

SMBUD 2021 - Project work 3

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1 Introduction

1.1 Problem Specification

The aim of this project was to design, store and query data on a NoSQL DB supporting a data analysis scenario over data about COVID-19 vaccination statistics. The purpose is that of building a comprehensive database of vaccinations.

A given vaccinations dataset has been assigned, with the purpose to pick a time interval of at least 3 months from it and, by using an ElasticSearch installation, import the data, apply the appropriate schema design choices, implement some queries aiming at exploring the data statistics and design a basic visualization dashboard of the results.

1.2 Hypothesis

The assumptions taken into account are the following:

- ...

2 Datasets

In the table shown below, the data types written are the 'original' ones, so the ones used by the datasets creators.

The same data types have been used to implement and use the dataset in ElasticSearch because they well represent the different parameters, so no changes were needed, except for the ISTAT region code field. It is better to keep all the ISTAT region codes as keywords instead of numbers for the following reason:

they are numbers but for compatibility reasons they should be considered as keywords. In Kibana, there is the possibility to associate data to regions according to ISTAT code convention, by the way, the format used by Kibana is the following "01, 02, 03, 04, ...", thus, if ISTAT codes are imported as numbers they will not be compatible with that convention as Kibana will find the following codes "1, 2, 3, 4, ...".

As the original datasets does not follow the Kibana convention, it has been adapted through the script "`dataset_cleaner.py`".

Both datasets used have Istat region code as field, to understand what it is it is suggested to visit the following link:

https://en.wikipedia.org/wiki/NUTS_statistical_regions_of_Italy.

When the two datasets will be imported, both created indexes will use Istat region code to identify a region. The original dataset used for `istat_population` did not assign a code to Trentino region (04), instead it assigned codes for Bolzano(21) and Trento (22) provinces. For this reason codes have been corrected in order to link the two indexes.

2.1 Vaccine administration dataset

The Dataset used for the project is named "somministrazioni-vaccini-latest.csv" and it has been downloaded from the "dati" folder from the official Italian Government Github repository at the following link : <https://github.com/italia/covid19-opendata-vaccini>.

2.1.1 Schema

This dataset contains information about administered vaccines in Italy and it is made by the following fields:

Field	Data type	Description
index	integer	Record identification code
area	string	Code of the delivery region
supplier	string	Complete name of the supplier of the vaccine
administration date	datetime	Administration date of the vaccines
age group	string	Age group to which the subjects to whom the vaccine were administered belong
male count	integer	Number of vaccinations administered to males per day, region and age group
female count	integer	Number of vaccinations administered to females per day, region and age group
first doses	integer	Number of people administered with the first dose
second doses	integer	Number of people administered with the second dose

post infection doses	integer	Number of administrations given to subjects with previous covid-19 infection in the 3-6 month period and who, therefore, conclude the vaccination cycle with a single dose
booster doses	integer	Number of people administered with an additional dose/recall
NUTS1 code	string	European classification of NUTS territorial units: NUTS level 1
NUTS2 code	string	European classification of NUTS territorial units: NUTS level 2
ISTAT region code	integer	ISTAT code of the Region
region name	string	Standard denomination of the area (where necessary bilingual denomination)

2.2 Istat population dataset

As optional point of this project, analysis has been integrated with another dataset which contains information about the Italian population, like number of people per age range and region or number of people per gender per region. The dataset has been downloaded from a Covid-19 related Github repository at the following link: <https://github.com/pcm-dpc/COVID-19>, it is located in the "dati-statistici-riferimento" folder and it is the one named "popolazione-istat-regione-range.csv".

2.2.1 Schema

This dataset contains information about population number per region and age range in Italy. It is made by the following fields:

Field	Data type	Description
ISTAT region code	integer	ISTAT code of the Region
NUTS1 code	string	European classification of NUTS territorial units: NUTS level 1
NUTS1 description	string	Cardinal direction based on the NUTS1 code
NUTS2 code	string	European classification of NUTS territorial units: NUTS level 2
region name	string	Standard denomination of the area (where necessary bilingual denomination)
area	string	Code of the region
region latitude	float	Latitude coordinate of the region
region longitude	float	Longitude coordinate of the region

age range	string	Age range to which the population numbers refers
male count	integer	Number of males in the population, per region and age range
female count	integer	Number of females in the population, per region and age range
total count	integer	Number of males plus females in the population, per region and age range

3 Queries and Commands

In the following chapter all the queries and commands parameters (part of the code to substitute with desired values) will be highlighted with **magenta** bold text.

Some parameters information can be useful for different queries or commands so they are written here to avoid writing them multiple times:

- **Start date** and **End date** are, respectively, the starting date of a period and the ending date of a period. Dates must be in the following format YYYY-MM-DD and, obviously, End date must be subsequent to Start date.
- **Date** is a generic date and it must be in the following format YYYY-MM-DD.
- **Supplier**, for coherence w.r.t other documents, must be one of the following: Moderna, Janssen, Pfizer/BioNTech or Vaxzevria (AstraZeneca).
- **Age range** must follow one of this format: 12-19, x0-x9 or 90+ (where x is a number between 2 and 8)

3.1 Queries

The first eight queries refer only on the vaccination dataset. Instead, the last two queries refer to both vaccination and Istat population dataset.

3.1.1 Delta vaccination per area

For each region, this query returns the percentage of the difference between vaccinations of a given date and its precedent day, calculated with respect to the amount of vaccinations performed the day before. If the vaccinations have increased, the percentage will be positive, negative otherwise.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs": {
    "group_by_date": {
      "terms": {
        "field": "nome_area"
      },
      "aggs": {
        "today_vaccinations" :{
          "filter": {
            "term" : {
              "data_somministrazione": "now-31d/d"
            }
          }
        }
      }
    },
  },
}
```

```

        "aggs": {
          "amount": {
            "sum": {
              "script": {
                "source": "doc['sesso_maschile'].value + doc['sesso_femminile'].value"
              }
            }
          }
        },
        "yesterday_vaccinations" : {
          "filter": {
            "term" : {
              "data_somministrazione": "now-32d/d"
            }
          },
          "aggs" : {
            "amount": {
              "sum" :{
                "script": {
                  "source": "doc['sesso_femminile'].value + doc['sesso_maschile'].value"
                }
              }
            }
          }
        },
        "delta_percentage" : {
          "bucket_script": {
            "buckets_path": {
              "today" : "today_vaccinations>amount",
              "yesterday" : "yesterday_vaccinations>amount"
            },
            "script": "(params.today - params.yesterday) / params.yesterday * 100"
          }
        }
      }
    }
  }
}

```

3.1.2 Percentage full covered vaccinations

The following query calculates the percentage of people which has already completed the vaccination cycle, starting from the date the vaccinations started. The percentage is calculated with respect to all the vaccinated people, so everyone that has already received at least one dose. The cycle is considered completed if a person:

- is vaccinated with Janssen vaccine.
- has already received the second dose.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs":{
    "group_by": {
      "date_range": {
        "field": "data_somministrazione",
        "ranges": [
          {
            "from": "2020-12-27",
            "to": "now"
          }
        ]
      },
    },
    "aggs": {
      "sum_first_dose": {
        "sum" :{
          "field" : "prima_dose"
        }
      },
      "sum_second_dose" : {
        "sum" : {
          "field" : "seconda_dose"
        }
      },
      "sum_Janssen": {
        "filter": {
          "term" : {
            "fornitore": "Janssen"
          }
        },
        "aggs": {
          "amount" : {
            "sum" : {
              "field": "prima_dose"
            }
          }
        }
      }
    }
  }
}
```


3.1.4 Brand administrated vaccines percentage for a given period

The following query, given a period of time, returns the percentage of the administrated vaccines per brand.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs":{
    "group_by": {
      "date_range": {
        "field": "data_somministrazione",
        "ranges": [
          {
            "from": "Start date",
            "to": "End date"
          }
        ]
      },
    },
    "aggs": {
      "Janssen_vaccinations": {
        "filter": {
          "term" : {
            "fornitore": "Janssen"
          }
        },
        "aggs": {
          "amount" : {
            "sum" : {
              "script": {
                "source": "doc['prima_dose'].value + doc['seconda_dose'].value + doc['dose_addizionale_booster'].value"
              }
            }
          }
        }
      },
      "Pfizer_vaccinations": {
        "filter": {
          "term" : {
            "fornitore": "Pfizer/BioNTech"
          }
        },
        "aggs": {
          "amount" : {
            "sum" : {
              "script": {
                "source": "doc['prima_dose'].value + doc['seconda_dose'].value + doc['dose_addizionale_booster'].value"
              }
            }
          }
        }
      }
    }
  }
}
```

```

    }
  }
},
"Moderna_vaccinations": {
  "filter": {
    "term" : {
      "fornitore": "Moderna"
    }
  },
  "aggs": {
    "amount" : {
      "sum" : {
        "script": {
          "source": "doc['prima_dose'].value + doc['seconda_dose'].value + doc['dose_addizionale_booster'].value"
        }
      }
    }
  }
},
"Astrazeneca_vaccinations": {
  "filter": {
    "term" : {
      "fornitore": "Vaxzevria (AstraZeneca)"
    }
  },
  "aggs": {
    "amount" : {
      "sum" : {
        "script": {
          "source": "doc['prima_dose'].value + doc['seconda_dose'].value + doc['dose_addizionale_booster'].value"
        }
      }
    }
  }
},
"Prifez_Percentage" : {
  "bucket_script": {
    "buckets_path": {
      "Pfizer": "Pfizer_vaccinations>amount",
      "Moderna": "Moderna_vaccinations>amount",
      "Janssen": "Janssen_vaccinations>amount",
      "Astrazeneca": "Astrazeneca_vaccinations>amount"
    },
    "script": "(params.Pfizer)/ (params.Pfizer + params.Moderna + params.Janssen + params.Astrazeneca) * 100"
  }
},

```

```

    "Moderna_Percentage" : {
      "bucket_script": {
        "buckets_path": {
          "Pfizer": "Pfizer_vaccinations>amount",
          "Moderna": "Moderna_vaccinations>amount",
          "Janssen": "Janssen_vaccinations>amount",
          "Astrazeneca": "Astrazeneca_vaccinations>amount"
        },
        "script": "(params.Moderna)/ (params.Pfizer + params.Moderna
+ params.Janssen + params.Astrazeneca) * 100"
      }
    },
    "Astrazeneca_Percentage" : {
      "bucket_script": {
        "buckets_path": {
          "Pfizer": "Pfizer_vaccinations>amount",
          "Moderna": "Moderna_vaccinations>amount",
          "Janssen": "Janssen_vaccinations>amount",
          "Astrazeneca": "Astrazeneca_vaccinations>amount"
        },
        "script": "(params.Astrazeneca)/ (params.Pfizer + params.
Moderna + params.Janssen + params.Astrazeneca) * 100"
      }
    },
    "Janssen_Percentage" : {
      "bucket_script": {
        "buckets_path": {
          "Pfizer": "Pfizer_vaccinations>amount",
          "Moderna": "Moderna_vaccinations>amount",
          "Janssen": "Janssen_vaccinations>amount",
          "Astrazeneca": "Astrazeneca_vaccinations>amount"
        },
        "script": "(params.Janssen)/ (params.Pfizer + params.Moderna
+ params.Janssen + params.Astrazeneca) * 100"
      }
    }
  }
}
}

```

3.1.5 Percentages of administrated doses, by dose number, for a given period

This query returns the percentage of first doses, second doses and boosters administrated during the given period.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs": {
    "group_by_date": {
      "date_range": {
        "field": "data_somministrazione",
        "ranges": [
          {
            "from": "Start date",
            "to": "End date"
          }
        ]
      },
    },
    "aggs": {
      "first_doses": {
        "sum": {
          "field" : "prima_dose"
        }
      },
      "second_doses": {
        "sum": {
          "field" : "seconda_dose"
        }
      },
      "boosters": {
        "sum": {
          "field" : "dose_addizionale_booster"
        }
      },
      "First_dose_Percentage" : {
        "bucket_script": {
          "buckets_path": {
            "First": "first_doses",
            "Second": "second_doses",
            "Booster": "boosters"
          },
          "script": "(params.First)/ (params.First + params.Second +
params.Booster) * 100"
        }
      },
      "Second_dose_Percentage" : {
        "bucket_script": {
```



```

    "buckets_path": {
      "First": "first_doses",
      "Second": "second_doses",
      "Booster": "boosters"
    },
    "script": "(params.Second)/ (params.First + params.Second +
params.Booster) * 100"
  }
},
"Booster_Percentage" : {
  "bucket_script": {
    "buckets_path": {
      "First": "first_doses",
      "Second": "second_doses",
      "Booster": "boosters"
    },
    "script": "(params.Booster)/ (params.First + params.Second +
params.Booster) * 100"
  }
}
}
}
}
}
```

3.1.6 Vaccination percentage per age range for a given period

The following query returns the percentage of vaccinated people per age range during the given period.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs": {
    "group_by_date": {
      "date_range": {
        "field": "data_somministrazione",
        "ranges": [
          {
            "from": "Start date",
            "to": "End date"
          }
        ]
      },
    },
    "aggs": {
      "age_range": {
        "terms": {
          "field": "fascia_anagrafica"
        },
        "aggs": {
          "amount": {
            "sum": {
              "script": {
                "source": "doc[' Sesso maschile'].value + doc[' Sesso femminile'].value"
              }
            }
          }
        }
      },
    },
    "total": {
      "sum": {
        "script": {
          "source": "doc[' Sesso maschile'].value + doc[' Sesso femminile'].value"
        }
      }
    },
    "teen_percentage" : {
      "bucket_script": {
        "buckets_path": {
          "Teen": "age_range['12-19']>amount",
          "tot": "total"
        },
        "script": "(params.Teen) / (params.tot) * 100"
      }
    }
  }
}
```

```

    }
  },
  "20s_percentage" : {
    "bucket_script": {
      "buckets_path": {
        "20": "age_range['20-29']>amount",
        "tot": "total"
      },
      "script": "(params.20)/ (params.tot) * 100"
    }
  },
  "30s_percentage" : {
    "bucket_script": {
      "buckets_path": {
        "30": "age_range['30-39']>amount",
        "tot": "total"
      },
      "script": "(params.30)/ (params.tot) * 100"
    }
  },
  "40s_percentage" : {
    "bucket_script": {
      "buckets_path": {
        "40": "age_range['40-49']>amount",
        "tot": "total"
      },
      "script": "(params.40)/ (params.tot) * 100"
    }
  },
  "50s_percentage" : {
    "bucket_script": {
      "buckets_path": {
        "50": "age_range['50-59']>amount",
        "tot": "total"
      },
      "script": "(params.50)/ (params.tot) * 100"
    }
  },
  "60s_percentage" : {
    "bucket_script": {
      "buckets_path": {
        "60": "age_range['60-69']>amount",
        "tot": "total"
      },
      "script": "(params.60)/ (params.tot) * 100"
    }
  },
  "70s_percentage" : {
    "bucket_script": {
      "buckets_path": {

```


3.1.7 Regions ranking per number of vaccinations for a given day

The following query returns the ranking of regions per number of vaccines administered, for a given date.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "query": {
    "bool": {
      "must":{
        "term": {
          "data_somministrazione": {
            "value": "Date"
          }
        }
      }
    }
  },
  "aggs": {
    "group_by_region": {
      "terms": {
        "field": "nome_area"
        , "size": 21
      },
      "aggs": {
        "sum_vaccinations": {
          "sum": {
            "script": {
              "source": "doc[' Sesso_maschile'].value + doc[' Sesso_femminile'].value"
            }
          }
        },
        "sort_by_vaccinations":{
          "bucket_sort": {
            "sort": [{ "sum_vaccinations": { "order": "desc" } }]
          }
        }
      }
    }
  }
}
```

3.1.8 Percentage of booster administrated

The following query returns percentage of people who received booster dose over those who completed the vaccination cycle at least 5 months ago and are potentially subject to booster dose.

```
GET istat_vaccinations/_search
{
  "size" : 0,
  "aggs": {
    "all_matching_docs": {
      "filters": {
        "filters": {
          "all": {
            "match_all": {}
          }
        }
      }
    },
    "aggs":{
      "sum_booster":{
        "sum": {
          "field": "dose_addizionale_booster"
        }
      },
      "booster_candidates": {
        "filter": {
          "range": {
            "data_somministrazione": {
              "lte": "2021-12-22||-5M"
            }
          }
        }
      },
      "aggs": {
        "sum_second_dose" : {
          "sum" : {
            "field" : "seconda_dose"
          }
        },
        "sum_janssen": {
          "filter": {
            "term" : {
              "fornitore": "Janssen"
            }
          }
        },
        "aggs": {
          "amount" : {
            "sum" : {
              "field": "prima_dose"
            }
          }
        }
      }
    }
  }
}
```

}

3.1.9 Percentage of vaccinated people per region

This query uses both datasets and returns the percentage of vaccinated people per region over its total population.

```
GET /istat*/_search
{
  "size" : 0,
  "aggs":{
    "group_by_region":{
      "terms" : {
        "field" : "codice_regione_ISTAT"
      },
      "aggs": {
        "total_vaccinated": {
          "sum": {
            "field" : "prima_dose"
          }
        },
        "total_people": {
          "sum": {
            "field" : "totale_generale"
          }
        },
        "ratio_vaccinated_people": {
          "bucket_script": {
            "buckets_path": {
              "vacc": "total_vaccinated",
              "total" : "total_people"
            },
            "script":"(params.vacc/params.total)*100"
          }
        }
      }
    }
  }
}
```


3.1.10 Query 10

The following query...

CODE

3.2 Commands

All the fields of the following commands are parameters, some will be highlighted in magenta, other won't, due to their exhaustive explanation that can be found in section 2.1.1.

3.2.1 Create new document

This command creates a new database document. Here it is reported a complete example.

```
POST /istat_vaccinations/_doc
{
  "data_somministrazione": "Date",
  "fornitore": "Supplier",
  "area": "ABR",
  "fascia_anagrafica": "Age range",
  " Sesso_maschile": "1",
  " Sesso_femminile": "1",
  "prima_dose": "1",
  "seconda_dose": "2",
  "pregressa_infezione": "0",
  "dose_addizionale_booster": "0",
  "codice_NUTS1": "ITF",
  "codice_NUTS2": "ITF1",
  "codice_regione_ISTAT": "13",
  "nome_area": "Abruzzo"
}
```

3.2.2 Update of number of first doses

This command, given a specific document id, update the number of first doses. Here it is reported both the command and also the query useful to find a document it.

Find document id

With this query it is possible to find a document id by specifying these fields: data_somministrazione, codice_regione_ISTAT, fornitore and fascia_anagrafica.

```
GET /istat_vaccinations/_search
{
  "query": {
    "bool": {
      "must": [
        {
          "match": {
            "data_somministrazione": "Date"
          }
        },
        {
          "match": {
            "codice_regione_ISTAT": "13"
          }
        },
        {
          "match": {
            "fornitore": "Supplier"
          }
        },
        {
          "match": {
            "fascia_anagrafica": "Age Range"
          }
        }
      ]
    }
  }
}
```

First doses update

Now it is possible to update the number of doses of the document found.

```
POST /istat_vaccinations/_update/8FjS_H0BhG8f5U0W2n46
{
  "doc": {
    "prima_dose" : 3000
  }
}
```

4 Dashboard description

The Kibana Dashboard is made by different section, each focusing on a sepxific analysis. Here there is a brief description of each part is given.

4.1 Percentage of Vaccines brand per age range

In this section a pie chart has been used to show two different things: in the inner layer there is the percentage of people vaccinated per age range, in the outer layer there is the percentage of brand vaccines used per age range.

4.2 First doses administrated

This histogram shows the trend of the total amount of first doses administrated and it division per vaccine brand.

4.3 Vaccines administrated per gender

This section shows the trend of the amount of vaccines administrated to men and to women

4.4 Vaccines administrated per region

Here a map has been used to show the percentage of first doses, second doses and boosters administrated from the beginning of the pandemic per region, with respect to its total population.

4.5 Description

This section has been used to briefly describe all the different graphs of the dashboard.

5 User guide

5.1 Import data

5.1.1 Import vaccinations dataset

After having opened Kibana, it is necessary to click on the "upload file" button present in the home page. Now the file named "cleaned_data.csv" must be dragged and dropped in the opened page.

After that, the "import" button must be clicked. In the new page, in the advanced setting section, it is necessary to use the "istat_vaccinations" index name. In the mapping section, at line number 16, the word "long" must be replaced with "keyword".

In the Ingest pipeline section, lines from number 36 to number 42 (both included) must be deleted. Then, by clicking the import button, vaccinations data will be imported successfully.

5.1.2 Import Istat population dataset

After having opened Kibana, it is necessary to click on the "upload file" button present in the home page. Now the file named "new_istat_code.csv" must be dragged and dropped in the opened page.

After that, the "import" button must be clicked. In the new page, in the advanced setting section, it is necessary to use the "istat_population" index name. In the mapping section, at line number 13, the word "long" must be replaced with "keyword".

In the Ingest pipeline section, lines from number 33 to number 39 (both included) must be deleted. Then, by clicking the import button, vaccinations data will be imported successfully.

5.1.3 Create merged index

...

5.2 Import dashboard

After having opened Kibana it is necessary to go in the "Stack management" section. From this page, the "Saved objects" button present in the left bar, in the Kibana section, must be clicked.

In the new page it is necessary to click the "Import data" button and then upload the "dashboard.ndjson" file.

It is important to select as index the one referred to (????? probabilmente ci andrà quello misto tra istat e vaccini ?????). After that just click the "Import" button; the dashboard will now be visible in "Dashboard" section.

6 Conclusion

Some interesting conclusions can be drawn from the development of this project:

Elasticsearch and Kibana are a perfect match to make different type of analysis about trends even by using a big amount of data.

Kibana makes Elasticsearch queries output really simple to understand and visualize, and it can be really helpful because in this way the analysis results can be understood even by those who doesn't have any knowledge about computer science.

7 References and Sources

- Elastic Guide: <https://www.elastic.co/guide/index.html>
- Italian Government repository: <https://github.com/italia/covid19-opendata-vaccini>