EDA

June 20, 2020

1 Automatic Impression Generation From Medical Imaging Report

2 1. Business Problem

2.1 Description

2.2 Open-i chest X-ray collection from Indiana University

Open-i (Open Access Biomedical Image Search Engine) service of the National Library of Medicine enables search and retrieval of abstracts and images (including charts, graphs, clinical images, etc.) from the open source literature, and biomedical image collections. Searching may be done using text queries as well as query images. Open-i provides access to over 3.7 million images from about 1.2 million PubMed Central® articles; 7,470 chest x-rays with 3,955 radiology reports; 67,517 images from NLM History of Medicine collection; and 2,064 orthopedic illustrations.

2.3 Introduction about Dataset

This dataset is about 1000 radiology reports for the chest x-ray images from indiana university hospital network. - Images are downloaded as png format - Reports are downloaded as xml format. - Each xml will have the report for corresponding patient. - To identify images associated with the reports we need to check the xml tag `<parentImages id="image-id">` id attribute we have the image name corresponding to the png images. - More than one mages could be associated with one report.

Original data source: https://openi.nlm.nih.gov/
Other Resources: https://www.kaggle.com/raddar/chest-xrays-indiana-university

2.4 Problem statement :

Generation of Impression from given medical imaging report (Chest X-Ray)

3 2. Deep Learning Problem Formulation

3.1 Data Overview

3.2 Dataset Preparation from raw report

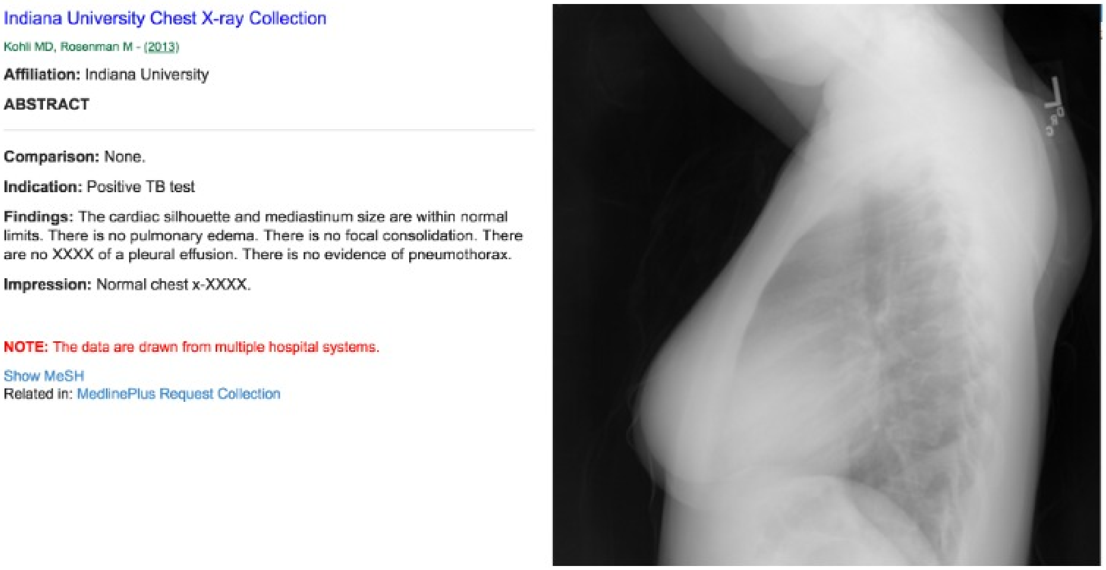
Data are in xml format. Need to do xml parsing to read the data and convert it into csv format

Image as input data with that We will also be taking the abstract, comparison, indication, findings as text inputs.
Impression as output/target variable it is a text data.

Below is the sample image and the report.

```
[4]: from IPython.display import Image
     Image(filename='x-ray.jpeg')
```

[4]:



Indiana University Chest X-ray Collection

Kohli MD, Rosenman M - (2013)

Affiliation: Indiana University

ABSTRACT

Comparison: None.

Indication: Positive TB test

Findings: The cardiac silhouette and mediastinum size are within normal limits. There is no pulmonary edema. There is no focal consolidation. There are no XXXX of a pleural effusion. There is no evidence of pneumothorax.

Impression: Normal chest x-XXXX.

NOTE: The data are drawn from multiple hospital systems.

Show MeSH
Related in: MedlinePlus Request Collection

```
[64]: import xml.etree.ElementTree as ET
      from bs4 import BeautifulSoup
      import pandas as pd
      import numpy as np
      from tqdm import tqdm
      import os
      import re
      import matplotlib.pyplot as plt
      import matplotlib.image as mpimg
      import seaborn as sns
      import warnings
      warnings.filterwarnings('ignore')
```

4 3. Data Preparation from raw xml data

```
[9]: #remove HTML from the Text column and save in the Text column only
     def preprocess_text(data, isCaption):
         # Combining all the above stundents
```

```
    preprocessed_reviews_eng = []

    # tqdm is for printing the status bar
    for sentance in tqdm(data.values):
        sentance = sentance.lower()
        sentance = re.sub(r"http\S+", "", sentance)
        sentance = BeautifulSoup(sentance, 'lxml').get_text()
        sentance = re.sub(r",", " ", sentance)
        sentance = re.sub(r"xxxx", "", sentance)
        sentance = re.sub(r"xxxxx", "", sentance)
        sentance = re.sub(r'[0-9]',"",sentance)
        sentance = re.sub(r"[-()\"#/@;:<>{}`+=~|.!?$%^&*'/+\[\]_]+", "",␣
 ↪sentance)
        sentance = re.sub(r"yearold", "", sentance)
        sentance = re.sub('\s+',' ',sentance)
        #if not isCaption:
            #sentance = '<start> ' + sentance + ' <end>'
        preprocessed_reviews_eng.append(sentance.strip())
    return preprocessed_reviews_eng
```

[10]:

```
columns = ["image_name", "image_caption", "comparison", "indication",␣
 ↪"findings", "impression"]
dataframe = pd.DataFrame(columns = columns)
#list files from Directory
for file in tqdm(os.listdir("ecgen-radiology/")):
    #find files ends with .xml only
    if file.endswith(".xml"):
        #parse the xml file
        tree = ET.parse("ecgen-radiology/"+file)
        #find images in each parentImage tag
        img_list = set()
        cap_list = set()
        for parent in tree.findall("parentImage"):
            img = parent.attrib['id']+".png"
            #for each image iterate and add the corresponding report
                #reading hight and width for image
            h = mpimg.imread("img/"+img).shape[0]
            w = mpimg.imread("img/"+img).shape[1]
            cap_list.add('' if parent.find('caption').text is None else parent.
 ↪find('caption').text)
            img_list.add(img)
        # finding root element
        tree = ET.parse("ecgen-radiology/"+file)
        comparision = tree.find(".//AbstractText[@Label='COMPARISON']").text
        indication = tree.find(".//AbstractText[@Label='INDICATION']").text
        findings = tree.find(".//AbstractText[@Label='FINDINGS']").text
        impression = tree.find(".//AbstractText[@Label='IMPRESSION']").text
        text_mesh = ""
        i = 1
        for child in tree.find("MeSH"):
            if len(tree.find("MeSH")) == i:
                text_mesh += child.text
            else:
                text_mesh += child.text+" "
            i+=1
        # add reports and image details to dataframe
        dataframe = dataframe.append(pd.Series([','.join(img_list), ','.
↪join(cap_list), comparision, indication, findings, impression],
                                                index = columns),␣
↪ignore_index = True)
```

```
100%|
 | 3956/3956 [01:54<00:00, 34.68it/s]
```

[11]:
```
dataframe.head()
```

[11]:
```
                                            image_name  \
0   CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png
1     CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png
2   CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png
3 CXR1000_IM-0003-2001.png,CXR1000_IM-0003-1001…
4 CXR1001_IM-0004-1002.png,CXR1001_IM-0004-1001.png

                                     image_caption  \
0                        Xray Chest PA and Lateral
1                PA and lateral chest x-XXXX XXXX.
2  CHEST 2V FRONTAL/LATERAL XXXX, XXXX XXXX PM
3                PA and lateral chest x-XXXX XXXX.
4   CHEST 2V FRONTAL/LATERAL XXXX, XXXX XXXX PM

                              comparison  \
0                                  None.
1                Chest radiographs XXXX.
2                                  None.
3 XXXX PA and lateral chest radiographs
4                                   None

                                            indication  \
0                                     Positive TB test
1                       XXXX-year-old male, chest pain.
2                                                 None
3                             XXXX-year-old male, XXXX.
4 dyspnea, subjective fevers, arthritis, immigra…
```

```
                                            findings  \
0  The cardiac silhouette and mediastinum size ar…
1  The cardiomediastinal silhouette is within nor…
2  Both lungs are clear and expanded. Heart and m…
3  There is XXXX increased opacity within the rig…
4  Interstitial markings are diffusely prominent …

                                          impression
0                               Normal chest x-XXXX.
1                  No acute cardiopulmonary process.
2                                 No active disease.
3  1. Increased opacity in the right upper lobe w…
4  Diffuse fibrosis. No visible focal acute disease.
```

[12]:
```
dataframe['image_caption'] = preprocess_text(dataframe['image_caption'].
 ↪fillna('Unknown'), True)
dataframe['comparison'] = preprocess_text(dataframe['comparison'].fillna('No␣
 ↪Comparison'), False)
dataframe['indication'] = preprocess_text(dataframe['indication'].fillna('No␣
 ↪Indication'), False)
dataframe['findings'] = preprocess_text(dataframe['findings'].fillna('No␣
 ↪Findings'), False)
dataframe['impression'] = preprocess_text(dataframe['impression'].fillna('No␣
 ↪Impression'), False)
```

```
100%|
| 3955/3955 [00:00<00:00, 4621.71it/s]
100%|
| 3955/3955 [00:01<00:00, 3087.45it/s]
100%|
| 3955/3955 [00:00<00:00, 4708.49it/s]
100%|
| 3955/3955 [00:00<00:00, 4457.74it/s]
100%|
| 3955/3955 [00:00<00:00, 4589.82it/s]
```

[13]:
```
dataframe.head()
```

[13]:
```
                                          image_name  \
0    CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png
1      CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png
2    CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png
3  CXR1000_IM-0003-2001.png,CXR1000_IM-0003-1001…
4  CXR1001_IM-0004-1002.png,CXR1001_IM-0004-1001.png

               image_caption                comparison  \
0  xray chest pa and lateral                      none
```

```
1     pa and lateral chest x                chest radiographs
2  chest v frontallateral pm                             none
3     pa and lateral chest x  pa and lateral chest radiographs
4  chest v frontallateral pm                             none

                                          indication  \
0                                   positive tb test
1                                    male chest pain
2                                      no indication
3                                               male
4  dyspnea subjective fevers arthritis immigrant …

                                            findings  \
0  the cardiac silhouette and mediastinum size ar…
1  the cardiomediastinal silhouette is within nor…
2  both lungs are clear and expanded heart and me…
3  there is increased opacity within the right up…
4  interstitial markings are diffusely prominent …

                                          impression
0                                     normal chest x
1                   no acute cardiopulmonary process
2                                  no active disease
3  increased opacity in the right upper lobe with…
4    diffuse fibrosis no visible focal acute disease
```

[14]:
```python
dataframe.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3955 entries, 0 to 3954
Data columns (total 6 columns):
image_name       3955 non-null object
image_caption    3955 non-null object
comparison       3955 non-null object
indication       3955 non-null object
findings         3955 non-null object
impression       3955 non-null object
dtypes: object(6)
memory usage: 185.5+ KB
```

[32]:
```python
dataframe.image_name.describe()
```

[32]:
```
count     3955
unique    3852
top
freq       104
Name: image_name, dtype: object
```

- There are some empty cells in image name column

Drop Missing image rows

```
[33]: dataframe.replace("", float("NaN"), inplace=True)
      dataframe.dropna(subset = ["image_name"], inplace=True)
      dataframe.shape
```

```
[33]: (3851, 8)
```

create word count column for findings and impression

```
[34]: dataframe['findings_count'] = dataframe['findings'].astype(str).str.split().
       ↪apply(lambda x: 0 if x==None else len(x))
      dataframe['impression_count'] = dataframe['impression'].astype(str).str.split().
       ↪apply(lambda x: 0 if x==None else len(x))
```

```
[46]: dataframe['image_count'] = dataframe['image_name'].astype(str).str.split(',').
       ↪apply(len)
```

```
[47]: dataframe.to_csv("data.csv", index=False)
```

```
[65]: data = pd.read_csv("data.csv")
```

```
[66]: data.head()
```

```
[66]:                                            image_name  \
      0    CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png
      1      CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png
      2    CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png
      3  CXR1000_IM-0003-2001.png,CXR1000_IM-0003-1001…
      4  CXR1001_IM-0004-1002.png,CXR1001_IM-0004-1001.png

                       image_caption                      comparison  \
      0  xray chest pa and lateral                              none
      1     pa and lateral chest x             chest radiographs
      2  chest v frontallateral pm                              none
      3     pa and lateral chest x  pa and lateral chest radiographs
      4  chest v frontallateral pm                              none

                                                 indication  \
      0                                   positive tb test
      1                                    male chest pain
      2                                      no indication
      3                                               male
      4  dyspnea subjective fevers arthritis immigrant …

                                                   findings  \
      0  the cardiac silhouette and mediastinum size ar…
      1  the cardiomediastinal silhouette is within nor…
      2  both lungs are clear and expanded heart and me…
      3  there is increased opacity within the right up…
      4  interstitial markings are diffusely prominent …

                                                 impression  findings_count  \
      0                                     normal chest x              33
      1                   no acute cardiopulmonary process              38
      2                                  no active disease              10
      3  increased opacity in the right upper lobe with…              52
      4    diffuse fibrosis no visible focal acute disease              14

         impression_count  image_count
      0                 3            2
      1                 4            2
      2                 3            2
      3                36            3
      4                 7            2
```

[50]:

```python
print("Shape of the dataframe ", data.shape)
```

```
Shape of the dataframe  (3851, 9)
```

[51]:

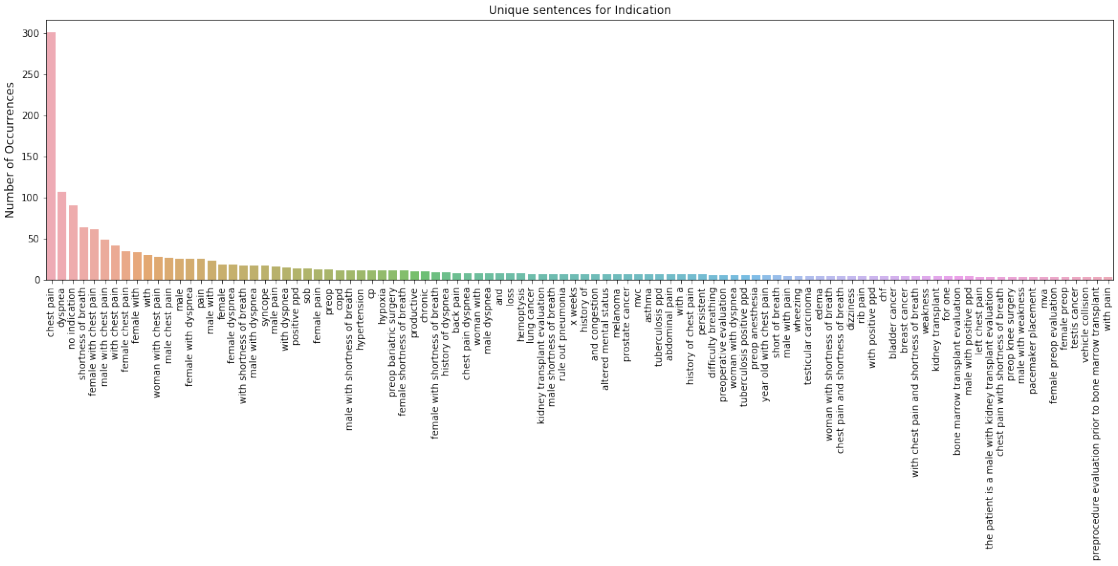
```python
print("Total number of unique Images {} ".format(len(data.image_name.unique())))
print("Total number of unique Caption {} ".format(len(data.image_caption.
 ↪unique())))
print("Total number of unique Comparison {} ".format(len(data.comparison.
 ↪unique())))
print("Total number of unique Indication {} ".format(len(data.indication.
 ↪unique())))
print("Total number of unique Findings {} ".format(len(data.findings.unique())))
print("Total number of unique Impression {} ".format(len(data.impression.
 ↪unique())))
```

```
Total number of unique Images 3851
Total number of unique Caption 402
Total number of unique Comparison 281
Total number of unique Indication 2098
Total number of unique Findings 2545
Total number of unique Impression 1692
```

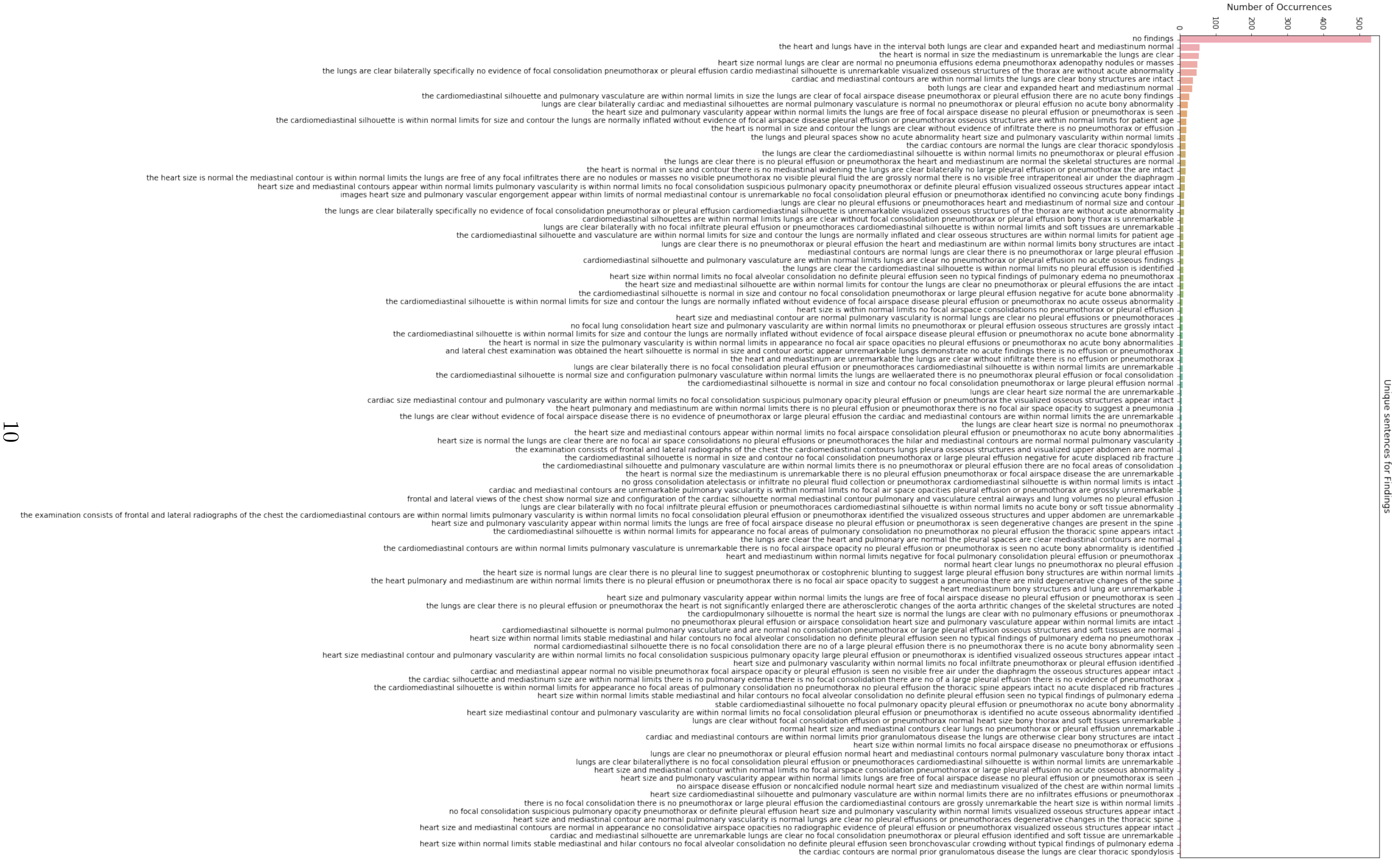
5 4. EDA on Text data

5.1 Lets see top 100 most occurring sentences

[82]:
```
indication = data.indication.value_counts()[:100]
plt.figure(figsize=(20,5))
sns.barplot(indication.index, indication.values, alpha=0.8)
plt.title("Unique sentences for Indication")
plt.ylabel('Number of Occurrences', fontsize=12)
plt.xticks(rotation=90)
plt.show()
```



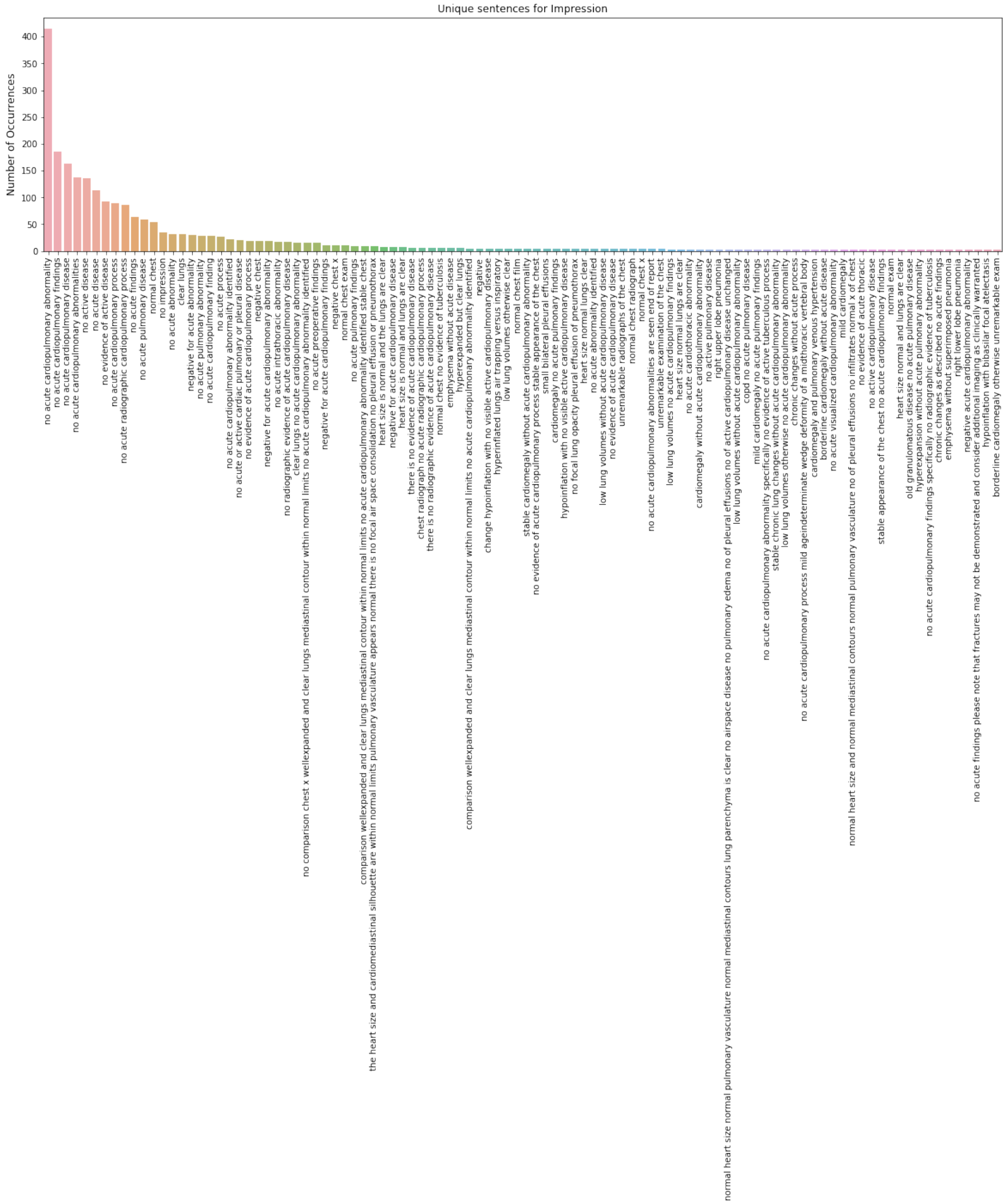
[83]:
```
findings = data.findings.value_counts()[:100]
plt.figure(figsize=(20,5))
sns.barplot(findings.index, findings.values, alpha=0.8)
plt.title("Unique sentences for Findings")
plt.ylabel('Number of Occurrences', fontsize=12)
plt.xticks(rotation=90)
plt.show()
```


Unique sentences for Findings
Number of Occurrences
0
100
200
300
400
500
no findings
the heart and lungs have in the interval both lungs are clear and expanded heart and mediastinum normal
the heart is normal in size the mediastinum is unremarkable the lungs are clear
heart size normal lungs are clear are normal no pneumonia effusions edema pneumothorax adenopathy nodules or masses
the lungs are clear bilaterally specifically no evidence of focal consolidation pneumothorax or pleural effusion cardio mediastinal silhouette is unremarkable visualized osseous structures of the thorax are without acute abnormality
cardiac and mediastinal contours are within normal limits the lungs are clear bony structures are intact
both lungs are clear and expanded heart and mediastinum normal
the cardiomediastinal silhouette and pulmonary vasculature are within normal limits in size the lungs are clear of focal airspace disease pneumothorax or pleural effusion there are no acute bony findings
lungs are clear bilaterally cardiac and mediastinal silhouettes are normal pulmonary vasculature is normal no pneumothorax or pleural effusion no acute bony abnormality
the heart size and pulmonary vascularity appear within normal limits the lungs are free of focal airspace disease no pleural effusion or pneumothorax is seen
the cardiomediastinal silhouette is within normal limits for size and contour the lungs are normally inflated without evidence of focal airspace disease pleural effusion or pneumothorax osseous structures are within normal limits for patient age
the heart is normal in size and contour the lungs are clear without evidence of infiltrate there is no pneumothorax or effusion
the lungs and pleural spaces show no acute abnormality heart size and pulmonary vascularity within normal limits
the cardiac contours are normal the lungs are clear thoracic spondylosis
the lungs are clear the cardiomediastinal silhouette is within normal limits no pneumothorax or pleural effusion
the lungs are clear there is no pleural effusion or pneumothorax the heart and mediastinum are normal the skeletal structures are normal
the heart is normal in size and contour there is no mediastinal widening the lungs are clear bilaterally no large pleural effusion or pneumothorax the are intact
the heart size is normal the mediastinal contour is within normal limits the lungs are free of any focal infiltrates there are no nodules or masses no visible pneumothorax no visible pleural fluid the are grossly normal there is no visible free intraperitoneal air under the diaphragm
heart size and mediastinal contours appear within normal limits pulmonary vascularity is within normal limits no focal consolidation suspicious pulmonary opacity pneumothorax or definite pleural effusion visualized osseous structures appear intact
images heart size and pulmonary vascular engorgement appear within limits of normal mediastinal contour is unremarkable no focal consolidation pleural effusion or pneumothorax identified no convincing acute bony findings
lungs are clear no pleural effusions or pneumothoraces heart and mediastinum of normal size and contour
the lungs are clear bilaterally specifically no evidence of focal consolidation pneumothorax or pleural effusion cardiomediastinal silhouette is unremarkable visualized osseous structures of the thorax are without acute abnormality
cardiomediastinal silhouettes are within normal limits lungs are clear without focal consolidation pneumothorax or pleural effusion bony thorax is unremarkable
lungs are clear bilaterally with no focal infiltrate pleural effusion or pneumothoraces cardiomediastinal silhouette is within normal limits and soft tissues are unremarkable
the cardiomediastinal silhouette and vasculature are within normal limits for size and contour the lungs are normally inflated and clear osseous structures are within normal limits for patient age
lungs are clear there is no pneumothorax or pleural effusion the heart and mediastinum are within normal limits bony structures are intact
mediastinal contours are normal lungs are clear there is no pneumothorax or large pleural effusion
cardiomediastinal silhouette and pulmonary vasculature are within normal limits lungs are clear no pneumothorax or pleural effusion no acute osseous findings
the lungs are clear the cardiomediastinal silhouette is within normal limits no pleural effusion is identified
heart size within normal limits no focal alveolar consolidation no definite pleural effusion seen no typical findings of pulmonary edema no pneumothorax
the heart size and mediastinal silhouette are within normal limits for contour the lungs are clear no pneumothorax or pleural effusions the are intact
the cardiomediastinal silhouette is normal in size and contour no focal consolidation pneumothorax or large pleural effusion negative for acute bone abnormality
the cardiomediastinal silhouette is within normal limits for size and contour the lungs are normally inflated without evidence of focal airspace disease pleural effusion or pneumothorax no acute osseus abnormality
heart size is within normal limits no focal airspace consolidations no pneumothorax or pleural effusion
heart size and mediastinal contour are normal pulmonary vascularity is normal lungs are clear no pleural effusions or pneumothoraces
no focal lung consolidation heart size and pulmonary vascularity are within normal limits no pneumothorax or pleural effusion osseous structures are grossly intact
the cardiomediastinal silhouette is within normal limits for size and contour the lungs are normally inflated without evidence of focal airspace disease pleural effusion or pneumothorax no acute bone abnormality
the heart is normal in size the pulmonary vascularity is within normal limits in appearance no focal air space opacities no pleural effusions or pneumothorax no acute bony abnormalities
and lateral chest examination was obtained the heart silhouette is normal in size and contour aortic appear unremarkable lungs demonstrate no acute findings there is no effusion or pneumothorax
the heart and mediastinum are unremarkable the lungs are clear without infiltrate there is no effusion or pneumothorax
lungs are clear bilaterally there is no focal consolidation pleural effusion or pneumothoraces cardiomediastinal silhouette is within normal limits are unremarkable
the cardiomediastinal silhouette is normal size and configuration pulmonary vasculature within normal limits the lungs are wellaerated there is no pneumothorax pleural effusion or focal consolidation
the cardiomediastinal silhouette is normal in size and contour no focal consolidation pneumothorax or large pleural effusion normal
lungs are clear heart size normal the are unremarkable
cardiac size mediastinal contour and pulmonary vascularity are within normal limits no focal consolidation suspicious pulmonary opacity pleural effusion or pneumothorax the visualized osseous structures appear intact
the heart pulmonary and mediastinum are within normal limits there is no pleural effusion or pneumothorax there is no focal air space opacity to suggest a pneumonia
the lungs are clear without evidence of focal airspace disease there is no evidence of pneumothorax or large pleural effusion the cardiac and mediastinal contours are within normal limits the are unremarkable
the lungs are clear heart size is normal no pneumothorax
the heart size and mediastinal contours appear within normal limits no focal airspace consolidation pleural effusion or pneumothorax no acute bony abnormalities
heart size is normal the lungs are clear there are no focal air space consolidations no pleural effusions or pneumothoraces the hilar and mediastinal contours are normal normal pulmonary vascularity
the examination consists of frontal and lateral radiographs of the chest the cardiomediastinal contours lungs pleura osseous structures and visualized upper abdomen are normal
the cardiomediastinal silhouette is normal in size and contour no focal consolidation pneumothorax or large pleural effusion negative for acute displaced rib fracture
the cardiomediastinal silhouette and pulmonary vasculature are within normal limits there is no pneumothorax or pleural effusion there are no focal areas of consolidation
the heart is normal size the mediastinum is unremarkable there is no pleural effusion pneumothorax or focal airspace disease the are unremarkable
no gross consolidation atelectasis or infiltrate no pleural fluid collection or pneumothorax cardiomediastinal silhouette is within normal limits is intact
cardiac and mediastinal contours are unremarkable pulmonary vascularity is within normal limits no focal air space opacities pleural effusion or pneumothorax are grossly unremarkable
frontal and lateral views of the chest show normal size and configuration of the cardiac silhouette normal mediastinal contour pulmonary and vasculature central airways and lung volumes no pleural effusion
lungs are clear bilaterally with no focal infiltrate pleural effusion or pneumothoraces cardiomediastinal silhouette is within normal limits no acute bony or soft tissue abnormality
the examination consists of frontal and lateral radiographs of the chest the cardiomediastinal contours are within normal limits pulmonary vascularity is within normal limits no focal consolidation pleural effusion or pneumothorax identified the visualized osseous structures and upper abdomen are unremarkable
heart size and pulmonary vascularity appear within normal limits the lungs are free of focal airspace disease no pleural effusion or pneumothorax is seen degenerative changes are present in the spine
the cardiomediastinal silhouette is within normal limits for appearance no focal areas of pulmonary consolidation no pneumothorax no pleural effusion the thoracic spine appears intact
the lungs are clear the heart and pulmonary are normal the pleural spaces are clear mediastinal contours are normal
the cardiomediastinal contours are within normal limits pulmonary vasculature is unremarkable there is no focal airspace opacity no pleural effusion or pneumothorax is seen no acute bony abnormality is identified
heart and mediastinum within normal limits negative for focal pulmonary consolidation pleural effusion or pneumothorax
normal heart clear lungs no pneumothorax no pleural effusion
the heart size is normal lungs are clear there is no pleural line to suggest pneumothorax or costophrenic blunting to suggest large pleural effusion bony structures are within normal limits
the heart pulmonary and mediastinum are within normal limits there is no pleural effusion or pneumothorax there is no focal air space opacity to suggest a pneumonia there are mild degenerative changes of the spine
heart mediastinum bony structures and lung are unremarkable
heart size and pulmonary vascularity appear within normal limits the lungs are free of focal airspace disease no pleural effusion or pneumothorax is seen
the lungs are clear there is no pleural effusion or pneumothorax the heart is not significantly enlarged there are atherosclerotic changes of the aorta arthritic changes of the skeletal structures are noted
the cardiopulmonary silhouette is normal the heart size is normal the lungs are clear with no pulmonary effusions or pneumothorax
no pneumothorax pleural effusion or airspace consolidation heart size and pulmonary vasculature appear within normal limits are intact
cardiomediastinal silhouette is normal pulmonary vasculature and are normal no consolidation pneumothorax or large pleural effusion osseous structures and soft tissues are normal
heart size within normal limits stable mediastinal and hilar contours no focal alveolar consolidation no definite pleural effusion seen no typical findings of pulmonary edema no pneumothorax
normal cardiomediastinal silhouette there is no focal consolidation there are no of a large pleural effusion there is no pneumothorax there is no acute bony abnormality seen
heart size mediastinal contour and pulmonary vascularity are within normal limits no focal consolidation suspicious pulmonary opacity large pleural effusion or pneumothorax is identified visualized osseous structures appear intact
heart size and pulmonary vascularity within normal limits no focal infiltrate pneumothorax or pleural effusion identified
cardiac and mediastinal appear normal no visible pneumothorax focal airspace opacity or pleural effusion is seen no visible free air under the diaphragm the osseous structures appear intact
the cardiac silhouette and mediastinum size are within normal limits there is no pulmonary edema there is no focal consolidation there are no of a large pleural effusion there is no evidence of pneumothorax
the cardiomediastinal silhouette is within normal limits for appearance no focal areas of pulmonary consolidation no pneumothorax no pleural effusion the thoracic spine appears intact no acute displaced rib fractures
heart size within normal limits stable mediastinal and hilar contours no focal alveolar consolidation no definite pleural effusion seen no typical findings of pulmonary edema
stable cardiomediastinal silhouette no focal pulmonary opacity pleural effusion or pneumothorax no acute bony abnormality
heart size mediastinal contour and pulmonary vascularity are within normal limits no focal consolidation pleural effusion or pneumothorax is identified no acute osseous abnormality identified
lungs are clear without focal consolidation effusion or pneumothorax normal heart size bony thorax and soft tissues unremarkable
normal heart size and mediastinal contours clear lungs no pneumothorax or pleural effusion unremarkable
cardiac and mediastinal contours are within normal limits prior granulomatous disease the lungs are otherwise clear bony structures are intact
heart size within normal limits no focal airspace disease no pneumothorax or effusions
lungs are clear no pneumothorax or pleural effusion normal heart and mediastinal contours normal pulmonary vasculature bony thorax intact
lungs are clear bilaterallythere is no focal consolidation pleural effusion or pneumothoraces cardiomediastinal silhouette is within normal limits are unremarkable
heart size and mediastinal contour within normal limits no focal airspace consolidation pneumothorax or large pleural effusion no acute osseous abnormality
heart size and pulmonary vascularity appear within normal limits lungs are free of focal airspace disease no pleural effusion or pneumothorax is seen
no airspace disease effusion or noncalcified nodule normal heart size and mediastinum visualized of the chest are within normal limits
heart size cardiomediastinal silhouette and pulmonary vasculature are within normal limits there are no infiltrates effusions or pneumothorax
there is no focal consolidation there is no pneumothorax or large pleural effusion the cardiomediastinal contours are grossly unremarkable the heart size is within normal limits
no focal consolidation suspicious pulmonary opacity pneumothorax or definite pleural effusion heart size and pulmonary vascularity within normal limits visualized osseous structures appear intact
heart size and mediastinal contour are normal pulmonary vascularity is normal lungs are clear no pleural effusions or pneumothoraces degenerative changes in the thoracic spine
heart size and mediastinal contours are normal in appearance no consolidative airspace opacities no radiographic evidence of pleural effusion or pneumothorax visualized osseous structures appear intact
cardiac and mediastinal silhouette are unremarkable lungs are clear no focal consolidation pneumothorax or pleural effusion identified and soft tissue are unremarkable
heart size within normal limits stable mediastinal and hilar contours no focal alveolar consolidation no definite pleural effusion seen bronchovascular crowding without typical findings of pulmonary edema
the cardiac contours are normal prior granulomatous disease the lungs are clear thoracic spondylosis

- There is more then 500 rows have no findings
- From above distribution we can see that there are 4 unique sentences which occurred more than 60 times.
- Most of the sentences are occurred almost 10 times

[84]:

```
impression = data.impression.value_counts()[:100]
plt.figure(figsize=(20,5))
sns.barplot(impression.index, impression.values, alpha=0.8)
plt.title("Unique sentences for Impression")
plt.ylabel('Number of Occurrences', fontsize=12)
plt.xticks(rotation=90)
plt.show()
```

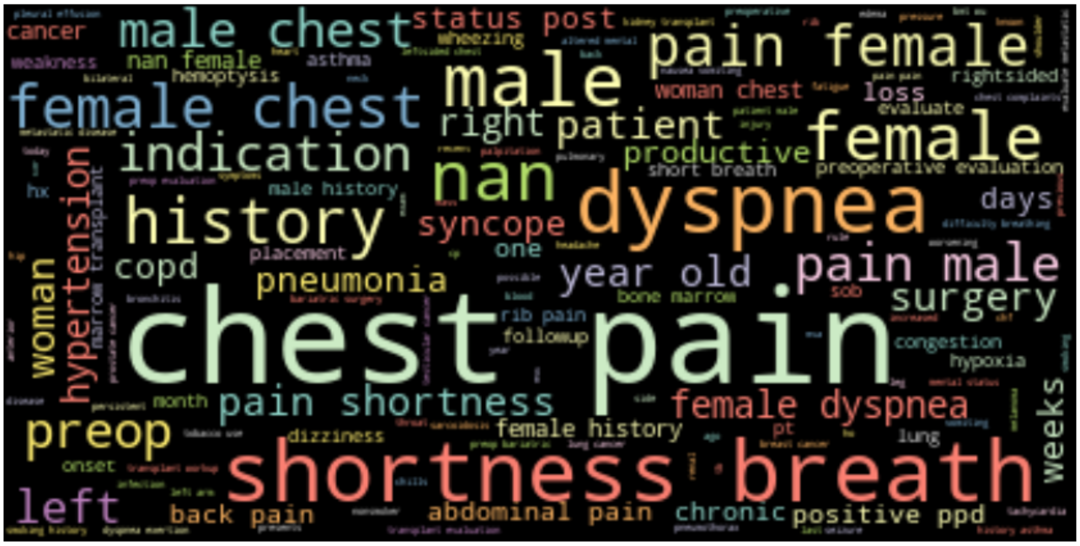


- From above distribution we can see that "No acute cardiopulmonary abnormality" occurred 600 times.
- Most of the sentences are occurred almost 10 times

5.2 Word cloud max 1000 words on Indication

[85]:

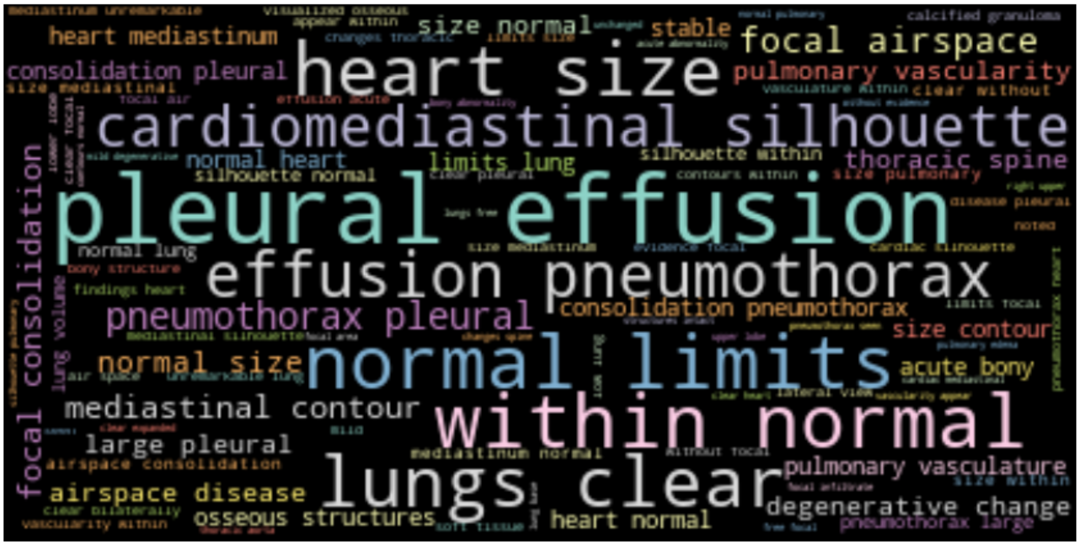
```
from wordcloud import WordCloud, ImageColorGenerator
wordcloud = WordCloud(max_words=1000,colormap='Set3', background_color="black").
 ↪generate(' '.join(data['indication'].astype(str)))
plt.figure(figsize=(15,10))
plt.imshow(wordcloud, interpolation='Bilinear')
plt.axis("off")
plt.figure(1,figsize=(12, 12))
plt.show()
```



5.3 Word cloud max 1000 words on Findings

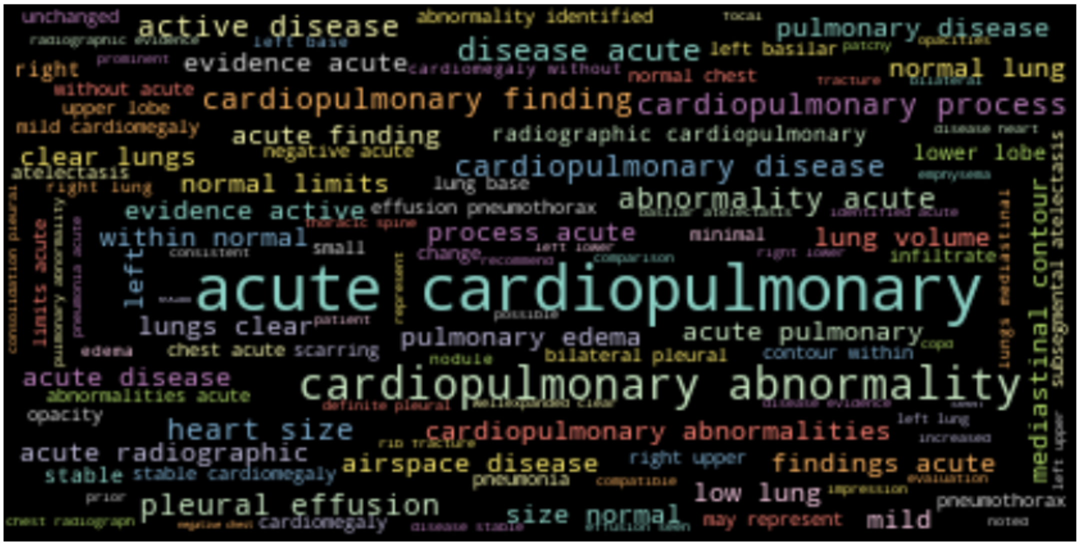
[86]:

```
wordcloud = WordCloud(max_words=1000,colormap='Set3', background_color="black").
 ↪generate(' '.join(data['findings'].astype(str)))
plt.figure(figsize=(15,10))
plt.imshow(wordcloud, interpolation='Bilinear')
plt.axis("off")
plt.figure(1,figsize=(12, 12))
plt.show()
```



5.4 Word cloud max 1000 words on Impression

[87]:
```
wordcloud = WordCloud(max_words=1000,colormap='Set3', background_color="black").
 ↪generate(' '.join(data['impression'].astype(str)))
plt.figure(figsize=(15,10))
plt.imshow(wordcloud, interpolation='Bilinear')
plt.axis("off")
plt.figure(1,figsize=(12, 12))
plt.show()
```

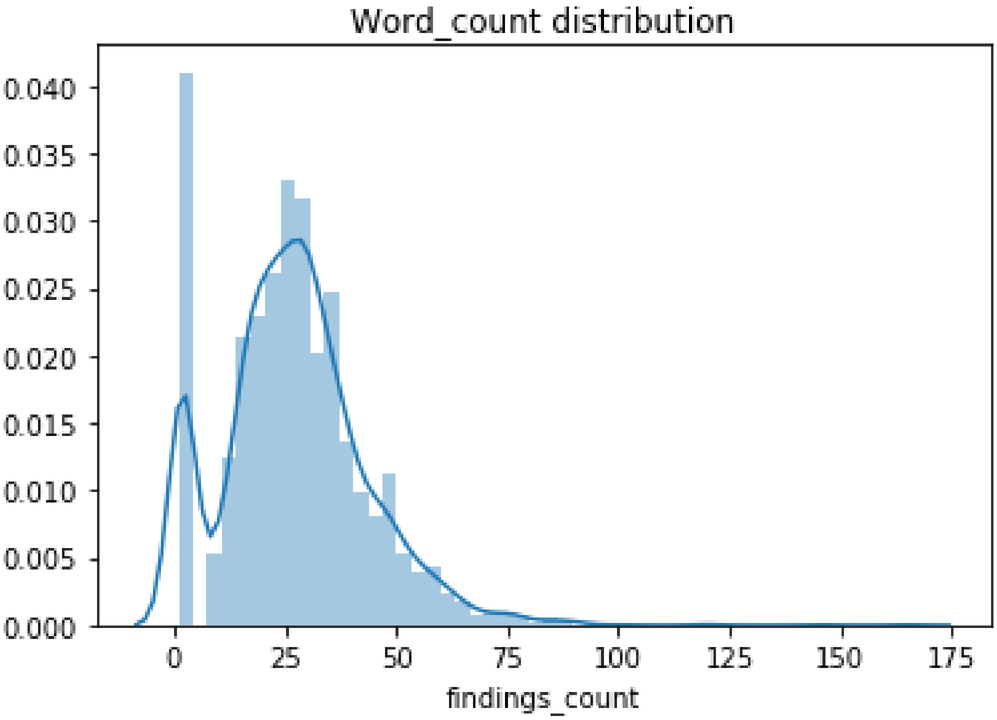


- Above word cloud are generated on the top 1000 max occurrence words.

5.5 Word count distribution

5.5.1 word count for Findings

[91]:
```
sns.distplot(data['findings_count'])
plt.title("Word_count distribution")
plt.show()
print("Minimum word count is {}".format(np.min(data['findings_count'].values)))
print("Maximum word count is {}".format(np.max(data['findings_count'].values)))
print("median word count is {}".format(np.median(data['findings_count'].
 ↪values)))
```

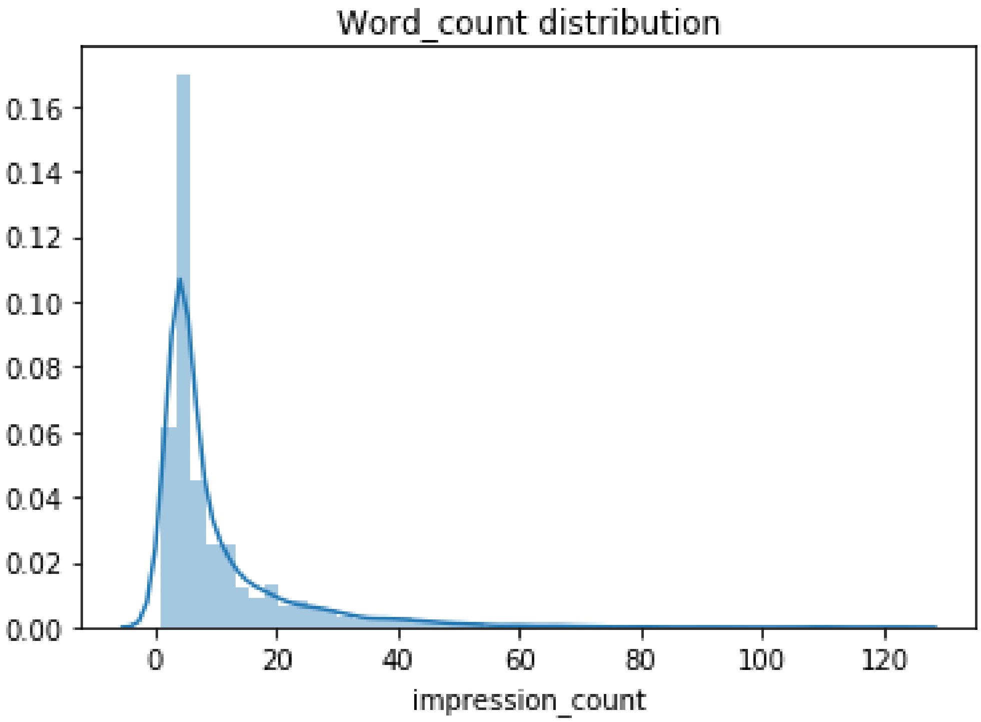


```
Minimum word count is 1
Maximum word count is 165
median word count is 26.0
```

- We can see the maximum and minimum word count.
- words max occurrence is 1 that is "No Findings"
- most often word count is between 25 to 30

word count for Impression

[92]:
```
sns.distplot(data['impression_count'])
plt.title("Word_count distribution")
plt.show()
print("Minimum word count is {}".format(np.min(data['impression_count'].
 ↪values)))
print("Maximum word count is {}".format(np.max(data['impression_count'].
 ↪values)))
print("median word count is {}".format(np.median(data['impression_count'].
 ↪values)))
```



```
Minimum word count is 1
Maximum word count is 122
median word count is 5.0
```

- We can see the maximum and minimum word count.
- word count max occurrence is 5
- most often word count is between 5 to 10

[93]:
```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Percentile", "Word Count findings", "Word Count impression"]

for i in range(0,101,5):
    x.add_row([i,np.round(np.percentile(data['findings_count'],i), 3), np.
↪round(np.percentile(data['impression_count'],i), 3)])
print(x)
```

```
+------------+---------------------+-----------------------+
| Percentile | Word Count findings | Word Count impression |
+------------+---------------------+-----------------------+
|     0      |         1.0         |          1.0          |
|     5      |         2.0         |          3.0          |
|     10     |         2.0         |          3.0          |
|     15     |         10.0        |          4.0          |
|     20     |         15.0        |          4.0          |
|     25     |         17.0        |          4.0          |
|     30     |         19.0        |          4.0          |
|     35     |         21.0        |          4.0          |
|     40     |         23.0        |          4.0          |
|     45     |         24.0        |          4.0          |
|     50     |         26.0        |          5.0          |
|     55     |         28.0        |          5.0          |
|     60     |         30.0        |          7.0          |
|     65     |         31.0        |          8.0          |
|     70     |         33.0        |          9.0          |
|     75     |         36.0        |          11.0         |
|     80     |         38.0        |          14.0         |
|     85     |         42.0        |          18.0         |
|     90     |         47.0        |          24.0         |
|     95     |         56.0        |          33.0         |
|    100     |        165.0        |         122.0         |
+------------+---------------------+-----------------------+
```

- From above percentile value the detailed view of the word count for findings and impression is printed using prettytable.

6 5. EDA on Image data

[83]:

```
list(data[324:325]['image_name'])
```

[83]:

```
['CXR1303_IM-0199-2001-0001.png,CXR1303_IM-0199-1001-0001.png,CXR1303_IM-0199-10
01-0002.png,CXR1303_IM-0199-2001-0003.png,CXR1303_IM-0199-2001-0002.png']
```

[76]:

```
data[data['image_count'] > 3]
```

[76]:

```
                                            image_name  \
19     CXR1015_IM-0013-1001.png,CXR1015_IM-0001-1001…
113    CXR1102_IM-0069-3001.png,CXR1102_IM-0069-2001…
324    CXR1303_IM-0199-2001-0001.png,CXR1303_IM-0199-…
563    CXR1525_IM-0340-1001.png,CXR1525_IM-0340-3001…
```

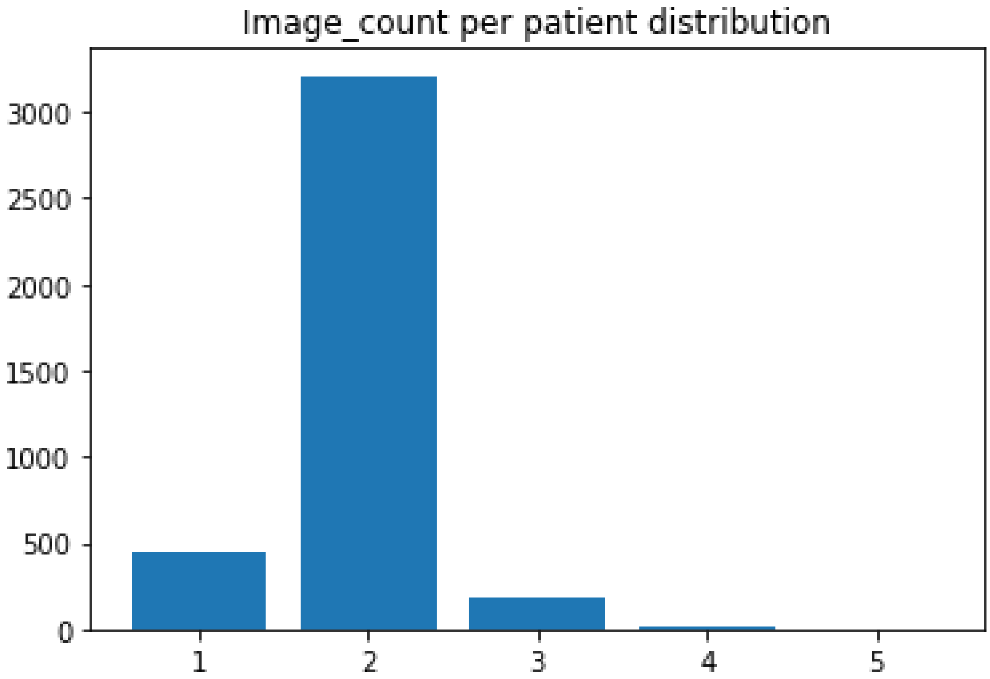
```
1158  CXR2084_IM-0715-2001-0001.png,CXR2084_IM-0715-…
1172  CXR2097_IM-0727-1001-0001.png,CXR2097_IM-0727-…
1329  CXR2243_IM-0840-4001.png,CXR2243_IM-0840-2001…
1370  CXR2280_IM-0867-1001-0001.png,CXR2280_IM-0867-…
1668  CXR2560_IM-1064-3001.png,CXR2560_IM-1064-4001…
2457  CXR3307_IM-1582-1004003.png,CXR3307_IM-1582-10…
2512  CXR3359_IM-1612-3001.png,CXR3359_IM-1612-6001…
2629  CXR3468_IM-1684-0001-0004.png,CXR3468_IM-1684-…
2734  CXR3566_IM-1751-1001.png,CXR3566_IM-1751-4004…
3131  CXR3932_IM-2004-1005.png,CXR3932_IM-2004-1002…
3167  CXR3965_IM-2028-1001-0002.png,CXR3965_IM-2028-…
3688  CXR846_IM-2368-0001-0003.png,CXR846_IM-2368-00…

                                   image_caption  \
19                          pa and lateral chest
113      ap and lateral views of the chest dated
324                    chest v frontallateral pm
563                    xray chest pa and lateral
1158             chest radiograph pa and lateral
1172                   chest v frontallateral pm
1329             pa and lateral chest radiograph
1370                     pa and lateral chest at
1668                           views chest hours
2457                   xray chest pa and lateral
2512                        pa and lateral chest
2629  pa and lateral views of the chest dated pm
2734                   xray chest pa and lateral
3131       pa and lateral chest radiograph views
3167                      chest v frontallateral
3688                   xray chest pa and lateral

                               comparison  \
19                                    NaN
113                                   NaN
324                                   NaN
563                         none clinical
1158                                 none
1172  chest x single view frontal from am
1329                     chest radiograph
1370                                 none
1668                                  NaN
2457                                 none
2512                       none available
2629                                  NaN
2734                       none available
3131                                 none
3167                                  NaN
```

```
3688                        no comparison

                                             indication  \
19             female copd exacerbation short of breath   
113      shortness of breath unable to for lateral view   
324                                               bleed   
563                                                 NaN   
1158                         yr old female with dyspnea   
1172                            repeat after stab wound   
1329                             female with chest pain   
1370                                         chest pain   
1668                                     and chest pain   
2457                                         chest pain   
2512                               male with chest pain   
2629  male preoperative evaluation for heart valve r…   
2734                                   male ladder feet   
3131                                         and sweats   
3167                                                NaN   
3688                                     bladder cancer   

                                               findings  \
19    streaky and patchy bibasilar opacities triangu…   
113   there is stable cardiomegaly with pulmonary va…   
324   in the interval a cm uncalcified mass has deve…   
563   images there is a large hydropneumothorax with…   
1158  left chest wall mediport placement with venous…   
1172  the trachea is midline cardiomediastinal silho…   
1329  the heart is normal size the mediastinum is un…   
1370                                        no findings   
1668  the cardiomediastinal contours are within norm…   
2457  the cardiomediastinal silhouette is normal siz…   
2512  heart size normal no focal airspace disease no…   
2629  heart size is at the upper limits of normal th…   
2734  normal heart size and mediastinal contours low…   
3131  the cardiac silhouette mediastinal contours ar…   
3167  the heart and lungs have in the interval both …   
3688  heart size and pulmonary vascularity appears n…   

                                             impression  findings_count  \
19    bibasilar opacities right greater than left fe…              38   
113   cardiomegaly vascular congestion and probable …              36   
324   right upper lobe mass suspicious for neoplasm …              75   
563   large left hydropneumothorax with complete col…              83   
1158  pathologic fractures seen at t and l left veno…              38   
1172  no acute cardiopulmonary abnormality seen on c…              30   
1329               no acute cardiopulmonary abnormality              40   
1370  heart size is normal multiple scattered small …               2   
```

```
1668               no acute cardiopulmonary abnormality              38
2457                   no acute cardiopulmonary disease              26
2512                  no acute cardiopulmonary findings              11
2629  no focal airspace consolidation emphysema stab…              46
2734  no acute cardiopulmonary abnormality technical…              42
3131                   no acute cardiopulmonary disease              25
3167                                  no active disease              18
3688                      no evidence of active disease              30

      impression_count  image_count
19                  14            4
113                 18            4
324                 19            5
563                 29            4
1158                12            4
1172                10            4
1329                 4            4
1370                27            4
1668                 4            4
2457                 4            4
2512                 4            4
2629                10            4
2734                14            4
3131                 4            4
3167                 3            4
3688                 5            4
```

[63]:

```
plt.bar(data['image_count'].value_counts().index, height=data['image_count'].
 ↪value_counts().values)
plt.title("Image_count per patient distribution")
plt.show()
print("Minimum Image count is {}".format(np.min(data['image_count'].values)))
print("Maximum Image count is {}".format(np.max(data['image_count'].values)))
print("median Image count is {}".format(np.median(data['image_count'].values)))
```

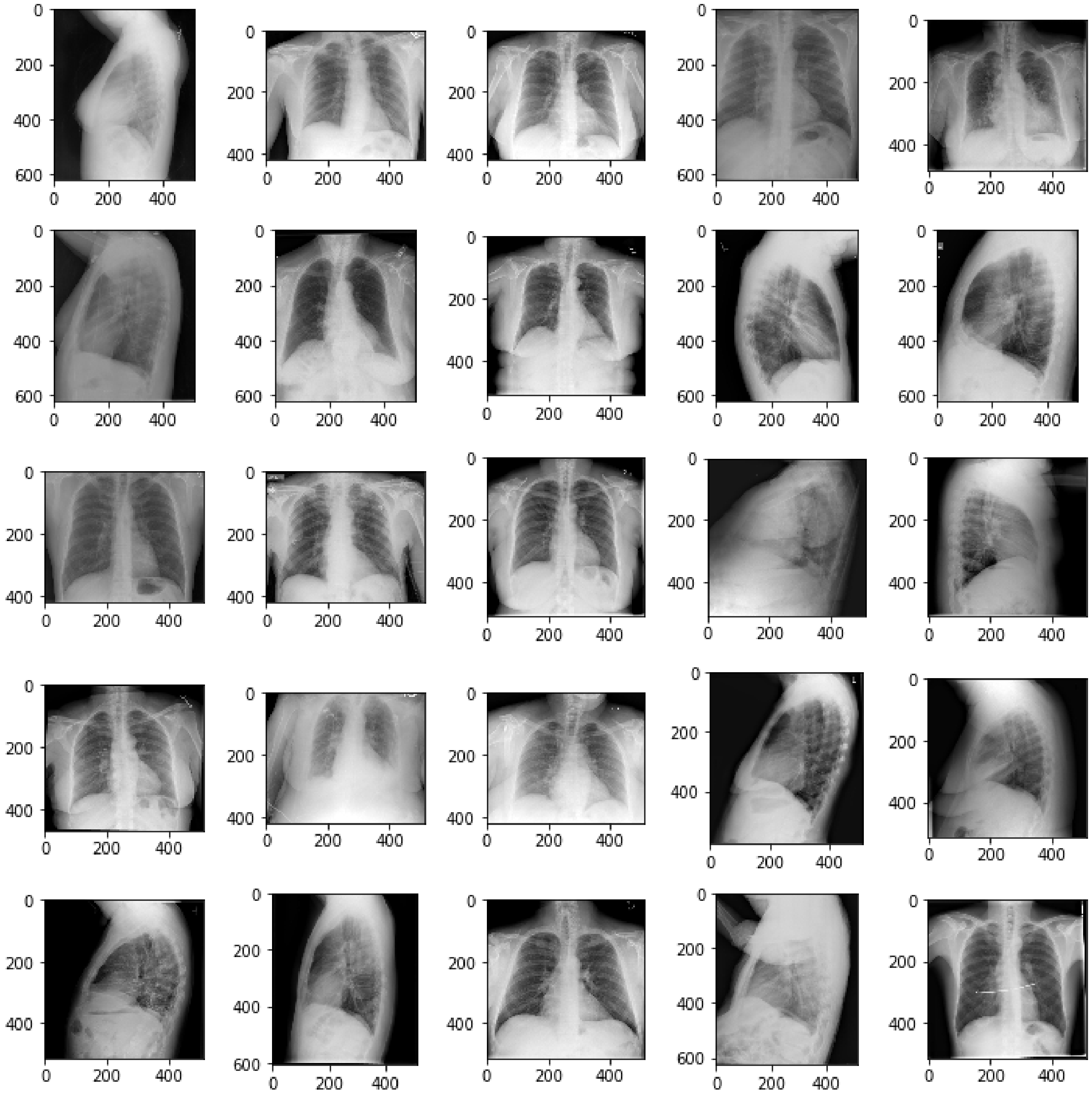


```
Minimum Image count is 1
Maximum Image count is 5
median Image count is 2.0
```

- Most occurring image count is 2

[111]:
```
print("==== Displaying random 25 patient X-Ray ====")
fig, axs = plt.subplots(5, 5, figsize = (10,10), tight_layout=True)
for row, subplot in zip(data[0:25].itertuples(), axs.flatten()):
    img=mpimg.imread("img/"+row.image_name.split(',')[0])
    subplot.imshow(img, cmap = 'bone')
plt.show()
```

```
==== Displaying random 25 patient X-Ray ====
```

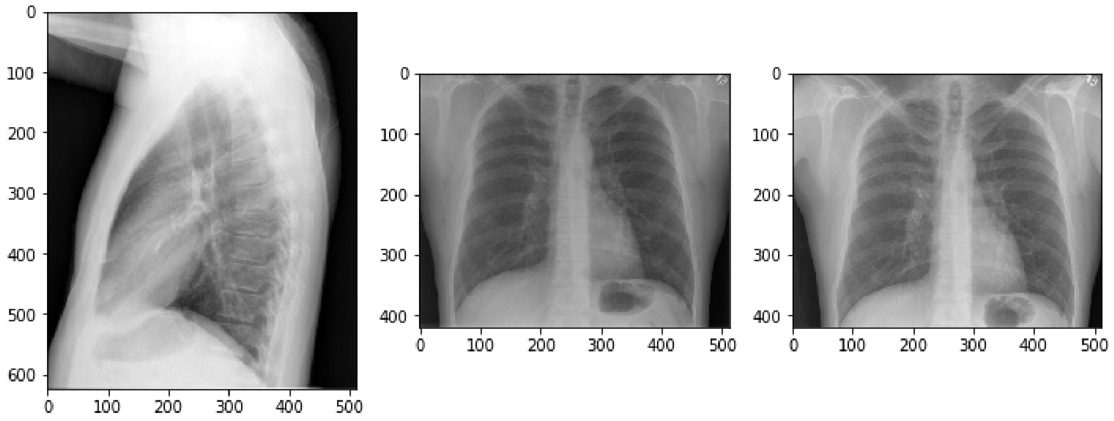


```
[78]: def test_img_cap(img_row):
          for i, row in img_row.iterrows():
              imgs = row["image_name"].split(',')
              fig, axs = plt.subplots(1, len(imgs), figsize = (10,10),␣
       ↪tight_layout=True)
              count = 0
              for img, subplot in zip(imgs, axs.flatten()):
                  img_=mpimg.imread("img/"+img)
                  imgplot = axs[count].imshow(img_, cmap = 'bone')
                  count +=1
              plt.show()

              print("Total Images present for this patient", len(imgs))
```

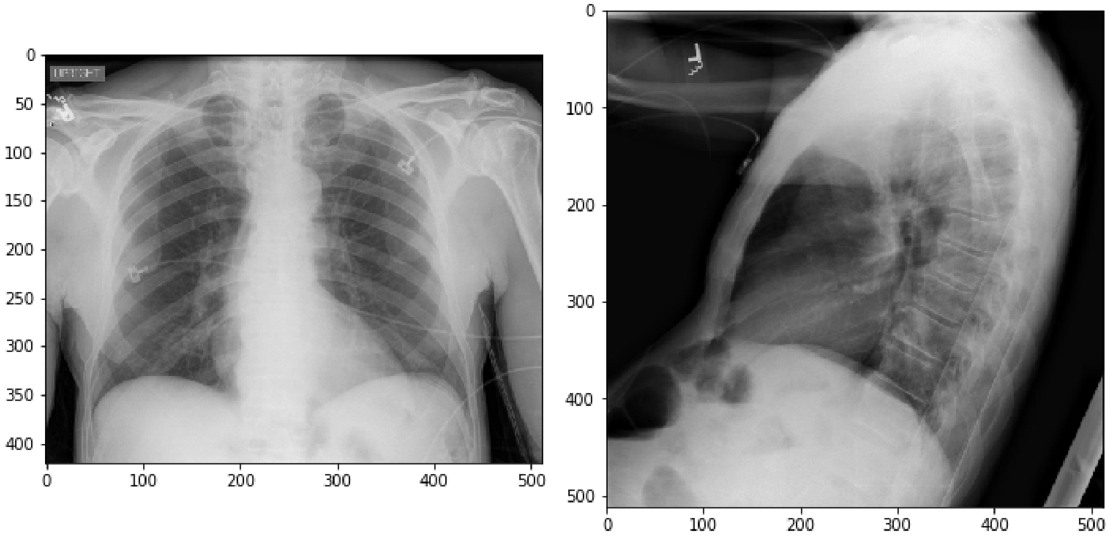
```
        print("="*100)
        print("Findings: Total No of words {} ".format(row['findings_count']))
        print(row['findings'])
        print("="*100)
        print("Impression: Total No of words {} ".
↪format(row['impression_count']))
        print(row['impression'])
        print("="*100)
```

6.1 visualizing the data row wise

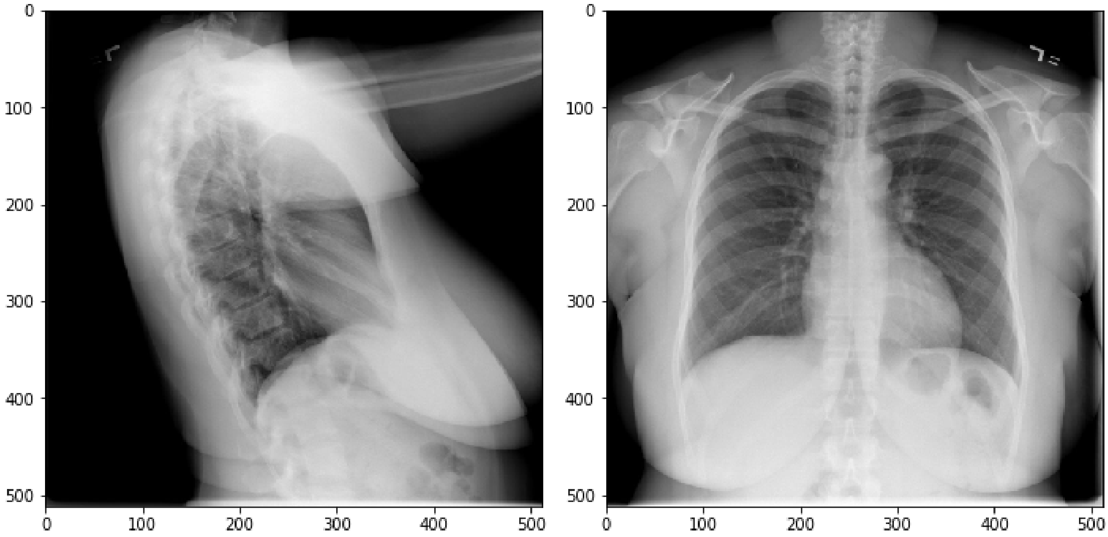
[80]:
```
test_img_cap(data[10:13])
```



```
Total Images present for this patient 3
================================================================================
====================
Findings: Total No of words 41
trachea is midline the cardiomediastinal silhouette is normal the lungs are
clear without evidence of acute infiltrate or effusion there is no pneumothorax
the visualized bony structures show no acute abnormalities lateral view reveals
mild degenerative changes of the thoracic spine
================================================================================
====================
Impression: Total No of words 4
no acute cardiopulmonary abnormalities
================================================================================
====================
```



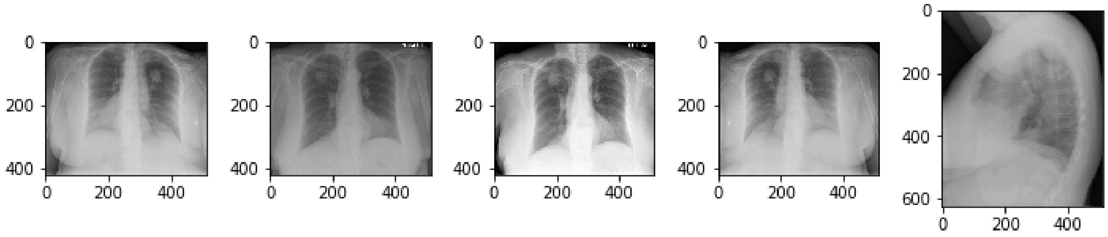
```
Total Images present for this patient 2
================================================================================
====================
Findings: Total No of words 26
heart size and mediastinal contours are normal in appearance no consolidative
airspace opacities no radiographic evidence of pleural effusion or pneumothorax
visualized osseous structures appear intact
================================================================================
====================
Impression: Total No of words 4
no acute cardiopulmonary abnormality
================================================================================
====================
```



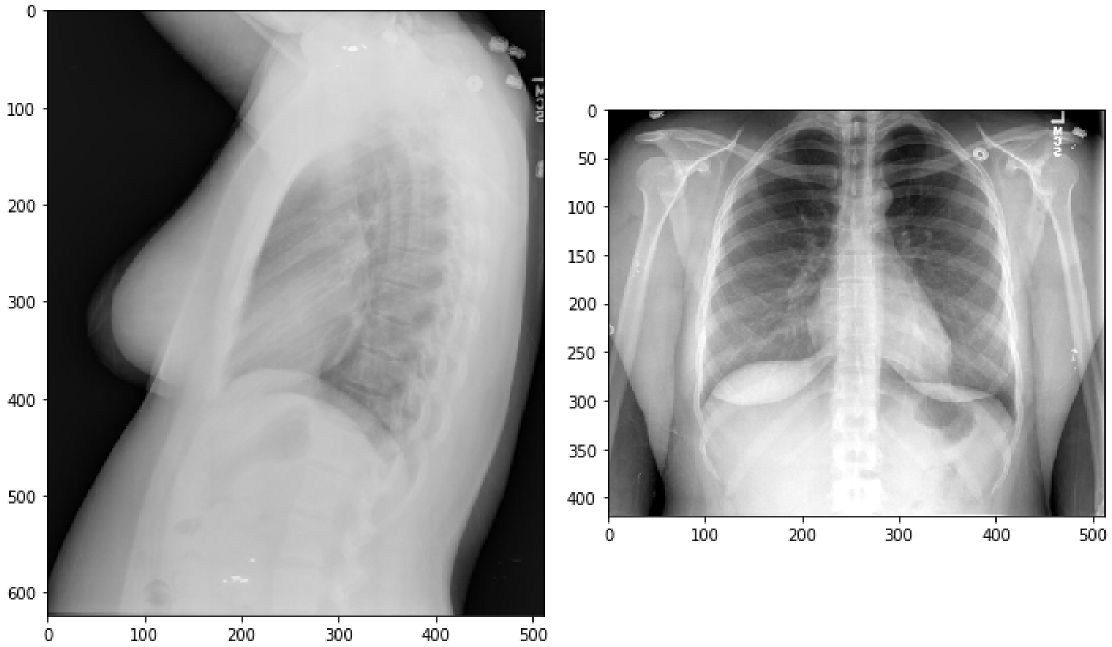
```
Total Images present for this patient 2
================================================================================
====================
Findings: Total No of words 24
the cardiomediastinal silhouette and pulmonary vasculature are within normal
limits there is no pneumothorax or pleural effusion there are no focal areas of
consolidation
================================================================================
====================
Impression: Total No of words 4
no acute cardiopulmonary abnormality
================================================================================
====================
```

[84]:

```
test_img_cap(data[324:326])
```



```
Total Images present for this patient 5
================================================================================
====================
Findings: Total No of words 75
in the interval a cm uncalcified mass has developed in the posterior segment of
the right upper lobe in addition on the pa view an mm opacity is adjacent to the
left of the heart this opacity cannot be well identified on the lateral view it
may be artifactual but another mass on the left cannot be excluded mediastinum
is normal with no evidence for adenopathy heart size normal note of an unchanged
hiatal hernia
================================================================================
====================
Impression: Total No of words 19
right upper lobe mass suspicious for neoplasm ct of chest abdomen and head would
be helpful for further evaluation
================================================================================
====================
```



```
Total Images present for this patient 2
================================================================================
====================
Findings: Total No of words 17
heart size normal lungs are clear are normal no pneumonia effusions edema
pneumothorax adenopathy nodules or masses
================================================================================
====================
Impression: Total No of words 2
normal chest
================================================================================
====================
```

7 6. Conclusion

- All the raw texts from xml files are parsed and created the dataset.
- Each patient have multiple x-rays associated with them.
- Major finding is the image sequence or number of images associated with each record.
- we have mostly of 2 images per record frontal and lateral. and also we have 3, 4, 5 images associated with each record.
- Other than findings All the features have few missing values.
- There are 543 missing values in findings.
- There is no missing files. We have total of 3955 records and 3 features (Comparison, Indication and Findings) and 1 Impression target variable.
- Most occurring words:

  - Indication: Chest pain
  - Findings: Pleural effusion
  - Impression: acute cardiopulmonary
- Images are in different shapes.
- All the X-Ray images are human upper body particularly about Chest part.
- In text features there are some unknown values like XXXX XXXXX these are replaced with empty string.

[ ]: