoding process to compare the location data. For this purpose, we needed to understand what geocoding is, and what kind of tools there are.

According to ArcGIS PRO, geocoding is “the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface.” For our dataset, since we have the exact address of the restaurants, we could geocode that with some existing tools to automatically extract its latitude and longitude. Surveying Geocoding methods:

There are many geocoding tools available nowadays, and the most prevalent use so far is perhaps the Google Earth Pro. However, using Google Earth has its downsides: (1) it only allows us to parse 2,500 address per day, and that (2) according to Whitehead (2015), when he tried to geocoding the addresses using Google Earth, he came across a large number of failures, he suspected that Google Earth apparently does not use Google Maps for geocoding. Alternative ways to do geocoding are using the ArcGis geographic information system. It is a comprehensive geographic information system that can do a lot of things, but since it is not open source software, users have to pay fees in order to use it. We also found another tool called ‘Batch Geocoders’ (<https://geocoder.ccjeng.com/>), a free online tool that can generate the latitude and longitude for the address after we post our address in the input section. Though simple and easy to use, the output this tool generate is text format, so it would require an extra effort to format it into the way we want and do a little bit of data cleaning before using it.

After surveying the tools at hand, we finally decided to use a tool provided by GridGIS that uses the Bing Maps API that takes addresses as input and make the output directly into Microsoft Excel Files. The tools can parse up to 10,000 records, more than Google Earth's 2500 records; and it is also quite simple to use.

III. Method – The proposal of Data Cleaning Framework

The following graph is the data cleaning framework we propose for this study:

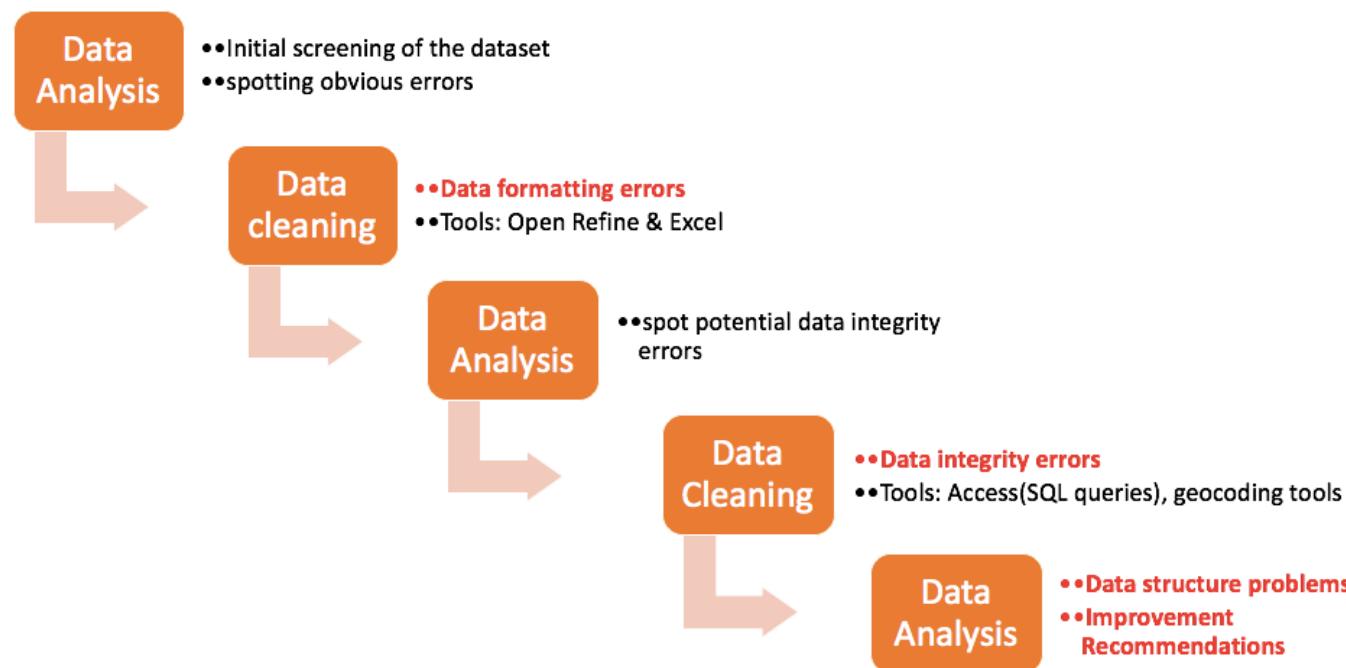


Figure 2. The data cleaning framework that we proposed

The above workflow shows that the data cleaning process is an iterative process constantly alternating between data analysis and the actual data cleaning tasks. As shown in the workflow, there are two main tasks would be performed which are **Data Analysis** and **Data Cleaning**. However, these two tasks would be repeated in three different stages:

- Stage 1: Focusing on data formatting errors, including 2 steps: identify data formatting errors and propose solutions to fix these errors. The reasons we want to focus on data formatting errors at the beginning are because these errors can be spotted by eyes or via simple filtering queries, also because there are many built-in applications that can help to spot these cosmetic errors and fix them easily (such as Open Refine).

- Stage 2: Focusing on data integrity errors, also including 2 steps: identify data integrity errors and propose solutions to fix these errors. The reason we want to focus on data integrity later than formatting errors because these are errors that normally involved meaning of the data; they are not easily to be spotted. Developers normally require higher technical skills and programming efforts in order to identify the errors and fix them.

- Stage 3: Focusing on data structure problem, including 2 steps: identify data structure problems and propose improvements. Data structure is important in data cleaning because a good data structure could help developers to prevent errors in the future. After cleaning data (through out the first 2 steps), the question now is how could we prevent these error happened in the future? We believe improvements in data structure should be included in the data cleaning framework as a necessary stage in order to tackle this issue.

As mentioned in the above description, for our study, we identified three types of errors during the cleaning process, these are: ***data formatting errors, data integrity errors and data structure problems***; so for the three cleaning and analysis tasks, we are aiming at fixing these problems. Moreover, in data cleaning tasks, employing different tools is inevitable. For the first stage of cleaning data formatting errors, we used Open Refine and Excel as our tools; for the integrity errors, we used Database Management System (such as Microsoft Access), geocoding tools to do the tasks.

All of the stages and error types will be described in more details in the section Results, when we applied our proposed data cleaning framework into a sample dataset.

IV. Introduction of the dataset

In order to examine the data cleaning framework to see if it is feasible to apply in the real world. We chose a random available dataset and followed the steps in the proposed framework to clean data of the dataset. Following is the introduction of our sample dataset.

The data set was downloaded from a public data portal created by Chicago government at "<https://www.cityofchicago.org>". The **portal** is dedicated to promoting access to government data and encouraging the development of creative tools to engage and serve Chicago's diverse community [citation here]. The site hosts over 200 datasets about City departments, services, facilities and performance. The dataset names "Food Inspection" dataset. It contains information which is derived from inspections of restaurants and other food establishments in Chicago from January 1, 2010 to the present. Inspections are performed by staff from the Chicago Department of Public Health's Food Protection Program using a standardized procedure. The results of the inspection are inputted into a database, then reviewed and approved by a State of Illinois Licensed Environmental Health Practitioner (LEHP).

The reason for us to choose this dataset is because its purpose to serve the community. The dataset itself is still updated regularly, thus potentially contains errors for data cleaning. According to the disclaimer made by Chicago Department of Public Health "Attempts have been made to minimize any and all duplicate inspection reports. However, the dataset may still contain such duplicates and the appropriate precautions should be exercised when viewing or analyzing these data." Our goals are using the data cleaning technologies (both were taught in class and available outsides) and

follow the proposed workflow, in order to improve the structure as well as accuracy of the dataset, thus improving analytic tasks could be performing later on.

The dataset includes over 135.000 records. It is initially a flat file which contains 17 columns. Below is the description of each column [*citation here*] including information of: data type, predefined values (if exist):

Column Name	Data Type	Description	Pre-defined values
Inspection ID	Number (unique)	An unique number generated for each inspection as a primary key	
DBA Name	Text	DBA stands for “Doing business as”. This is legal name of the establishment.	
AKA Name	Text	Stands for “Also known as”. This is the name the public would know the establishment as.	
License #	Number (unique)	This is a unique number assigned to the establishment for the purposes of licensing by the Department of Business Affairs and Consumer Protection.	
Facility Type	Text (with pre-defined values)	Each establishment is categorized into a specific type of pre-defined categorization of facility.	
Risk	Text	Each establishment is categorized as to its risk of adversely affecting the public’s health, with 1 being the highest and 3 the lowest. The frequency of inspection is tied to this risk, with risk 1 establishments inspected most frequently and risk 3 least frequently.	Risk 1 (High) Risk 2 (Medium) Risk 3 (Low)
Address	Text	Street address of facility	

City	Text	City of the facility	
State	Text	State of the facility	IL
Zip	Number	Zip code of the facility address	
Inspection Date	Date	This is the date the inspection occurred. A particular establishment is likely to have multiple inspections which are denoted by different inspection dates.	
Inspection type	Text (pre-defined)	Each inspection is categorized into pre-defined type of inspection. Re-inspections can occur for most types of these inspections and are indicated as such.	
Results	Text (pre-defined)	An inspection can pass, pass with conditions or fail.	Pass, Fail
Violations	Text	An establishment can receive one or more of 45 distinct violations (violation numbers 1-44 and 70). For each violation number listed for a given establishment, the requirement the establishment must meet in order for it to NOT receive a violation is noted, followed by a specific description of the findings that caused the violation to be issued.	An inspection can pass, pass with conditions or fail. Establishments receiving a 'pass' were found to have no critical or serious violations (violation number 1-14 and 15-29, respectively). Establishments receiving a 'pass with conditions' were found to have critical or serious violations, but these were corrected during the inspection. Establishments receiving a 'fail' were found to have critical or serious violations that were not correctable during the inspection. An establishment receiving a 'fail' does not necessarily mean the establishment's licensed is suspended. Establishments found to be out of business or not located are indicated as such.
Longitude	Number	Longitude information of the facility's location	
Latitude	Number	Longitude information of the facility's location	

Location		Geographical information of the facility's location (combination of longitude and latitude information)	
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V. Results

In this session, we are going to apply our proposed framework into the Chicago inspection dataset in order to examine whether the framework could help to improve the data quality through out the steps. In the end, we will come up with a summary table to show how many errors are spotted and resolved in each stage and how does the data quality compare with the original one so as to evaluate the improvements.

STAGE 1: DATA FORMATTING PROBLEMS

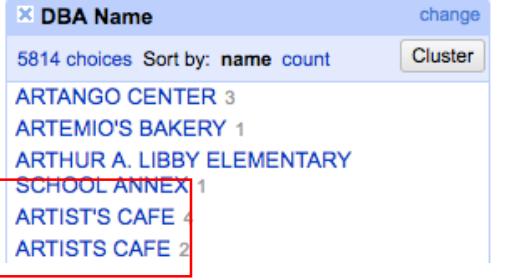
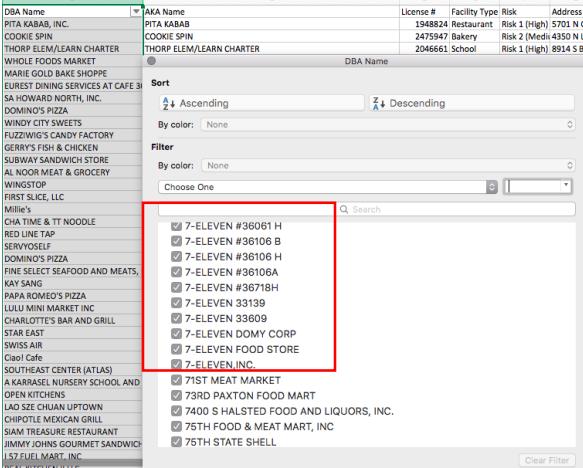
A. Analysis of Data Formatting Errors:

In this stage of analysis, the goal is to closely look at the data, identify **data formatting errors** and propose **cleaning solutions** to solve these errors. The reasons we want to focus on data formatting errors at the beginning are because these errors can be spotted by eyes or via simple filtering queries, also because there are many built-in applications that can help to spot these cosmetic errors and fix them easily (OpenRefine is one of them).

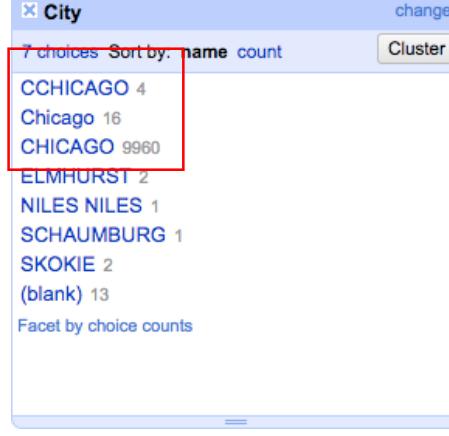
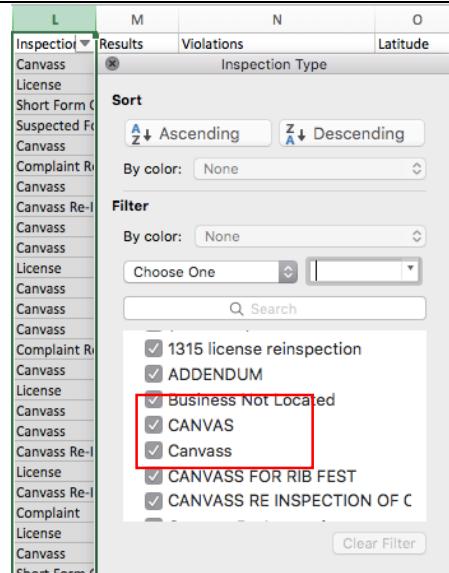
As define in the above session, data formatting errors mainly occur at instance level (or we can call it record level). With the Chicago Food inspection dataset, we have allocated 3 types of formatting errors as described below. Notice that the list of errors is unnecessary to be fixed or completed. For each dataset, the list of formatting errors could be different depending on data characteristics. However, we believe these 3 below errors are the most common errors that most of dataset will have at least:

- **Misspellings:** are errors that involved spelling mistakes. In this case they are mainly mistakes with tail and head white spaces, double white spaces. Spelling mistakes can be spotted using tools, such as OpenRefine, but some really need to look at data closely in order to identify. Therefore, there are still manual works involved.
- **Non-standardizations:** are errors happen when the data doesn't follow a certain format standard that is pre-defined (including uppercase, lowercase, first letter uppercase, etc.). In this dataset, even though there is not a fixed standard in term of upper-case or lower-case for each column. However, we would like to propose the most common-sense standards in order to make the data look more comprehensive.
- **Inconsistencies:** are errors happen when data which refers to the same thing but have different formats in different records. Thus, they should be re-format into one comprehensive presentation.

In order to identify formatting errors, we mainly used Excel and Facet function in OpenRefine as a filtering tool. Below is the list of errors that we identified in the Chicago Food Inspection dataset:

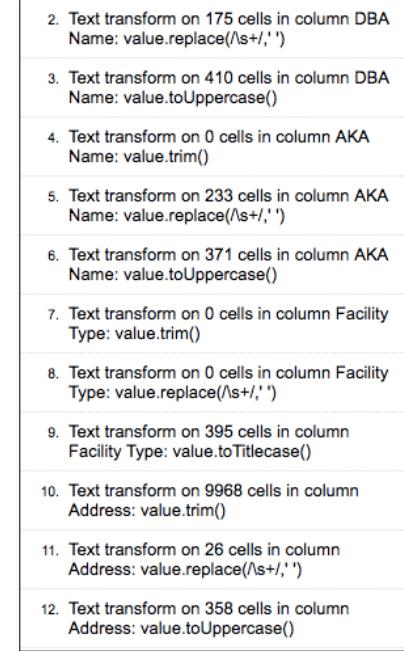
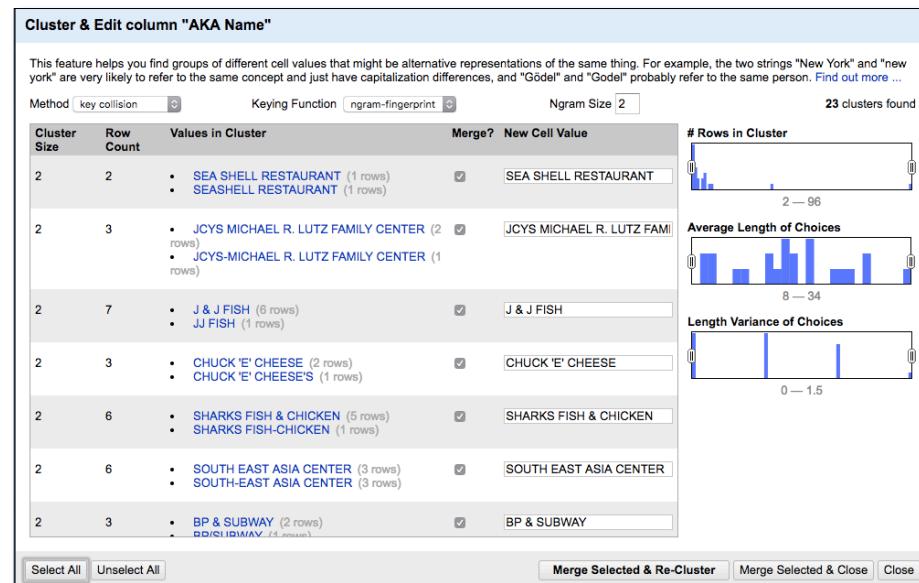
Column Name	Error Type	Error Description	Screenshot	Proposed Solution
DBA Name	Inconsistencies	<p>Some DBA names seem to refer to the same restaurant, however were described by different names.</p> <p>Ex.: the screenshot showed an example of two DBA Names “Artist’s Cafe” and “Artists Cafe”, which actually refer to the same café store.</p>		Using OpenRefine, clustering function to spot these inconsistent data and fix them.
DBA Name	Non-standardizations	<p>Some DBA names have not followed the standard format.</p> <p>Ex.: The screenshot showed an example of standard format for 7 Eleven shops, which can be “7-Eleven #branch_number branch_character”.</p>		Using OpenRefine, clustering function to spot these unstandardized format data and using RLE to fix the format.

Facility Type	Inconsistencies	<p>Some Facility Type seem to refer to a same type, however were described by different names.</p> <p>Ex.: the screenshot showed an example of two facility types “Convenience” and “Convenience Store”, which actually refer to the same type of facility.</p>	<table border="1"> <thead> <tr> <th>Facility Type</th> <th>Count</th> </tr> </thead> <tbody> <tr><td>Children's Services Facility</td><td>183</td></tr> <tr><td>Childrens Services Facility</td><td>1</td></tr> <tr><td>Church</td><td>4</td></tr> <tr><td>Church Kitchen</td><td>5</td></tr> <tr><td>Church/special Events</td><td>1</td></tr> <tr><td>Coffee Shop</td><td>1</td></tr> <tr><td>Coffee/tea</td><td>1</td></tr> <tr><td>College</td><td>2</td></tr> <tr><td>Convenience</td><td>5</td></tr> <tr><td>Convenience Store</td><td>5</td></tr> <tr><td>Cooking School</td><td>2</td></tr> <tr><td>Culinary Arts School</td><td>1</td></tr> <tr><td>Culinary School</td><td>4</td></tr> </tbody> </table>	Facility Type	Count	Children's Services Facility	183	Childrens Services Facility	1	Church	4	Church Kitchen	5	Church/special Events	1	Coffee Shop	1	Coffee/tea	1	College	2	Convenience	5	Convenience Store	5	Cooking School	2	Culinary Arts School	1	Culinary School	4	Using OpenRefine, clustering function to spot these inconsistent data and fix them.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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WALLS, CEILINGS, ATT</td></tr> <tr><td>8914 S BUFFALO</td><td>CHICAGO</td><td>IL</td><td>60617</td><td>11/8/16</td><td>Short Form C</td><td>Pass</td><td></td></tr> <tr><td>832 W 63RD</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Address</td></tr> <tr><td>5752 N CALIFORNIA</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Sort</td></tr> <tr><td>300 N LA SALLE</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Ascend</td></tr> <tr><td>1649 W HOWARD</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Descend</td></tr> <tr><td>2455 W FULLER</td><td></td><td></td><td></td><td></td><td></td><td></td><td>By color:</td></tr> <tr><td>3326 W WESLEY</td><td></td><td></td><td></td><td></td><td></td><td></td><td>None</td></tr> <tr><td>4401 N RAVENSWOOD</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>1817 W WELLINGTON</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> <tr><td>2017 S 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City	Misspellings Unstandardized format	Ex.: there are three records which refer to the same city "Chicago". However, one of them has a spelling mistake as shown in the besides picture.		Using OpenRefine, clustering function to spot these unstandardized format data and using RLE to fix the format.
Inspection Type	Non-standardizations	Some Facility Types are not following standards. Here we expect all the values are in lowercase with the first letter is uppercase.		Using OpenRefine, clustering function to spot these unstandardized format data and using RLE to fix the format.

B. Data Formatting Errors Cleaning Solutions:

After identifying the list of formatting errors, we used OpenRefine as the main tool to resolve these errors. It is unnecessary to use OpenRefine, other applications are encouraged (such as using Excel). However, in the scope of this class, since OpenRefine was introduced, therefore we would like to use it. The following are the steps that we implemented in OpenRefine to fix the above errors:

Step	Screenshot																																								
<p>Step 1:</p> <p>We used Open Refine to implement some basic transformation for all columns, including: <i>trim leading and trailing whitespace, collapse consecutive whitespace, to titlecase, to uppercase.</i> And the results were as shown in the besides screenshot.</p> <p>As we can see, these errors couldn't be spotted by eyes, still the number of these cosmetic errors are quite high. Therefore, it is always a good idea to run these basic transformations in all dataset and repeated them if necessary each time you change your data.</p>	 <pre> 2. Text transform on 175 cells in column DBA Name: value.replace(/\s+/, '') 3. Text transform on 410 cells in column DBA Name: value.toUpperCase() 4. Text transform on 0 cells in column AKA Name: value.trim() 5. Text transform on 233 cells in column AKA Name: value.replace(/\s+/, '') 6. Text transform on 371 cells in column AKA Name: value.toUpperCase() 7. Text transform on 0 cells in column Facility Type: value.trim() 8. Text transform on 0 cells in column Facility Type: value.replace(/\s+/, '') 9. Text transform on 395 cells in column Facility Type: value.toTitlecase() 10. Text transform on 9968 cells in column Address: value.trim() 11. Text transform on 26 cells in column Address: value.replace(/\s+/, '') 12. Text transform on 358 cells in column Address: value.toUpperCase() </pre>																																								
<p>Step 2:</p> <p>We used cluster function in Open Refine to eliminate any inconsistencies & non-standardizations formatting errors that detected in columns: Facility Type, Inspection Type and DBA Name & AKA Name.</p> <p>As for AKA Name column, Open Refine cluster is able to allocate the potential matched values and suggest for merging, which is very helpful. Ex.: SEA SHELL RESTAURANT and SEASHELL RESTAURANT (this is <i>inconsistencies</i> error) most likely refer to the same restaurant. At this point, we can go ahead and merge them.</p>	 <p>Cluster & Edit column "AKA Name"</p> <p>This feature helps you find groups of different cell values that might be alternative representations of the same thing. For example, the two strings "New York" and "new york" are very likely to refer to the same concept and just have capitalization differences, and "Gödel" and "Goedel" probably refer to the same person. Find out more ...</p> <p>Method: key collision Keying Function: ngram-fingerprint Ngram Size: 2 23 clusters found</p> <table border="1"> <thead> <tr> <th>Cluster Size</th> <th>Row Count</th> <th>Values in Cluster</th> <th>Merge?</th> <th>New Cell Value</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>2</td> <td>• SEA SHELL RESTAURANT (1 rows) • SEASHELL RESTAURANT (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>SEA SHELL RESTAURANT</td> </tr> <tr> <td>2</td> <td>3</td> <td>• JOYS MICHAEL R. LUTZ FAMILY CENTER (2 rows) • JOYS-MICHAEL R. LUTZ FAMILY CENTER (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>JCYS MICHAEL R. LUTZ FAMI</td> </tr> <tr> <td>2</td> <td>7</td> <td>• J & J FISH (6 rows) • JJ FISH (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>J & J FISH</td> </tr> <tr> <td>2</td> <td>3</td> <td>• CHUCK 'E' CHEESE (2 rows) • CHUCK 'E' CHEESES (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>CHUCK 'E' CHEESE</td> </tr> <tr> <td>2</td> <td>6</td> <td>• SHARKS FISH & CHICKEN (5 rows) • SHARKS FISH-CHICKEN (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>SHARKS FISH & CHICKEN</td> </tr> <tr> <td>2</td> <td>6</td> <td>• SOUTH EAST ASIA CENTER (3 rows) • SOUTH-EAST ASIA CENTER (3 rows)</td> <td><input checked="" type="checkbox"/></td> <td>SOUTH EAST ASIA CENTER</td> </tr> <tr> <td>2</td> <td>3</td> <td>• BP & SUBWAY (2 rows) • BP/SUBWAY (1 rows)</td> <td><input checked="" type="checkbox"/></td> <td>BP & SUBWAY</td> </tr> </tbody> </table> <p># Rows in Cluster: 2 — 96 Average Length of Choices: 8 — 34 Length Variance of Choices: 0 — 1.5</p> <p>Select All Unselect All Merge Selected & Re-Cluster Merge Selected & Close Close</p>	Cluster Size	Row Count	Values in Cluster	Merge?	New Cell Value	2	2	• SEA SHELL RESTAURANT (1 rows) • SEASHELL RESTAURANT (1 rows)	<input checked="" type="checkbox"/>	SEA SHELL RESTAURANT	2	3	• JOYS MICHAEL R. LUTZ FAMILY CENTER (2 rows) • JOYS-MICHAEL R. LUTZ FAMILY CENTER (1 rows)	<input checked="" type="checkbox"/>	JCYS MICHAEL R. LUTZ FAMI	2	7	• J & J FISH (6 rows) • JJ FISH (1 rows)	<input checked="" type="checkbox"/>	J & J FISH	2	3	• CHUCK 'E' CHEESE (2 rows) • CHUCK 'E' CHEESES (1 rows)	<input checked="" type="checkbox"/>	CHUCK 'E' CHEESE	2	6	• SHARKS FISH & CHICKEN (5 rows) • SHARKS FISH-CHICKEN (1 rows)	<input checked="" type="checkbox"/>	SHARKS FISH & CHICKEN	2	6	• SOUTH EAST ASIA CENTER (3 rows) • SOUTH-EAST ASIA CENTER (3 rows)	<input checked="" type="checkbox"/>	SOUTH EAST ASIA CENTER	2	3	• BP & SUBWAY (2 rows) • BP/SUBWAY (1 rows)	<input checked="" type="checkbox"/>	BP & SUBWAY
Cluster Size	Row Count	Values in Cluster	Merge?	New Cell Value																																					
2	2	• SEA SHELL RESTAURANT (1 rows) • SEASHELL RESTAURANT (1 rows)	<input checked="" type="checkbox"/>	SEA SHELL RESTAURANT																																					
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2	3	• BP & SUBWAY (2 rows) • BP/SUBWAY (1 rows)	<input checked="" type="checkbox"/>	BP & SUBWAY																																					

Notice that, for suspicious values, before deciding to merge or not, we can view the rows in details to look at other attributes such as Address, Location, to decide whether they are really one business or not.

Ex.: PIZZA NOVA and NOVA PIZZA as shown in the beside screenshots seem to be the same restaurant, but they are actually not. Therefore, we have to be very carefully check through the records in details before deciding to merge.

Cluster & Edit column "AKA Name"

This feature helps you find groups of different cell values that might be alternative representations of the same thing. For example, the two strings "New York" and "new york" are very likely to refer to the same concept and just have capitalization differences, and "Gödel" and "Godel" probably refer to the same person. [Find out more ...](#)

Method: key collision Keying Function: fingerprint 3 clusters found

Cluster Size	Row Count	Values in Cluster	Merge?	New Cell Value
2	3	• PIZZA NOVA (2 rows) • NOVA PIZZA (1 rows)	<input type="checkbox"/>	PIZZA NOVA
2	3	• SOUTH EAST ASIA CENTER (2 rows) • SOUTH - EAST ASIA CENTER (1 rows)	<input checked="" type="checkbox"/>	SOUTH EAST ASIA CENTER
2	14	• MC DONALD'S (9 rows) • MC DONALDS (5 rows)	<input checked="" type="checkbox"/>	MCDONALD'S

Rows in Cluster
3 — 14

Average Length of Choices
10 — 23

Length Variance of Choices
0 — 1

Select All Unselect All Merge Selected & Re-Cluster Merge Selected & Close Close

As for **DBA Name** column, we also did the same thing with AKA Name column. We tried all of different clustering methods and keying functions that provided in Open Refine in order to allocate all of possible potential matches.

Ex.: Besides screenshot is “Key Collision” method with “Fingerprint” keying function.

Cluster & Edit column "DBA Name"

This feature helps you find groups of different cell values that might be alternative representations of the same thing. For example, the two strings "New York" and "new york" are very likely to refer to the same concept and just have capitalization differences, and "Gödel" and "Godel" probably refer to the same person. [Find out more ...](#)

Method: key collision Keying Function: fingerprint 57 clusters found

Cluster Size	Row Count	Values in Cluster	Merge?	New Cell Value
3	13	• DUNKIN DONUTS & BASKIN ROBBINS (8 rows) • DUNKIN DONUTS BASKIN ROBBINS (3 rows) • DUNKIN DONUTS / BASKIN ROBBINS (2 rows)	<input type="checkbox"/>	DUNKIN DONUTS & BASKIN ROBBINS
3	3	• WENDY'S OLD FASHIONED HAMBURGER'S OF NEW YORK, INC (1 rows) • WENDY'S OLD FASHIONED HAMBURGERS OF NEW YORK, INC (1 rows) • WENDY'S OLD FASHIONED HAMBURGERS OF NEW YORK, INC (1 rows)	<input type="checkbox"/>	WENDY'S OLD FASHIONED HAMBURGERS OF NEW YORK, INC
3	13	• 7 - ELEVEN (6 rows) • 7 ELEVEN (4 rows) • 7-ELEVEN (3 rows)	<input type="checkbox"/>	7 - ELEVEN
2	3	• RAINFOREST LEARNING CENTER, INC (2 rows) • RAINFOREST LEARNING CENTER, INC (1 rows)	<input type="checkbox"/>	RAINFOREST LEARNING CENTER
2	4	• VAUGHAN'S PUB (2 rows) • VAUGHANS PUB (2 rows)	<input type="checkbox"/>	VAUGHAN'S PUB
2	2	• LALO'S MEXICAN RESTAURANT (1 rows)	<input type="checkbox"/>	LALO'S MEXICAN RESTAURANT

Choices in Cluster
2 — 3

Rows in Cluster
2 — 64

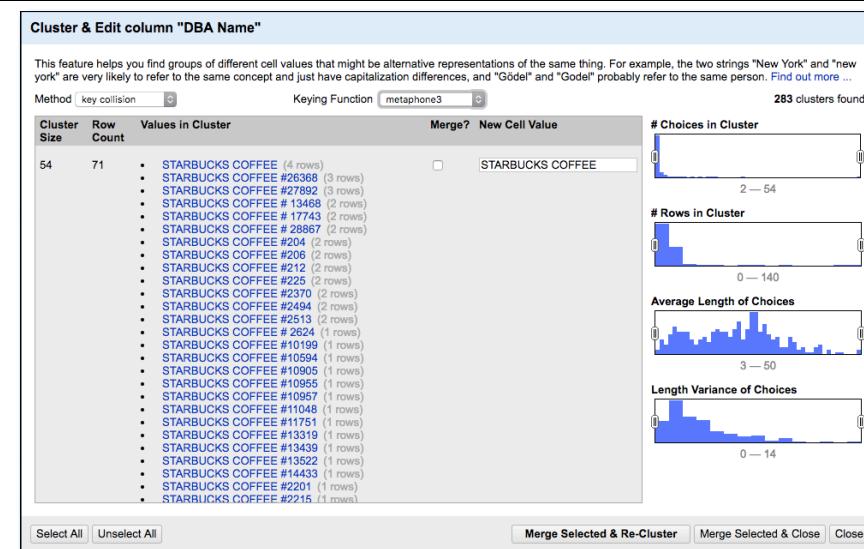
Average Length of Choices
6 — 50

Length Variance of Choices
0 — 2

Select All Unselect All Merge Selected & Re-Cluster Merge Selected & Close Close

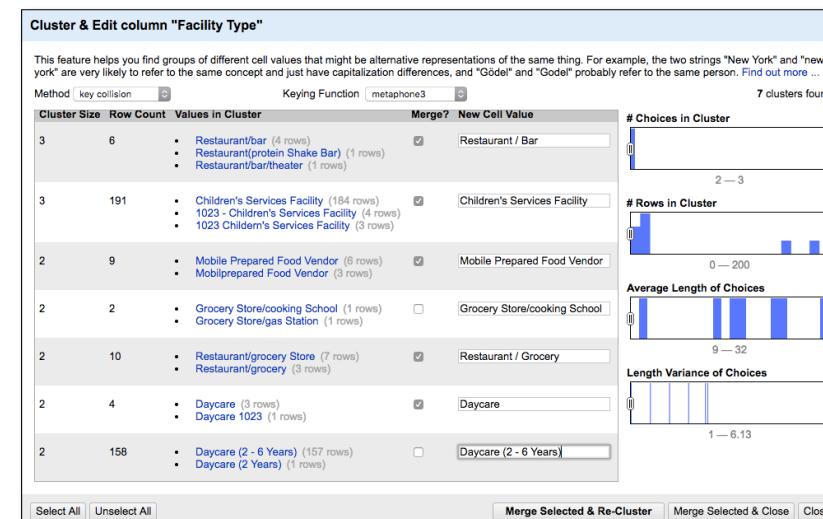
Notice that, some clustering algorithms do not really provide good results compared with others (or they are designed to cluster different types of matching values, which are not really applicable to our cases).

Ex.: Besides screenshot is “Key collision” method with “Metaphone3” keying function. It listed all of STARBUCKS COFFEE shops in the list, all the shops following by # + a number (maybe the numbers are unique and used to identify which Starbucks shops). We cannot merge these shops into one because they are still separate coffee shops with different locations.



As for **Facility Type** column, we also did the same thing with other columns. We tried all of different clustering methods and keying functions that provided in Open Refine in order to allocate all of possible potential matches.

Ex.: Besides screenshot is “Key Collision” method with “metaphone3” keying function.



Notice that, for some non-standardization errors, we also needed to use regular expression queries to fix them.

Ex.: Facility Type values “Grocery” and “Grocery Store” should be standardized into one. In order to do so, we wrote a query to convert all the “Grocery Store” value to “Grocery” as shown in the besides screenshot.

Custom text transform on column Facility Type

Expression: `if(value.contains('Grocery Store'),value.replace('Grocery Store','Grocery'),value)` Language: General Refine Expression Language (GREL) No syntax error.

Preview History Starred Help

row	value	if(value.contains('Grocery Store'),value.replace('Grocery Store','Grocery'),value)
1.	Restaurant	Restaurant
2.	Bakery	Bakery
3.	School	School
4.	Grocery Store	Grocery
5.	Restaurant	Restaurant
6.	Restaurant	Restaurant
7.	Other	Other

On error: keep original Re-transform up to 10 times until no change
 set to blank store error

OK Cancel

C. Cleaning Results & Key Take-away:

- Cleaning Results: (Open Refine scripts are provided with the documentation)

- + There are total 44 steps were performed in OpenRefine.
- + There are total 434 head and tail whitespaces errors fixed.
- + There are total 9968 double whitespaces errors fixed.
- + DBA Name, AKA Name, Address, Violations, City columns are all standardized into all UPPERCASE. Other columns are all TitleCase.
- + Mass edit thousands cells to fix inconsistency and non-standardization errors.

Overall, after the data analysis and cleaning of data formatting errors, we had a cleaner dataset in such way all the formats are standardized, thus making future analysis tasks such as filtering, searching, querying values become more accurate.

- Key Take-away:

- + Utilizes built-in tools to reduce manual inspections and programming efforts: It is important to keep updating the technologies and applications that can help developers to clean data and implement at least some basic transformation. Open Refine is an excellent example for a cleaning tool that can help with basic formatting errors without any programming skills required. And also be flexible in how to apply these tools in your cleaning tasks, such as: during analysis phase, we not only used Open Refine, but also used traditional tool such as Excel to spot formatting problems. Understanding advantages of each tool would be very helpful that can help developers to perform the tasks faster.

+ *Always perform common transformations:* As mentioned above, there are some common formatting errors that are hardly spotted by eyes (such as: double whitespaces, head or tail whitespaces, uppercase, lowercase, etc.). Therefore, our recommendation is always implement these basic transformations and repeat them as needed (especially when you change your data values at some points of time). By doing so, developers can eliminate difficulties in analysis tasks later on.

+ *Be aware of manual works:* Even though, developers always have great supports from data cleaning tools which contain various built-in functions. However, no technologies can capture all of the formatting errors for all datasets because of the variety of the data characteristics. Each dataset might have different formatting problems. Therefore, be aware that data cleaning really heavily involves manual works. Developers are highly recommended to take a look at the data close at much as possible using different tools and techniques.

STAGE 2: DATA INTEGRITY PROBLEMS

A. Analysis of Data Integrity Problems:

Moving further from data formatting errors, we have identified some other errors that was not issues of simply data format, but of ‘data integrity’. The goal of this stage of analysis is to find these data integrity problems and do minimal cleaning tasks. In order to really fix the dataset, it would require a higher level of background knowledge of the dataset or of the discipline.

As mentioned in the Literature Review section, there are types of errors identified by Rahm and Do (2000). In our dataset, we believe there are three types of data integrity problems, these are:

- **Blank value errors:** these are errors when the record in the dataset has a ‘blank’ (or null) value when the record is not supposed to have a blank cell. Examples can be seen here in our dataset, where we believe that the cells in the “AKA name” column should all have values in it; even if the restaurant did not have a shortened name, the data handler should still fill the cells with its full name for the purpose to provide a complete and comprehensive name list.

Inspection II	DBA Name	AKA Name
1970941	LULU MINI MARKET INC	
1970906	VEZENEY LLC	
1970871	SARIKA FOOD INC	
1955339	SOLURI'S DELI,INC	
1970780	M & G GROCERY	
1970606	MY CHOCOLATE SOUL	
1955327	MAY STREET GROCERIES	
1970503	CAIRO KEBOB	
1970498	MICHAELS FAST FOOD & GROCERY, INC	
1970426	DEVIL DAWGS	
1970278	BARRY'S BOOTCAMP	

- **Unique value errors:** these are errors when the data in a column should be a unique value but instead have duplicate values. For instance, in our dataset, the license number should be the sole number attributed to a restaurant at a specific location. However, for license number 23051, we have different records of Starbucks coffee, and another two records on Ebinger elementary school.

23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO
23051 STARBUCKS COFFEE #2215	STARBUCKS COFFEE	828 N STATE ST	CHICAGO
23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO

- **Data accuracy errors:** these are errors when the data contains inaccurate values. However, these are harder to spot at first sight, and may require the use of different cleaning tools to find them. For example, in our dataset, when we marked some sample latitude and longitude data to google map, we find out that there are actually discrepancies on the true location of the restaurant as opposed to the location provided in the dataset (see figure 1 & figure 2 for detail).

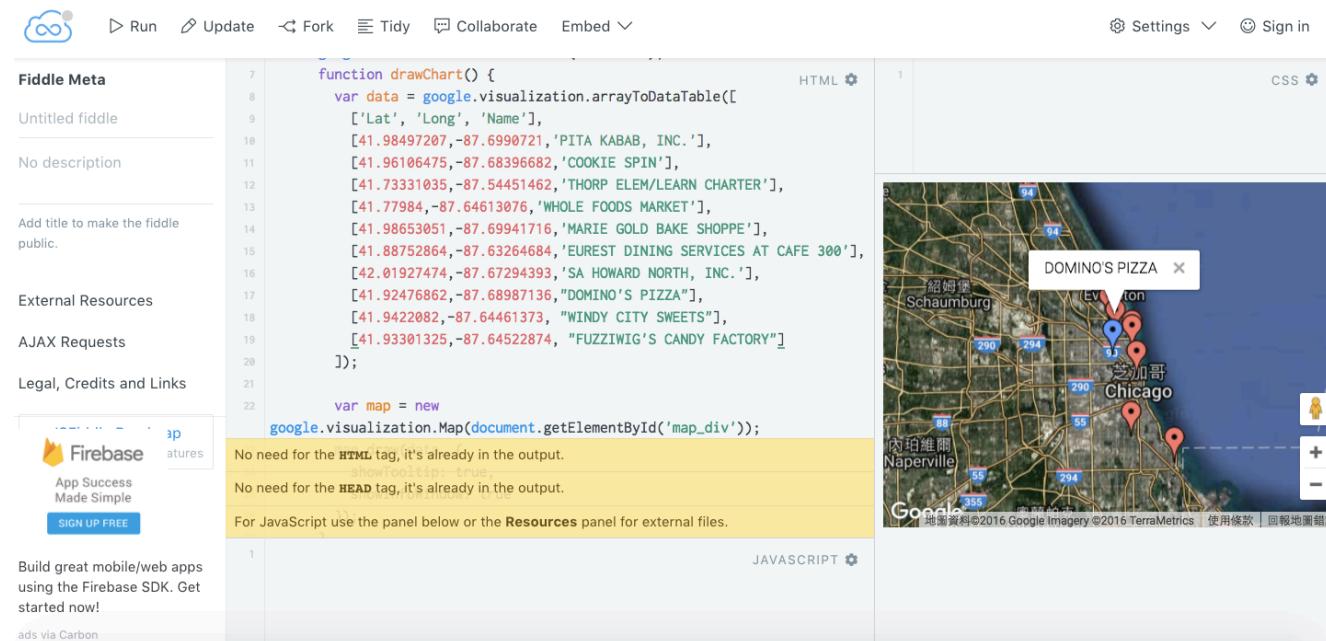


Figure 3. marking the location data on to Google map using JSFiddle



Figure 4. In the left picture, according to the dataset, Domino's Pizza is located at the top left corner, but the true location of Domino's marked in Google map is actually on the center to right. In the right picture, Whole Foods Markets is marked on a sidewalk of a street.

B. Data Integrity Errors Cleaning Solutions:

For the blank value errors and the unique value errors, what we did was we wrote some SQL queries to extract the list of errors. The SQL queries are provided along with the documentation and being released on GitHub.

Step	Screenshot
Step 1. Write the SQL queries that finds the license number violations	<pre>SELECT License_Number, DBA_Name, AKA_Name, Address, City, State, ZIP FROM Food_Inspections WHERE License_Number IN (SELECT License_Number FROM (SELECT DISTINCT License_Number, DBA_Name FROM Food_Inspections GROUP BY License_Number, DBA_name) GROUP BY License_Number HAVING count(DBA_Name) >1)</pre>

Step 2. Implement the query in Microsoft Access in order to extract the list of violation data

Licence_Number	DBA_Name	AKA_Name	Address	City	State	ZIP
0 ST. JEROME PARISH	ST. JEROME	1709 W LUNT	CHICAGO	IL	60626	
6856 HALSTED HARP	HALSTED HARP	2138 N HALSTED ST	CHICAGO	IL	60614	
6856 MASON	MASON	2138 N HALSTED ST	CHICAGO	IL	60614	
6856 MASON	MASON	2138 N HALSTED ST	CHICAGO	IL	60614	
7214 EL JEREZANO RESTAURANT	EL JEREZANO RESTAURANT	5037-5039 W DIVERSEY AVE	CHICAGO	IL	60639	
7214 ZACATECAS RESTAURANT	ZACATECAS RESTAURANT	5037-5039 W DIVERSEY AVE	CHICAGO	IL	60639	
23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO	IL	60631	
23051 STARBUCKS COFFEE #2215	STARBUCKS COFFEE	828 N STATE ST	CHICAGO	IL	60610	
23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO	IL	60631	
25152 JOSEPHINE'S COOKIN'	JOSEPHINE'S COOKIN'	436 - 440 E 79TH ST	CHICAGO	IL	60619	
25152 CHAVEZ UPPER GRADE CENTER	CHAVEZ UPPER GRADE CENTER	4831 S HERMITAGE	CHICAGO	IL	60609	
25152 JOSEPHINE'S COOKIN'	JOSEPHINE'S COOKIN'	436 - 440 E 79TH ST	CHICAGO	IL	60619	
34173 WOLFGANG PUCK, T-3	WOLFGANG PUCK (T3 K1)	11601 W TOUHY AVE	CHICAGO	IL	60666	
34173 PUBLICAN TAVERN K1	PUBLICAN TAVERN K1	11601 W TOUHY AVE	CHICAGO	IL	60666	
34173 PUBLICAN TAVERN K1	PUBLICAN TAVERN K1	11601 W TOUHY AVE	CHICAGO	IL	60666	
34173 PUBLICAN TAVERN K1	PUBLICAN TAVERN K1	11601 W TOUHY AVE	CHICAGO	IL	60666	
39237 BURNT CITY	BURNT CITY BREWING	2743 - 2749 N LINCOLN AVE	CHICAGO	IL	60614	
39237 BURNT CITY	BURNT CITY BREWING	2743 - 2749 N LINCOLN AVE	CHICAGO	IL	60614	
39237 SEVEN TEN/ATLAS	SEVEN TEN	2743 - 2749 N LINCOLN AVE	CHICAGO	IL	60614	
1042664 LOWCOUNTRY	LOWCOUNTRY	3343 N CLARK ST	CHICAGO	IL	60657	
1042664 LOWCOUNTRY	LOWCOUNTRY	3343 N CLARK ST	CHICAGO	IL	60657	
1042664 LOWCOUNTRY	LOWCOUNTRY	3343 N CLARK ST	CHICAGO	IL	60657	
1042664 LOWCOUNTRY	LOWCOUNTRY	3343 N CLARK ST	CHICAGO	IL	60657	

Step 3: SQL queries to extract null values of AKA name column and updated new values for it

```
SELECT Food_Inspections.[Inspection ID], Food_Inspections.[DBA Name], Food_Inspections.[AKA Name]
FROM Food_Inspections
WHERE (((Food_Inspections.[AKA Name]) Is Null));

UPDATE Food_Inspections
SET AKA_Name = DBA_Name
WHERE AKA_Name is null
```

For the data accuracy error, because the inaccuracies occur in the geographical data, we decided to employ some geocoding tools to use the addresses provided by the dataset to automatically extract the real latitude and longitude for us; then, Our purpose here is to compare (a) the latitude and longitude data we get from geocoding with (b) the latitude and longitude data that was provided in the dataset. If the (a) and (b) turned out to be an exact match, then we could believe that the location data in this dataset is believable. If not matched, the dataset might require further analyzing. In our situation, we employed the GridGIS Bing Maps API Excel Geocoding tools.

Steps	Screenshot/sub-steps
Step 1. Initial setting of the geocoding tool	<ol style="list-style-type: none"> Download the excel sheet from (https://github.com/maxrice/excel-geocoding-tool/releases/download/3.6.1/excel-geocoding-tool.xls). Open the downloaded excel file and if it is open in protected view (highlight yellow bar on the top) then click enable editing. After that process, enable macros.

4. In Excel 2013: Go to File -> Options -> on the left side, choose **Trust Center** -> click on **Trust Center Settings** and **Macro Settings**
5. Then check the **Enable all macros**
6. Generate Bing Maps API key from (<https://www.bingmapsportal.com/>), detailed instructions are written in (<http://grindgis.com/software/microsoft-excel/geocoding-excel-and-bing>).
7. Open the geocoding excel tool we downloaded in step 1, then fill out the Bing Map Key, and we are good to go.

Step 2. Data formatting for geocoding preparation. The address data in our original dataset split up the address, city and state; in order to do geocoding, we have to combine the three together in the Address, City, State format. Combine different columns in Excel spreadsheet use the following formula:

F(x)=C2&","&D2&","&E2

And double-clicked the right corner so that the formula continues to the end of this column. this will give us the result with Address, City, State concatenated in one line.

B	C	D	E	F
Name	Address	City	State	Address+City+State
KABAB, I	5701 N CALIFORNIA AVE	CHICAGO	IL	5701 N CALIFORNIA AVE ,CHICAGO,IL
IE SPIN	4350 N LEAVITT AVE	CHICAGO	IL	4350 N LEAVITT AVE ,CHICAGO,IL
P ELEM/I	8914 S BUFFALO AVE BSMT	CHICAGO	IL	8914 S BUFFALO AVE BSMT ,CHICAGO,IL
J E FOODS	832 W 63RD	CHICAGO	IL	832 W 63RD ,CHICAGO,IL
E GOLD	15752 N CALIFORNIA AVE	CHICAGO	IL	5752 N CALIFORNIA AVE ,CHICAGO,IL
ST DININ	300 N LA SALLE ST	CHICAGO	IL	300 N LA SALLE ST ,CHICAGO,IL
WARD N	1649 W HOWARD ST	CHICAGO	IL	1649 W HOWARD ST .CHICAGO.II.

Step 3. Start geocoding. We can start geocoding simly by putting our address data into the geocoding tool in the location column. Then, press the ‘Geocode all rows’ button on the top left corner. The latitude and longitude data will start to be automatically extracted.

Location	Name	Description	Google Maps Link
5701 N CALIFORNIA AVE ,CHICAGO,IL			http://maps.google.com/maps?q=5701+N+CALIFORNIA+AVE,+CHICAGO,IL
4350 N LEAVITT AVE ,CHICAGO,IL			http://maps.google.com/maps?q=4350+N+LEAVITT+AVE,+CHICAGO,IL
8914 S BUFFALO AVE BSMT ,CHICAGO,IL			http://maps.google.com/maps?q=8914+S+BUFFALO+AVE+BSMT,+CHICAGO,IL
832 W 63RD ,CHICAGO,IL			http://maps.google.com/maps?q=832+W+63RD,+CHICAGO,IL
5752 N CALIFORNIA AVE ,CHICAGO,IL			http://maps.google.com/maps?q=5752+N+CALIFORNIA+AVE,+CHICAGO,IL
300 N LA SALLE ST ,CHICAGO,IL			http://maps.google.com/maps?q=300+N+LA+SALLE+ST,+CHICAGO,IL
1649 W HOWARD ST .CHICAGO.II.			http://maps.google.com/maps?q=1649+W+HOWARD+ST.+CHICAGO.II.

Geocoded 60% of the rows

excel-geocoding-tool [Compatibility Mode] - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DEVELOPER ACROBAT

Create Preferences PDF Create and Attach to Email Create and Send For Shared Commenting Create PDF and Run Action * Create Adobe PDF Create and Email Review And Comment Create and Run Action

A B C D E F G H I

1 Geocode selected rows # of addresses: 10000
2 Geocode all rows % of addresses geocoded: 6619 66%
3 Geocode Not Found rows % of addresses found: 6619 100%
4
5 Clear Data Entry Area

12 Latitude Longitude Confidence Location Name Description Google Maps Link

13 41.985088 -87.6989975 High 5701 N CALIFORNIA AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.985088348
14 41.961025 -87.684166 High 4350 N LEAVITT AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.961025238
15 41.732894 -87.545059 High 8914 S BUFFALO AVE BSMT ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.732894.-87
16 41.779968 -87.6462708 High 832 W 63RD, CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.779968261
17 41.986454 -87.6996155 High 5752 N CALIFORNIA AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.986454010
18 41.888156 -87.6325549 High 300 N LA SALLE ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.888156086
19 42.019335 -87.6736102 High 1649 W HOWARD ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=42.019334882
20 41.924845 -87.6896585 High 2455 W FULLERTON AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.924845352
21 41.942025 -87.6445156 High 3308 N BROADWAY ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.942049711
22 41.93305 -87.6451875 High 2808 N CLARK ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.933050230
23 41.678586 -87.6204615 High 11857 S MICHIGAN AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.678585706

11 41.678586 -87.6204615 High 11857 S MICHIGAN AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.678585706

Settings and Instructions Geocode

Looking for 400 S WELLS ST ,CHICAGO,IL

Finished geocoding.

excel-geocoding-tool [Compatibility Mode] - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DEVELOPER ACROBAT

Create Preferences PDF Create and Attach to Email Create and Send For Shared Commenting Create PDF and Run Action * Create Adobe PDF Create and Email Review And Comment Create and Run Action

A B C D E F G H I

1 Geocode selected rows # of addresses: 10000
2 Geocode all rows % of addresses geocoded: 10000 100%
3 Geocode Not Found rows % of addresses found: 9999 100%
4
5 Clear Data Entry Area

12 Latitude Longitude Confidence Location Name Description Google Maps Link

13 41.985088 -87.6989975 High 5701 N CALIFORNIA AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.985088348
14 41.961025 -87.684166 High 4350 N LEAVITT AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.961025238
15 41.732894 -87.545059 High 8914 S BUFFALO AVE BSMT ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.732894.-87
16 41.779968 -87.6462708 High 832 W 63RD, CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.779968261
17 41.986454 -87.6996155 High 5752 N CALIFORNIA AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.986454010
18 41.888156 -87.6325549 High 300 N LA SALLE ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.888156086
19 42.019335 -87.6736102 High 1649 W HOWARD ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=42.019334882
20 41.924845 -87.6896585 High 2455 W FULLERTON AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.924845352
21 41.942025 -87.6445156 High 3308 N BROADWAY ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.942049711
22 41.93305 -87.6451875 High 2808 N CLARK ST ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.933050230
23 41.678586 -87.6204615 High 11857 S MICHIGAN AVE ,CHICAGO,IL http://maps.google.com/maps?f=q&hl=en&geocode=&q=41.678585706

Step 4. Compare results. Put data into separate spreadsheet.

After we automatically generated latitude and longitude, we wanted to compare the geocoding result with the latitude and longitude in the original file; so we put all these data in a separate spreadsheet so as to not tamper with the original file.

A	B	C	D	E	F
Inspection ID	DBA Name	Latitude(original)	Longitude (original)	Latitude(geocode)	Longitude(geocode)
1971056	PITA KABAE	41.98497207	-87.6990721	41.98508835	-87.6989975
1971019	COOKIE SPIN	41.96106475	-87.68396682	41.96102524	-87.68416595
1970998	THORP ELEM	41.73331035	-87.54451462	41.732894	-87.545059
1970999	WHOLE FOO	41.77984	-87.64613076	41.77996826	-87.64627075
1970991	MARIE GOLI	41.98653051	-87.69941716	41.98645401	-87.69961548
1970987	EUREST DIN	41.88752864	-87.63264684	41.88815609	-87.63255492
1970980	SA HOWARD	42.01927474	-87.67294393	42.01933488	-87.67361015
1970976	DOMINO'S PI	41.92476862	-87.68987136	41.92484535	-87.68965848
1970975	WINDY CITY	41.9422082	-87.64461373	41.94204971	-87.64451556
1970958	FUZZIWIG'S	41.93301325	-87.64522874	41.93305023	-87.64518745
1970933	GERRY'S FIS	41.67816957	-87.62036637	41.67858571	-87.62046151
1970760	SUBWAY SA	41.99767708	-87.69924898	41.99763782	-87.6988665
1970974	AL NOOR MI	41.99757189	-87.69263305	41.99766934	-87.6926934
1970973	WINGSTOP	41.94207713	-87.68839243	41.94208995	-87.68831
1970972	FIRST SLICE	41.96161934	-87.67383267	41.96177292	-87.67353821
1971017	Millie's	41.93586585	-87.67433854	41.93571472	-87.67431641
1970968	CHA TIME &	41.85478378	-87.63273281	41.854751	-87.632598
1970966	RED LINE T/	42.00936036	-87.66637744	42.00912857	-87.66583252

Step 5. Round numbers. Because latitude and longitude are really long numbers, in order to quickly fix the problem of not matching anything because of the tiny differences in decimal points, we decided to round numbers to 3 decimal points. Using the formula below, we can round the numbers:

$$F(x)=\text{ROUND}(A,B)$$

Where A is the cell number we want to round up, B is the number of decimal points we want; so the formula would look something similar like this:

$$F(x)=\text{ROUND}(C2,3)$$

Latitude_original	Latitude_geocode	Longitude_original	Longitude_geocode
41.985	41.985	-87.699	-87.699
41.961	41.961	-87.684	-87.684
41.733	41.733	-87.545	-87.545
41.78	41.78	-87.646	-87.646
41.987	41.986	-87.699	-87.7
41.888	41.888	-87.633	-87.633
42.019	42.019	-87.673	-87.674
41.925	41.925	-87.69	-87.69
41.942	41.942	-87.645	-87.645
41.933	41.933	-87.645	-87.645
41.678	41.679	-87.62	-87.62
41.998	41.998	-87.699	-87.699
41.998	41.998	-87.693	-87.693
41.942	41.942	-87.688	-87.688
41.962	41.962	-87.674	-87.674
41.936	41.936	-87.674	-87.674
41.855	41.855	-87.633	-87.633
42.009	42.009	-87.666	-87.666
41.962	41.962	-87.68	-87.68
41.925	41.925	-87.69	-87.69
41.766	41.766	-87.61	-87.61
41.943	41.943	-87.644	-87.645
41.961	41.961	-87.728	-87.728
41.689	41.689	-87.621	-87.621
41.969	41.969	-87.778	-87.779

Step 6. Matching numbers. After rounding the numbers to three decimal points, we employ a formula to check the integrity of the original location data by comparing and seeing if there's an exact match in both the original and geocoding latitudes and longitudes. The formula we used is:

F(x)=IF(AND(G2=H2, I2=J2), "Full match", "")

Where if Column G (original latitude) equals Column H (geocoded latitude) **AND** Column I(original longitude) equals Column J(geocode longitude), it will show on column K that they fully matched. If not, the cell would just be blank. And we highlighted the blank cell ones that did not match in red shade.

B	C	D	E	F	G	H	I	J	K
Name	Latitude(original)	Longitude (original)	Latitude(geocode)	Longitude(geocode)	Latitude_origin	Latitude_geocode	Longitude_original	Longitude_geocode	Match/NoMatch
KABAE	41.98497207	-87.6990721	41.98508835	-87.699975	41.985	41.985	-87.699	-87.699	"Full match", "")
KIE SPIN	41.96106475	-87.68396682	41.96102524	-87.68416595	41.961	41.961	-87.684	-87.684	Full match
RP ELEN	41.73331035	-87.54451462	41.732894	-87.545059	41.733	41.733	-87.545	-87.545	Full match
LE FOO	41.779984	-87.64613076	41.77996826	-87.64627075	41.78	41.78	-87.646	-87.646	Full match
IE GOLI	41.98653051	-87.69941716	41.98645401	-87.69961548	41.987	41.986	-87.699	-87.699	"Full match", "")
ST DIN	41.88752864	-87.63264684	41.88815609	-87.63255492	41.888	41.888	-87.633	-87.633	Full match
OWARE	42.01927474	-87.67294393	42.01933488	-87.67361015	42.019	42.019	-87.673	-87.674	
INO'S PI	41.92476862	-87.68987136	41.92484535	-87.68965848	41.925	41.925	-87.69	-87.69	Full match
YY CITY	41.9422082	-87.64461373	41.94204971	-87.64451556	41.942	41.942	-87.645	-87.645	Full match
TWIG'S	41.93301325	-87.64522874	41.93305023	-87.64518745	41.933	41.933	-87.645	-87.645	Full match
RY'S FIS	41.67816957	-87.62036637	41.67858571	-87.62046151	41.678	41.679	-87.62	-87.62	
VAY SA	41.99767708	-87.69924898	41.99763782	-87.6988665	41.998	41.998	-87.699	-87.699	Full match
GOR MI	41.99757189	-87.69263305	41.99766934	-87.6926934	41.998	41.998	-87.693	-87.693	Full match
STOP	41.94207713	-87.68839243	41.94208995	-87.68831	41.942	41.942	-87.688	-87.688	Full match
T SLICE	41.96161934	-87.67383267	41.96177292	-87.67353821	41.962	41.962	-87.674	-87.674	Full match
TS	41.93586585	-87.67433854	41.93571472	-87.67431641	41.936	41.936	-87.674	-87.674	Full match
TIME &	41.85478378	-87.63273281	41.854751	-87.632598	41.855	41.855	-87.633	-87.633	Full match
LINE T/	42.00936036	-87.66637744	42.00912857	-87.66583252	42.009	42.009	-87.666	-87.666	Full match

C. Cleaning Results & Key Take-away:

- Cleaning Results:

As mentioned earlier, data integrity problems are harder to fix; sometimes we may need an expert's opinion in order to fix them. What we can do best for this dataset, thus, is to extract from using SQL queries and geocoding tools, the list of violations of blank value errors, unique value errors, and geographical data accuracy errors.

For the geographical locations, after employing geocoding tools with the conjunction of Excel, we found out that:

- + Out of the 9,999 records, 3,748 records were not matched.
- + Out of the 9,999 records, there's 41 empty cells on the original latitude and longitude—suggest that there're also blank value errors within geographical location data.

- Key Take-away:

+ *Understand the business process behind before deciding to update or delete any data:* It is really not our say to decide what data should be updated or deleted from the dataset. Like we suggested, this would require a pair of expert's eyes, or to leave it to the hands who created this dataset. The extracted list of violation data we provided is still powerful and useful in the sense that potential future users of this dataset can just refer to our extracted lists.

+ *Always store back-up data and log queries for provenance purpose:* It is our belief that one of the best practices to doing data cleaning task, is to always keep track of every move we take and to keep the original files alongside the comparison data. This way, we would not carelessly delete any original records by accident, nor would we lost our query for subjectable changes in our provenance queries.

+*Consider alternative methods when dealing with numbers:* One of the obstacles we have when we encounter the location data, is the method for ‘rounding’ the numbers. Whether to round it up, round it down, round it, or employ any other similarity methods that measures distances between two objects to see if they are close enough, such as the Euclidean distance. The purpose of our paper is to demonstrate a simple way for working with these cleaning tasks, and rounding numbers is supported easily in Excel, thus, we did not go deeper into details on the similarity measurements. These are places where future researchers can think whether or not to use an alternative measurement to deal with the long decimal numbers.

STAGE 3: DATA STRUCTURE PROBLEMS

A. Analysis of Data Structure Problems:

In this stage of analysis, the goal is looking at data structure to identify problems that can be improved. A data structure is a specialized format for organizing and storing data. By improving the data structure, developers could prevent errors can be happened in the future such as redundancies, duplication or integrity errors; therefore, avoid a lot of later data cleaning works. A good data structure also helps developers to perform more data analytic tasks and get more accurate results. We will discuss more details about these benefits later on with examples from our Chicago Food Inspection dataset.

As mentioned above, we started this phase by looking at the original data structure of our dataset, Chicago Food Inspection as shown in the following screenshot:

Inspection_ID	DBA_Name	AKA_Name	License_Nun	Facility_Type	Risk	Address	City	State	Zip	Inspection_C	Inspection_T	Results
1199806 FAIRYLAND NUI FAIRYLAND NUI 1771126				Daycare (2 - 6 Y)	Risk 1 (High)	4350 N MILWAU	CHICAGO	IL	60641	7/29/2015	Canvass	Out of Business
1325416 CICS RALPH ELL CICS RALPH ELL 2247640	School			Risk 1 (High)	1817 W 80TH S'	CHICAGO	IL	60620	9/24/2015	Canvass	Pass	
1418960 DOUGHNUT VA DOUGHNUT VA 2349613	Restaurant			Risk 2 (Medium	111 N CANAL ST	CHICAGO	IL	60606	5/1/2015	Canvass	Pass	
1418962 GATEWAY NEW GATEWAY NEW 2146677				Risk 3 (Low)	175 W JACKSON	CHICAGO	IL	60604	5/4/2015	Canvass	Out of Business	
1418963 F&S FAST FOO F&S FAST FOO 1300118				Risk 3 (Low)	77 W JACKSON	CHICAGO	IL	60604	5/4/2015	Canvass	Out of Business	
1418999 FIREHOUSE SUE FIREHOUSE SUE 2398900	Restaurant			Risk 1 (High)	209 W JACKSON	CHICAGO	IL	60606	5/15/2015	License	Not Ready	
1419000 CAMPUS CENTE CAMPUS CENTE 2152981	Restaurant			Risk 1 (High)	37 S WABASH A'	CHICAGO	IL	60603	5/15/2015	Canvass	Pass	
1419027 BIG BIG 1918	Restaurant			Risk 1 (High)	151 E WACKER	CHICAGO	IL	60601	5/28/2015	Canvass	Pass	
1419178 7-ELEVEN #337#7-ELEVEN #337#1842592	Grocery			Risk 2 (Medium	216 W JACKSON	CHICAGO	IL	60606	11/17/2015	Canvass	Out of Business	
1419179 ARAMARK COR ARAMARK - BO 1169489	Restaurant			Risk 2 (Medium	100 N RIVERSID	CHICAGO	IL	60606	11/17/2015	Canvass	Out of Business	
1419180 I DREAM OF FA I DREAM OF FA 2032750	Restaurant			Risk 1 (High)	331-333 S FRAN	CHICAGO	IL	60606	11/17/2015	Canvass	Out of Business	
1441881 THE RADLER THE RADLER 2252564	Restaurant			Risk 1 (High)	2375-2377 N M	CHICAGO	IL	60647	5/12/2015	Complaint	Pass	
1441936 RAINFOREST LE RAINFOREST LE 2220945	Daycare (Above Risk 1 (High)			Risk 2 (High)	2545 W DIVERS	CHICAGO	IL	60647	6/15/2015	Canvass	Pass	
1442077 CAFE LAGUARD CAFE LAGUARD 78121	Restaurant			Risk 1 (High)	2111 W ARMIT	/CHICAGO	IL	60647	9/4/2015	Canvass	Out of Business	
1442236 W CROSSINGS W CROSSINGS 1948288	Grocery			Risk 2 (Medium	2060-2062 W N	CHICAGO	IL	60647	12/3/2015	Canvass	Pass	
1442291 ST. ANDREW SC ST. ANDREW SC 1981254	School			Risk 1 (High)	1710 W ADDISC	CHICAGO	IL	60613	1/8/2016	Canvass	Pass	
1447780 AFCSUSHI@NU AFC SUSHI 1998085	Restaurant			Risk 1 (High)	251 E HURON S	CHICAGO	IL	60611	4/28/2015	Canvass	Out of Business	
1447944 TEXAS DE BRAZ TEXAS DE BRAZ 2379986	Restaurant			Risk 1 (High)	210 E ILLINOIS S	CHICAGO	IL	60611	8/20/2015	License	Pass	
1447961 BOCKWINKELS BOCKWINKEL'S 2398979	Grocery			Risk 3 (Low)	320 E OHIO ST	CHICAGO	IL	60611	8/26/2015	License	Not Ready	
1448004 SUBWAY SUBWAY 38514	Restaurant			Risk 2 (Medium	700 N MICHIGA	CHICAGO	IL	60611	9/24/2015	Canvass	Out of Business	
1448069 STUDENT LOUN PUCK'S CAFE 2271544	Restaurant			Risk 2 (Medium	450 N CITYFRO	CHICAGO	IL	60611	11/6/2015	Canvass	Pass	
1448096 NEW REBOZO C NEW REBOZO C 1933945	Restaurant			Risk 1 (High)	46 E SUPERIOR	CHICAGO	IL	60611	11/23/2015	Canvass	No Entry	
1448109 SARAH'S PASTR SARAH'S PASTR 1822467	Restaurant			Risk 2 (Medium	70 E OAK ST	CHICAGO	IL	60611	12/4/2015	Canvass	Out of Business	

This data structure that we called “a flat file” data structure, whereas all data & information are stored in one single table. This is a typical considered as bad data structure since it potentially contains many redundancies, duplications and very hard to extract information due to the loads of data in a single place.

Some of examples illustrate the bad data structure of our dataset and solution discussions:

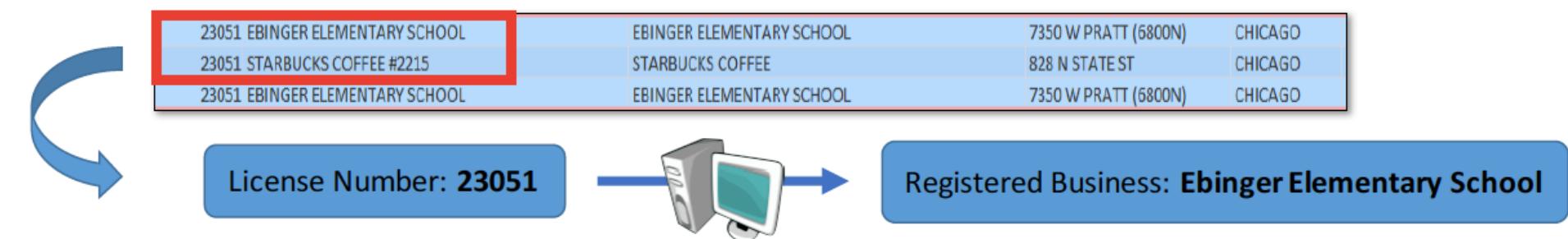
- Data Integrity Error that happened with Business License Number as described in the second stage:

23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO
23051 STARBUCKS COFFEE #2215	STARBUCKS COFFEE	828 N STATE ST	CHICAGO
23051 EBINGER ELEMENTARY SCHOOL	EBINGER ELEMENTARY SCHOOL	7350 W PRATT (6800N)	CHICAGO

Inspection_ID	DBA_Name	AKA_Name	License_Nur	Facility_Type	Risk	Address	City	State	Zip
1965498	LARK	LARK	1492585	Restaurant	Risk 1 (High)	3441 N HALSTED ST	CHICAGO	IL	60657
1960938	HALSTED'S BAR & GRILL	HALSTED'S BAR & GRILL	1492585	Restaurant	Risk 1 (High)	3441 N HALSTED ST	CHICAGO	IL	60657
1060942	LARK	LARK	1492585	Restaurant	Risk 1 (High)	3441 N HALSTED ST	CHICAGO	IL	60657

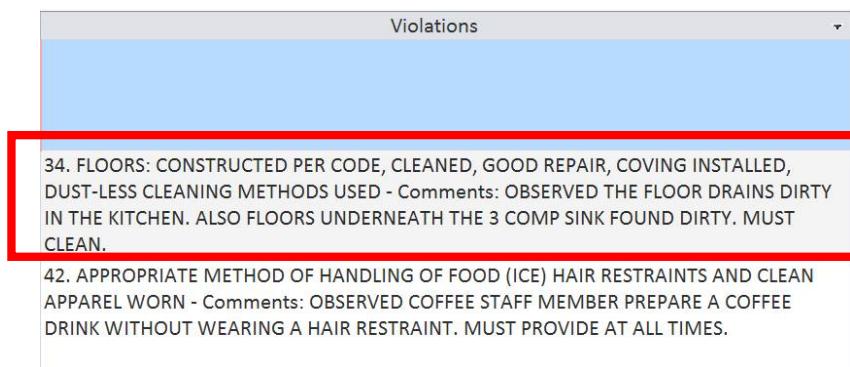
As shown in the screenshots above, the License Number: 23051 were used for two different businesses: Ebinger Elementary School and Starbucks Coffee, which is violated. Or the License Number 1965498 were used for two different businesses: Lark and Halsted's Bar & Grill at the same address, which led to a question are they actually the same business with a different name?

These kinds of errors were hard to spot, and required a complex SQL query in order to identify all of the violations (as described in the second stage). In order to avoid this kind of integrity error happened in future, developers can increase data integrity checking and do it automatically. The idea is to create a **unique relationship** between License Number and Business, it means one license number only can be registered (or tied) to one single business at one location. By doing so, whenever users fill in a license number into the system, computers could be able to check whether is there any relationship between that License Number with a Registered Business (as shown in the diagram below), and automatically provides the corresponding business that tied to the license number accordingly:



- Data Analytic Difficulty with Violations information:

As we can see in our original dataset, the Violations field capture quite a lot of information in one single column, including: Violation Number, Violation Description, and Comments as shown in the screenshot below:



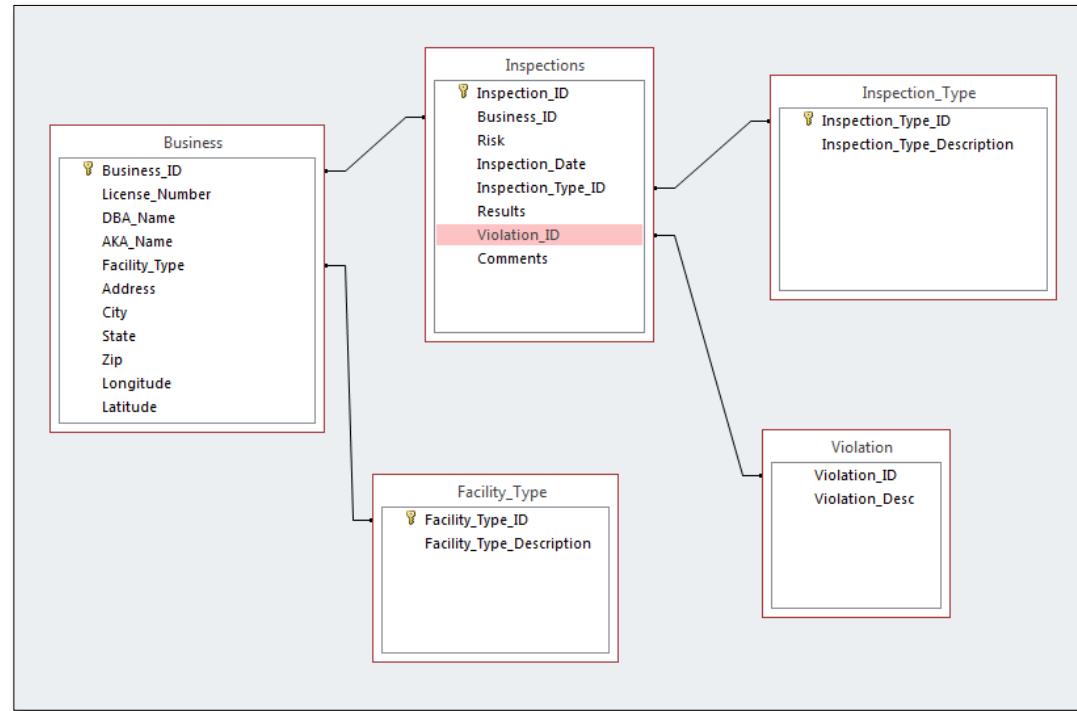
This kind of data structure would create difficulties to users when trying to perform data analytic tasks. For example: if a user wants to run a report to show what is the most common violation code (with description of it), it is very hard to extract only the “violation number” in this field and run query. Also for example, if a user wants to do data mining (such as text mining) to see what are the common things in Comments (which filled in manually by the persons who do inspections), he/she needs to extract the “comments” part from the field first.

In order to tackle this issue, we can see that it would be much easier to filter, run query or extract information if the data is broken down into smaller piece of information. As shown in the diagram below, if we separate Violation Code with Violation Description with Comments in our data structure, then users can just easily take out whatever they care about without hesitating run complex queries to extract it from a big data field.



B. Data Structure Improvement Solutions:

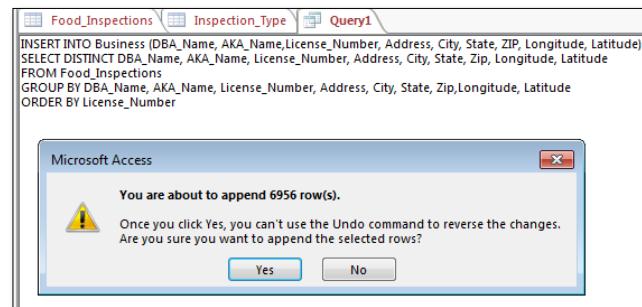
Step 1: After identifying data structure problems in our dataset, we proposed a new data structure that could help to prevent future error and support better data analytic tasks. The new data structure was described in the below ERD diagram:



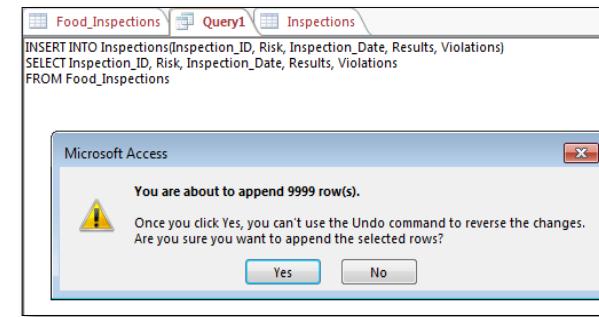
This data structure improvement is called “database normalization” (or simply normalization), which is the process of organizing the columns (attributes) and tables (relations) of a relational database to reduce data redundancy and improve data integrity. Instead of using one single table and store all of the information in it, we broke down our dataset into 5 main tables:

- **Inspections table:** would be the table which stores all of the information related to Inspections, such as: Inspection ID, Inspection Date, Inspection Type, Inspection Results, Violation ID (which will link to Violation table for Description), Business ID (which will link to Business table for more details about the business) & Comments.
- **Business table:** would be the table which stores all of the information related to Business, such as: ID, DBA Name, AKA Name, Address, Location, Facility Type ID (which will link to Facility table for description).
- **Facility Type, Inspection Type, Violation:** all three tables are sub tables to store specific information about facility type, inspection type & violation type. Normally including code & description.

Step 2: After having the data structure, we created these tables in a database using Microsoft Access. Then writing SQL queries to import data into each table as shown in the following screenshots (*Notice: screenshots only show examples, the detailed SQL queries file is provided attached with the documentation*):



SQL query to load data into Business table



SQL query to load data into Inspections table

C. Data Structure Improvement Results & Key Take-away:

- Data Structure Improvement Results: Now instead of one flat file, in our database, we have 5 tables, each store specific information that allows users to filter, extract information, running reports easily:

Inspection_Type_ID	Inspection_Type_Description	Click to Add
1	2 Canvass	
2	3 Canvass Re-inspection	
3	4 Complaint	
4	5 Complaint Re-inspection	
5	6 Consultation	
6	7 License	
7	8 License Re-inspection	
8	9 Recent Inspection	
9	10 Short Form Complaint	
10	11 Special Events (festivals)	
11	12 Suspected Food Poisoning	
12	13 Suspected Food Poisoning Re-inspe	
13	14 Tag Removal	

Inspection Type table includes: Unique ID & Description

Facility_Type	Facility_Number_Violation	Create_Facility_Type Records
1	2 Airport Lounge	+ Click To Add
2	3 A non-for-profit Chef Training Program	
3	4 Bar	
4	5 Assisted Living	
5	6 Bakery	
6	7 Bakery / Restaurant	
7	8 Banquet / Kitchen	
8	9 Banquet Hall	
9	10 Bar	
10	11 Beverage / Silverware Warehouse	
11	12 Beverage	
12	13 Cafeteria	
13	14 Butcher	
14	15 Cafe / Store	
15	16 College	
16	17 Candy / Gelato	
17	18 Childcare	
18	19 Children's Services Facility	
19	20 Church	
20	21 Church / Special Events	
21	22 Coffee / Tea	
22	23 Coffee Shop	
23	24 College	
24	25 Convenience Store	
25	26 Daycare School	
26	27 Culinary School	
27	28 Daycare	
28	29 Daycare	
29	30 Daycare (2-3 Year Old)	
30	31 Daycare (3-4 Year Old)	
31	32 Daycare (4 Years Old)	
32	33 Daycare (Above And Under 2 Years Old)	
33	34 Daycare (Under 2 Years Old)	
34	35 Daycare Combo 1386	
35	36 Daycare Daylight	
36	37 Dining Hall	
37	38 Dollar & Grocery	
38	39 Donut Shop	
39	40 Fitness Center	

Facility Type table includes: Unique ID & Description

Business_ID	License	DBA_Name	AKA_Name	Facility_Type	Address	City	State	Zip	Longitude	Latitude	Click to A
25 241		HARD WATER BAR & GRILL	HARD WATER BAR & GRILL	83 7541-7545 N CL CHICAGO	IL	60626			-87.67595815	42.01890351	
26 257		GEJA'S CAFE	GEJA'S CAFE	83 340 W ARMITA/ CHICAGO	IL	60614			-87.63800743	41.91844524	
27 265		THE CLOSET	THE CLOSET	63 3235 S BROAD/ CHICAGO	IL	60657			-87.6443254	41.94003823	
28 276		BUTCH MC GUIRE'S, INC.	BUTCH MC GUIRE'S, INC.	83 20 W DIVISION/ CHICAGO	IL	60610			-87.62950232	41.90403823	
29 349		KELLY'S PUB	KELLY'S PUB	83 949 W WEBSTEI/ CHICAGO	IL	60614			-87.65300408	41.91263662	
30 429		TONY'S ITALIAN DELI	TONY'S ITALIAN DELI	46 6708 N NORTH/ CHICAGO	IL	60631			-87.81656422	42.00289469	
31 491		LA UNICA FOOD MART, INC.	LA UNICA FOOD MART	88 1515 W DEVON/ CHICAGO	IL	60660			-87.66842789	41.99793446	
32 574		ZAVEN INC.	ZAVEN INC.	83 260 E CHESTNUT/ CHICAGO	IL	60611			-87.61947058	41.98856447	
33 644		MAXIM'S RESTAURANT INC	MAXIM'S RESTAURANT INC	83 20 N CLARK/ CHICAGO	IL	60602			-87.63149701	41.98856447	
34 663		EL NUEVO GUADALAJARA INC	EL NUEVO GUADALAJARA INC	83 820 W ASHLEY/ CHICAGO	IL	60609			-87.66526024	41.94471222	
35 691		FOUR FARTHINGS TAVERNS & GRILL	FOUR FARTHINGS TAVERNS & GRILL	83 2655 N CL CHICAGO	IL	60634			-87.61414929	41.22010529	
36 697		SIXTY SIX & ONE CLUB	SIXTY SIX & ONE CLUB	63 6601 S WESTER/ CHICAGO	IL	60636			-87.6833444	41.73369881	
37 732		WOODLAWN GARDENS	WOODLAWN GARDENS	66 1200 S 93RD ST/ CHICAGO	IL	60619			-87.59403176	41.72558318	
38 766		MUGS BUNNY	MUGS BUNNY	107 13401 S BALTIM/ CHICAGO	IL	60633			-87.54012026	41.63170776	
39 800		RESI'S BIERTUBE INC	RESI'S BIERTUBE	83 2034 W IRVING/ CHICAGO	IL	60618			-87.68030425	41.95424367	
40 822		JOE'S FOOD & LIQUOR	JOE'S FOOD & LIQUOR	46 3626 W LAWN/ CHICAGO	IL	60625			-87.71941658	41.96844525	
41 833		STEVE'S LOUNGE	STEVE'S LOUNGE	83 1200 S BALTIM/ CHICAGO	IL	60633			-87.54729797	41.65541665	
42 845		ANDYS 11 EAST LOUNGE	ANDYS JAZZ CLUB	83 11 E HUBBARD/ CHICAGO	IL	60611			-87.62750992	41.88956387	
43 853		RJ GRUNTS	RJ GRUNTS	83 2054-2056 N LIP/ CHICAGO	IL	60614			-87.63845555	41.92003078	
44 928		TEASER'S PUB	TEASER'S PUB	83 7123 W HIGGIN/ CHICAGO	IL	60656			-87.80571278	41.98072682	
45 955		FREDY'S INN	FRANK & MARY'S	83 2905 N ELSTON/ CHICAGO	IL	60618			-87.69047826	41.93416814	
46 968		CHEZ MOU	CHEZ MOU	83 2100 N HALSTEAD/ CHICAGO	IL	60604			-87.64450204	41.92003079	
47 980		HALSTED FOOD AND LIQUORS, INC.	HALSTED FOOD AND LIQUORS, INC.	46 700 N HALSTEAD/ CHICAGO	IL	60621			-87.64450204	41.92003079	
48 990		FALCO'S PIZZA	FALCO'S PIZZA	83 2006 W 60TH PI/ CHICAGO	IL	60632			-87.69487471	41.82033997	
49 1077		MONK'S PUB	MONK'S PUB	83 205-207 W LAKI/ CHICAGO	IL	60606			-87.63120723	41.85841849	
50 1094		ONE STOP FOOD & LIQUOR STORE	ONE STOP FOOD & LIQUOR STORE	46 4201-4223 S LIA/ CHICAGO	IL	60653			-87.59888884	41.61668515	
51 1187		SADDLE AND CYCLE CLUB	SADDLE AND CYCLE CLUB	83 900 W FOSTER/ CHICAGO	IL	60640			-87.62657664	41.97634173	
52 1196		HOPSMITH TAVERN	HOPSMITH TAVERN	83 15 W DIVISION/ CHICAGO	IL	60610			-87.6232853	41.90382088	
53 1242		PALM RESTAURANT	PALM RESTAURANT	83 322 E WACKER/ CHICAGO	IL	60601			-87.61965509	41.87566004	
54 1254		DINO'S PIZZA	DINO'S PIZZA	83 7004-7006 W HI/ CHICAGO	IL	60656			-87.80254235	41.98026875	
55 1303		TREASURE ISLAND FOODS INC	TREASURE ISLAND	46 7 W ELM ST/ CHICAGO	IL	60610			-87.6134877	41.90302614	
56 1307		TREASURE ISLAND FOODS	TREASURE ISLAND FOODS	46 1639 N WELLIS S CHICAGO	IL	60614			-87.63459886	41.91231118	
57 1311		TREASURE ISLAND FOODS	TREASURE ISLAND FOODS	46 3460 W BROAD/ CHICAGO	IL	60657			-87.64589349	41.94482827	
58 1315		TREASURE ISLAND FOODS	TREASURE ISLAND FOODS	46 2121 N LYBDOU/ CHICAGO	IL	60614			-87.66180554	41.91989968	
59 1319		TREASURE ISLAND FOODS	TREASURE ISLAND FOODS	46 680 N ICE SHC/ CHICAGO	IL	60611			-87.61596655	41.94798337	
60 1323		JEWEL FOOD STORE #3443	JEWEL FOOD STORE #3443	46 5343 N BROAD/ CHICAGO	IL	60640			-87.65980585	41.97942825	
61 1324		JEWEL FOOD STORE #3454	JEWEL FOOD STORE #3454	46 400 N BROAD/ CHICAGO	IL	60613			-87.65980585	41.97942825	
62 1337		JEWEL FOOD STORE #3282	JEWEL FOOD STORE	46 4729 N CENTRA/ CHICAGO	IL	60630			-87.76729948	41.96679711	
63 1366		JEWEL FOOD STORE #3170	JEWEL / OSCO	46 5205 N PLASLU/ CHICAGO	IL	60632			-87.72339188	41.79619709	
64 1368		JEWEL FOOD STORE #3181	JEWEL FOOD STORE #3181	46 87 W 87TH ST/ CHICAGO	IL	60620			-87.62691784	41.79614513	

Business table includes: Unique ID & all of the information related to business

Violations	Food_Inspections	Violation	Relationships
Violation_ID	Violation	Violation_Desc	
		SOURCE SOUND CONDITION, NO SPOILAGE, FOODS PROPERLY LABELED, SHELLFISH TAGS IN PLACE	
		10. SEWAGE AND WASTE-WATER DISPOSAL, NO BACK SIPHONAGE, CROSS CONNECTION AND/OR BACK FLOW	
		11. ADEQUATE NUMBER, CONVENIENT, ACCESSIBLE, DESIGNED, AND MAINTAINED	
		12. HAND WASHING FACILITIES: WITH SOAP AND SANITARY HAND DRYING DEVICES, CONVENIENT AND ACCESSIBLE TO FOOD PREP AREA	
		13. NO EVIDENCE OF RODENT OR INSECT INFESTATION, NO BIRDS, TURTLES OR OTHER ANIMALS	
		14. PREVIOUS SERIOUS VIOLATION CORRECTED, 7-42-09	
		16. FOOD PROTECTED DURING STORAGE, PREPARATION, DISPLAY, SERVICE AND TRANSPORTATION	
		17. POTENTIALLY HAZARDOUS FOOD PROPERLY THAWED	
		18. NO EVIDENCE OF RODENT OR INSECT OUTER OPENINGS PROTECTED/RODENT PROOFED, A WRITTEN LOG SHALL BE MAINTAINED AVAILABLE TO OUTSIDE GARBAGE WASTE GREASE AND STORAGE AREA; CLEAN, RODENT PROOF, ALL CONTAINERS COVERED	
		2. FACILITIES TO MAINTAIN PROPER TEMPERATURE	
		20. INSIDE CONTAINERS OR RECEPTACLES: ADEQUATE NUMBER, PROPERLY COVERED AND INSECT/RODENT PROOF	
		21. * CERTIFIED FOOD MANAGER ON SITE WHEN POTENTIALLY HAZARDOUS FOODS ARE PREPARED AND SERVED	
		22. DISH MACHINES: PROVIDED WITH ACCURATE THERMOMETERS, CHEMICAL TEST KITS AND SUITABLE GAUGE COCK	
		23. DISHES AND UTENSILS FLUSHED, SCRAPED, SOAKED	
		24. DISH WASHING FACILITIES: PROPERLY DESIGNED, CONSTRUCTED, MAINTAINED, INSTALLED AND OPERATED	
		25. TOXIC ITEMS PROPERLY STORED, LABELED AND USED	
		26. ADEQUATE NUMBER, CONVENIENT, ACCESSIBLE, PROPERLY DESIGNED AND INSTALLED	
		27. TOILET ROOMS ENCLOSED CLEAN, PROVIDED WITH HAND CLEANSER, SANITARY HAND DRYING DEVICES AND PROPER WASTE RECEPTACLES	
		28. * INSPECTION REPORT SUMMARY DISPLAYED AND VISIBLE TO ALL CUSTOMERS	
		29. PREVIOUS MINOR VIOLATION(S) CORRECTED 7-42-09	
		30. POTENTIALLY HAZARDOUS FOOD MEETS TEMPERATURE REQUIREMENT DURING STORAGE, PREPARATION DISPLAY AND SERVICE	
		31. CLEAN MULTI-USE UTENSILS AND SINGLE SERVICE ARTICLES PROPERLY STORED: NO REUSE OF SINGLE SERVICE ARTICLES	
		32. FOOD AND NON-FOOD CONTACT SURFACES PROPERLY DESIGNED, CONSTRUCTED AND MAINTAINED	
		33. FOOD AND NON-FOOD CONTACT EQUIPMENT UTENSILS CLEAN, FREE OF ABRASIVE DETERGENTS	
		34. FLOORS: CONSTRUCTED PER CODE, CLEANED, GOOD REPAIR, COVING INSTALLED, DUST-LESS CLEANING METHODS USED	
		35. WALLS, CEILINGS, ATTACHED EQUIPMENT CONSTRUCTED PER CODE: GOOD REPAIR, SURFACES CLEAN AND DUST-LESS CLEANING METHODS	
		36. LIGHTING: REQUIRED MINIMUM FOOT-CANDLES OF LIGHT PROVIDED, FIXTURES SHIELDED	
		37. TOILET ROOM DOORS SELF CLOSING: DRESSING ROOMS WITH LOCKERS PROVIDED; COMPLETE SEPARATION FROM LIVING/SLEEPING QUARTERS	
		38. VENTILATION: ROOMS AND EQUIPMENT VENTED AS REQUIRED; PLUMBING: INSTALLED AND MAINTAINED	
		39. LINEN: CLEAN AND SOLID PROPERLY STORED	
		4. SOURCE OF CROSS CONTAMINATION CONTROLLED I.E., CUTTING BOARDS, FOOD HANDLERS, UTENSILS, ETC	
		40. REFRIGERATION AND METAL STEM THERMOMETERS PROVIDED AND CONSPICUOUS	
		41. PREMISES MAINTAINED FREE OF LITTER, UNNECESSARY ARTICLES, CLEANING EQUIPMENT PROPERLY STORED	
		42. APPROPRIATE METHOD OF HANDLING OF FOOD (ICE) HAIR RESTRAINTS AND CLEAN APPAREL WORN	

Violation table includes: Unique ID & description

Inspection	Food_Inspections	Violation	Relationships
Inspection_ID	Food_Inspections	Violation	Relationships
Business_ID	Business	Risk	Inspection_Type_ID
Inspection_Date	Inspection	Results	Violation_ID
Business_ID	Business	Risk	Comments
119806 2181		Risk 1 (High)	Out of Business
1325416 4229		Risk 1 (High)	Pass
1418960 4919		Risk 2 (Medium)	Pass
1418962 3487		Risk 3 (Low)	Out of Business
1418963 1505		Risk 3 (Low)	Out of Business
1418999 5449		Risk 1 (High)	Not Ready
1419000 3530		Risk 1 (High)	Pass
1419027 96		Risk 1 (High)	Pass
1419178 2311		Risk 2 (Medium)	Out of Business
1419179 1380		Risk 2 (Medium)	Out of Business
1419180 2969		Risk 1 (High)	Out of Business
1419181 4237		Risk 1 (High)	Pass
1419196 4093		Risk 1 (High)	Pass
1442077 1159		Risk 1 (High)	Out of Business
1442236 2619		Risk 2 (Medium)	Pass
1442291 2752		Risk 1 (High)	Pass
1447780 2819		Risk 1 (High)	Out of Business
1447944 5270		Risk 1 (High)	Pass
1447961 5452		Risk 3 (Low)	Not Ready
1448004 783		Risk 2 (Medium)	Out of Business
1448069 4349		Risk 2 (Medium)	Pass
1448096 2570		Risk 1 (High)	No Entry
1448109 2287		Risk 2 (Medium)	Out of Business
1448137 3542		Risk 2 (Medium)	Pass
1453910 2564		Risk 1 (High)	Pass
1453999 5469		Risk 1 (High)	Pass
1454041 3659		Risk 1 (High)	Out of Business
1464683 487		Risk 1 (High)	Pass
1464686 827		Risk 1 (High)	Pass
1464687 473		Risk 1 (High)	Pass
1464877 240		Risk 3 (Low)	Pass w/ Condit
1464908 1082		Risk 3 (Low)	Pass
1465032 5538		Risk 3 (Low)	Not Ready
1465079 2686		Risk 1 (High)	Pass
1465129 1544		Risk 2 (Medium)	Pass
1465162 2891		Risk 1 (High)	Out of Business
1465163 1852		Risk 1 (High)	No Entry
1465164 2565		Risk 1 (High)	No Entry

Inspection table includes: Unique ID & all information related to inspection

- Key take-away:

+ *Increase automatic data integrity checking as much as possible*: data integrity checking could be done automatically if developers have good enough data structure. Normally is unique (also called primary) keys to check for duplication or violation via already written queries. Every time a new record created in the database, system could automatically check for existing records based the the primary key for any violation.

+ *Breakdown into smaller piece of information*: it is always a good idea to break down information that is stored in one field into more specific, thus helping users to perform any data analytic tasks faster and more efficient.

VI. Conclusion and Future Works

In this paper, we proposed a data cleaning framework emphasizing on the notion that data cleaning is an iterative process in which data analysis and data cleaning tasks should be performed alternatively and repeatedly depending on error types. The error categorizations also play an important role in cleaning strategy and requires a comprehensive organization scheme for it. We also aware that the cleaning process may require the employment of different tools and technologies which should be flexibly used. Overall, we don't think the framework is finished, but it would be a good starting point towards a more completed guideline for data cleaning best practice and require many future works.

As for future works, firstly, it is admitted that even though the cleaning process and solutions results show that our framework is a feasible practice, however, each dataset has its uniqueness, so future researchers may employ different tools from what we have used in our study and may have spot more kinds of errors than we have. In addition, our error categorizations were just initial suggestions. They are definitely needed to be regularly updated when we work with more sample datasets in the future. Nevertheless, the cleaning process and the key take-aways we listed for each types of errors are similar which can apply to most studies and can be regarded as a general guideline to future researchers.

VII. Reference

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