

Supplementary Material

Real-Time Classification of Causes of Death Using AI: Sensitivity Analysis

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Supplementary Material

Functions

Function to implement Westgard [17] rules for the definition of excess mortality periods

```
f.westgard <- function(z) {  
  a95 <- z > qnorm(1 - 0.05/2)  
  a99 <- z > qnorm(1 - 0.01/2)  
  turn_on <- a99 | (a95 & c(tail(a95, -1), NA)) | (a95 & c(FALSE, head(a95, -1)))  
  turn_off <- (!a95 & !c(tail(a95, -1), NA)) | (!a95 & !c(NA, head(a95, -1)))  
  
  state <- logical(length(turn_on))  
  state[1] <- turn_on[1]  
  for (i in 2:(length(state))) {  
    if (is.na(turn_on[i]) | is.na(turn_off[i])) {  
      state[i] <- NA  
    } else if (state[i - 1] & turn_off[i]) {  
      state[i] <- FALSE  
    } else if ( !state[i - 1] & turn_on[i]) {  
      state[i] <- TRUE  
    } else {  
      state[i] <- state[i - 1]  
    }  
  }  
  return(state)  
}
```

Whereas z is the z-score.

Function to implement Westgard rules for the definition of severe excess mortality periods (>4 SDs)

```
f.westgard <- function(z) {  
  plus4 <- z > 4  
  turn_on <- (plus4 & c(tail(plus4, -1), NA)) | (plus4 & c(FALSE, head(plus4, -1)))  
  turn_off <- (!plus4 & !c(tail(plus4, -1), NA)) | (!plus4 & !c(NA, head(plus4, -1)))  
  
  state <- logical(length(turn_on))  
  state[1] <- turn_on[1]  
  for (i in 2:(length(state))) {  
    if (is.na(turn_on[i]) | is.na(turn_off[i])) {  
      state[i] <- NA  
    } else if (state[i - 1] & turn_off[i]) {  
      state[i] <- FALSE  
    } else if ( !state[i - 1] & turn_on[i]) {  
      state[i] <- TRUE  
    } else {  
      state[i] <- state[i - 1]  
    }  
  }  
  return(state)  
}
```

Whereas z is the z-score.

Function to implement Westgard rules for the definition of extreme excess mortality periods (>6 SDs)

```
f.westgard <- function(z) {  
  plus6 <- z > 6  
  turn_on <- (plus6 & c(tail(plus6, -1), NA)) | (plus6 & c(FALSE, head(plus6, -1)))  
  turn_off <- (!plus6 & !c(tail(plus6, -1), NA)) | (!plus6 & !c(NA, head(plus6, -1)))  
  
  state <- logical(length(turn_on))  
  state[1] <- turn_on[1]  
  for (i in 2:(length(state))) {  
    if (is.na(turn_on[i]) | is.na(turn_off[i])) {  
      state[i] <- NA  
    } else if (state[i - 1] & turn_off[i]) {  
      state[i] <- FALSE  
    } else if ( !state[i - 1] & turn_on[i]) {  
      state[i] <- TRUE  
    } else {  
      state[i] <- state[i - 1]  
    }  
  }  
  return(state)  
}
```

Whereas z is the z-score.

Formula to calculate the weighted-average of performance metrics

$$\sum_{i=1}^N \mathbf{PF}_{class\ i} \times \mathbf{W}_{class\ i}$$

Where **PF** stands for the performance metric for each of the classes evaluated;
class stands either for the ICD-10 chapters or ICD-10 blocks;

And **W** stands for the number of true labels of each class, in our case, it stands for the **detection prevalence** calculated by the package “caret” [18, 19]

Performance metrics for classification algorithms

Supplementary Table 1 - Performance metrics calculated by the "confusionMatrix" function of the "caret" package

| | | Human Coders (GOLD-STANDARD) | |
|--|----------|--|---|
| | | Event | No Event |
| AUTOCOD | Event | True Positives (TP) | False Positives (FP) |
| | No Event | False Negatives (FN) | True Negatives (TN) |
| | | Sensitivity / Rate of TP $\frac{TP}{TP + FN}$ | Specificity $\frac{TN}{TN + FP}$ |
| Prevalence $\frac{TP + FN}{TP + FP + FN + TN}$ | | | |
| Positive Predictive Value $\frac{sensitivity \times prevalence}{((sensitivity \times prevalence) + (1 - specificity) \times (1 - prevalence))}$ | | | |
| Negative Predictive Value $\frac{specificity \times (1 - prevalence)}{((1 - sensitivity) \times prevalence) + (specificity) \times (1 - prevalence)}$ | | | |
| Balanced Accuracy $(sensitivity + specificity)/2$ | | | |
| | | Detection Rate $\frac{TP}{TP + FN + FP + TN}$ | Detection Prevalence $\frac{TP + FP}{TP + FN + FP + TN}$ |
| | | Precision $\frac{TP}{TP + FP}$ | Recall $\frac{TP}{TP + FN}$ |
| F1-Score $\frac{(1 + \beta^2) \times precision \times recall}{(\beta^2 \times precision) + recall}$ | | | |

ICD-10 chapter analysis

Performance metrics – global overview

Supplementary Table 2 - Performance Metrics of AUTOCOD, by chapter, for all the periods analyzed

| | I | | | | II | | | | III | | | | IV | | | | V | | | |
|-----|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|
| | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD |
| Sen | 0.67 | 0.67 | 0.67 | 0.65 | 0.95 | 0.95 | 0.94 | 0.95 | 0.57 | 0.55 | 0.58 | 0.41 | 0.81 | 0.81 | 0.81 | 0.82 | 0.77 | 0.78 | 0.78 | 0.77 |
| Spe | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.98 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 |
| PPV | 0.61 | 0.64 | 0.65 | 0.62 | 0.98 | 0.97 | 0.97 | 0.96 | 0.46 | 0.51 | 0.53 | 0.36 | 0.69 | 0.69 | 0.69 | 0.69 | 0.82 | 0.80 | 0.80 | 0.83 |
| NPV | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| F1 | 0.64 | 0.65 | 0.66 | 0.63 | 0.96 | 0.96 | 0.96 | 0.96 | 0.51 | 0.53 | 0.55 | 0.38 | 0.74 | 0.74 | 0.74 | 0.75 | 0.80 | 0.79 | 0.79 | 0.80 |
| Pre | 0.02 | 0.02 | 0.02 | 0.02 | 0.27 | 0.23 | 0.20 | 0.19 | 0.00 | 0.00 | 0.01 | 0.00 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 |
| DR | 0.01 | 0.01 | 0.01 | 0.01 | 0.26 | 0.21 | 0.19 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 |
| DP | 0.02 | 0.02 | 0.02 | 0.02 | 0.27 | 0.22 | 0.20 | 0.19 | 0.01 | 0.01 | 0.01 | 0.00 | 0.06 | 0.06 | 0.06 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 |
| BA | 0.83 | 0.83 | 0.83 | 0.82 | 0.97 | 0.97 | 0.97 | 0.97 | 0.79 | 0.78 | 0.79 | 0.70 | 0.89 | 0.90 | 0.89 | 0.90 | 0.88 | 0.89 | 0.88 | 0.88 |
| | VI | | | | VII | | | | VIII | | | | IX | | | | X | | | |
| | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD |
| Sen | 0.79 | 0.80 | 0.79 | 0.79 | 0.00 | 0.00 | NA | NA | 0.18 | 0.25 | 0.40 | NA | 0.91 | 0.91 | 0.91 | 0.91 | 0.90 | 0.89 | 0.90 | 0.89 |
| Spe | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.97 | 0.96 | 0.96 | 0.96 | 0.98 | 0.97 | 0.97 | 0.97 |
| PPV | 0.86 | 0.86 | 0.85 | 0.88 | NaN | NaN | NA | NA | 0.67 | 0.67 | 0.67 | NA | 0.92 | 0.91 | 0.91 | 0.90 | 0.83 | 0.85 | 0.86 | 0.86 |
| NPV | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | NA | NA | 1.00 | 1.00 | 1.00 | NA | 0.96 | 0.96 | 0.96 | 0.96 | 0.99 | 0.98 | 0.98 | 0.98 |
| F1 | 0.82 | 0.83 | 0.82 | 0.83 | NA | NA | NA | NA | 0.29 | 0.36 | 0.50 | NA | 0.91 | 0.91 | 0.91 | 0.91 | 0.86 | 0.87 | 0.88 | 0.88 |
| Pre | 0.04 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.30 | 0.31 | 0.31 | 0.11 | 0.14 | 0.16 | 0.16 |
| DR | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.28 | 0.28 | 0.28 | 0.10 | 0.13 | 0.14 | 0.15 |
| DP | 0.03 | 0.04 | 0.03 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.30 | 0.31 | 0.31 | 0.12 | 0.15 | 0.16 | 0.17 |
| BA | 0.90 | 0.90 | 0.89 | 0.89 | 0.50 | 0.50 | NA | NA | 0.59 | 0.63 | 0.70 | NA | 0.94 | 0.94 | 0.93 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 |
| | XI | | | | XII | | | | XIII | | | | XIV | | | | XV | | | |
| | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD |
| Sen | 0.80 | 0.79 | 0.76 | 0.76 | 0.28 | 0.35 | 0.40 | 0.20 | 0.42 | 0.42 | 0.42 | 0.32 | 0.76 | 0.76 | 0.76 | 0.74 | 0.00 | 0.00 | 0.00 | 0.00 |
| Spe | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| PPV | 0.85 | 0.85 | 0.83 | 0.85 | 0.47 | 0.56 | 0.54 | 0.33 | 0.61 | 0.61 | 0.56 | 0.50 | 0.76 | 0.75 | 0.76 | 0.76 | NaN | NaN | NA | NA |
| NPV | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.83 | 0.82 | 0.79 | 0.80 | 0.35 | 0.43 | 0.46 | 0.25 | 0.49 | 0.50 | 0.48 | 0.39 | 0.76 | 0.75 | 0.76 | 0.75 | NA | NA | NA | NA |
| Pre | 0.05 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| DR | 0.04 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| DP | 0.04 | 0.04 | 0.04 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| BA | 0.90 | 0.89 | 0.88 | 0.88 | 0.64 | 0.68 | 0.70 | 0.60 | 0.71 | 0.71 | 0.71 | 0.66 | 0.88 | 0.87 | 0.88 | 0.87 | 0.50 | 0.50 | 0.50 | 0.50 |
| | XVI | | | | XVII | | | | XVIII | | | | XIX | | | | XX | | | |
| | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD | No Excess | Excess Mort. | Severe >4SD | Extreme >6SD |
| Sen | 0.07 | 0.00 | 0.00 | NA | 0.39 | 0.34 | 0.32 | 0.20 | 0.93 | 0.93 | 0.92 | 0.90 | NA | 0.00 | 0.00 | NA | 0.79 | 0.76 | 0.75 | 0.00 |
| Spe | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| PPV | 1.00 | NaN | NA | NA | 0.76 | 0.71 | 0.71 | 0.67 | 0.88 | 0.88 | 0.88 | 0.88 | NA | NaN | NA | NA | 0.88 | 0.88 | 0.87 | 0.00 |
| NPV | 1.00 | 1.00 | 1.00 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | NA | 1.00 | 1.00 | NA | 0.99 | 0.99 | 0.99 | 0.00 |
| F1 | 0.12 | NA | NA | NA | 0.51 | 0.46 | 0.44 | 0.31 | 0.90 | 0.90 | 0.90 | 0.89 | NA | NA | NA | NA | 0.83 | 0.82 | 0.81 | 0.00 |
| Pre | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.06 | 0.06 | 0.07 | NA | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.00 |
| DR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.06 | 0.06 | NA | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 | 0.03 | 0.00 |
| DP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.06 | 0.06 | 0.07 | NA | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 | 0.04 | 0.00 |
| BA | 0.53 | 0.50 | 0.50 | NA | 0.69 | 0.67 | 0.66 | 0.60 | 0.96 | 0.96 | 0.96 | 0.94 | NA | 0.50 | 0.50 | NA | 0.89 | 0.88 | 0.87 | 0.00 |

Caption: Sen – Sensitivity; Spe – Specificity; PPV – Positive Predictive Value; NPV – Negative Predictive Value; F1 – F1-score; Pre – Prevalence; DR – Detection Rate; DP – Detection Prevalence; BA – Balanced Accuracy; I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality; NA – Missing values; NaN – not possible to calculate

Supplementary Table 3 - Average for performance metrics for different periods, for ICD-10's chapter classification of AUTOCOD

| | | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 score | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|--------------------------|-----------------|-------------|-------------|----------------|----------------|----------|------------|----------------|----------------------|-------------------|
| Weighted-averaged | No Excess Mort. | 0.88 | 0.98 | 0.88 | 0.98 | 0.88 | 0.18 | 0.17 | 0.18 | 0.93 |
| | Excess Mort. | 0.88 | 0.98 | 0.88 | 0.98 | 0.88 | 0.18 | 0.16 | 0.18 | 0.93 |
| | Severe >4 SD | 0.87 | 0.98 | 0.87 | 0.98 | 0.87 | 0.18 | 0.16 | 0.18 | 0.93 |
| | Extreme >6 SD | 0.85 | 0.94 | 0.84 | 0.94 | 0.84 | 0.17 | 0.16 | 0.17 | 0.89 |

All periods

Supplementary Table 4 – Distribution of death certificates in the dataset, according to source of classification

| Source | N | % |
|----------------|----------------|---------------|
| AUTOCOD | 330 098 | 50.00 |
| DGS | 330 098 | 50.00 |
| Total | 660 196 | 100.00 |

Supplementary Table 5 - Distribution of death certificates in the dataset, according to ICD-10 chapter (descendent order)

| Chapter | Chapter Description | N | % |
|--------------|--|----------------|---------------|
| IX | Diseases of the circulatory system | 97 420 | 29.51 |
| II | Neoplasms | 85 837 | 26.00 |
| X | Diseases of the respiratory system | 40 202 | 12.18 |
| IV | Endocrine, nutritional and metabolic diseases | 16 430 | 4.98 |
| XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 16 269 | 4.93 |
| XI | Diseases of the digestive system | 14 892 | 4.51 |
| XX | External causes of morbidity and mortality | 14 128 | 4.28 |
| V | Mental and behavioural disorders | 12 742 | 3.86 |
| VI | Diseases of the nervous system | 11 810 | 3.58 |
| XIV | Diseases of the genitourinary system | 10 277 | 3.11 |
| I | Certain infectious and parasitic diseases | 6 156 | 1.86 |
| XIII | Diseases of the musculoskeletal system and connective tissue | 1 397 | 0.42 |
| III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 1 334 | 0.40 |
| XII | Diseases of the skin and subcutaneous tissue | 583 | 0.18 |
| XVII | Congenital malformations, deformations and chromosomal abnormalities | 494 | 0.15 |
| XVI | Certain conditions originating in the perinatal period | 58 | 0.02 |
| XV | Pregnancy, childbirth and the puerperium | 35 | 0.01 |
| VIII | Diseases of the ear and mastoid process | 30 | 0.01 |
| VII | Diseases of the eye and adnexa | 2 | 0.00 |
| XIX | Injury, poisoning and certain other consequences of external causes | 2 | 0.00 |
| Total | | 330 098 | 100.00 |

Supplementary Table 6 - Distribution of death certificates according to year of death

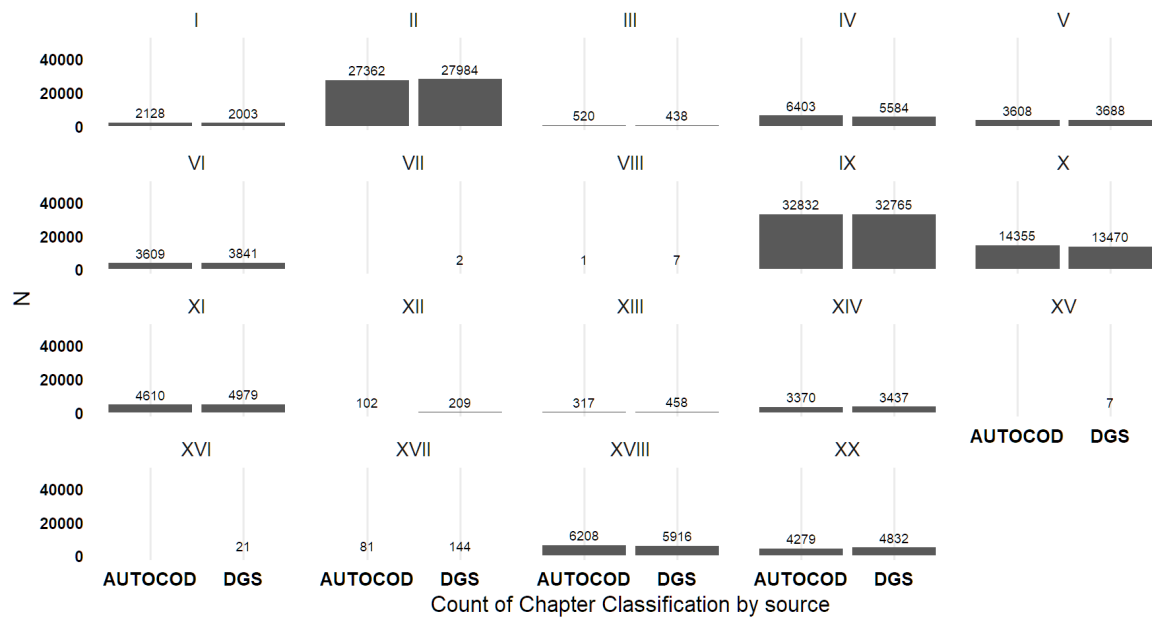
| Year of Death | N | % |
|---------------|----------------|--------------|
| 2016 | 109 785 | 33.26 |
| 2017 | 105 534 | 31.97 |
| 2018 | 107 467 | 32.56 |
| 2019 | 7 312 | 2.22 |
| Total | 330 098 | 100.0 |

Supplementary Table 7 - Distribution of death certificates, according to year of death and ICD-10 chapter

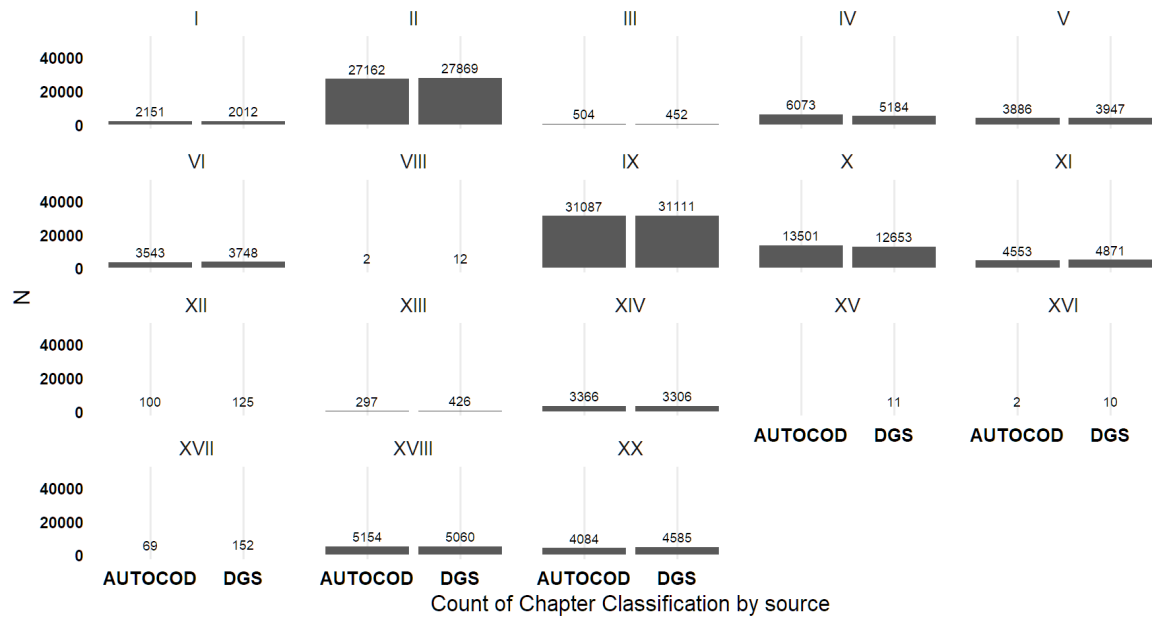
| Year of death | Chapter | Chapter Description | N | % |
|---------------|---------|--|--------|------|
| 2016 | IX | Diseases of the circulatory system | 32 765 | 9.93 |
| 2018 | IX | Diseases of the circulatory system | 31 262 | 9.47 |
| 2017 | IX | Diseases of the circulatory system | 31 111 | 9.42 |
| 2018 | II | Neoplasms | 28 293 | 8.57 |
| 2016 | II | Neoplasms | 27 984 | 8.48 |
| 2017 | II | Neoplasms | 27 869 | 8.44 |
| 2016 | X | Diseases of the respiratory system | 13 470 | 4.08 |
| 2018 | X | Diseases of the respiratory system | 13 114 | 3.97 |
| 2017 | X | Diseases of the respiratory system | 12 653 | 3.83 |
| 2016 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 5 916 | 1.79 |
| 2016 | IV | Endocrine, nutritional and metabolic diseases | 5 584 | 1.69 |
| 2018 | IV | Endocrine, nutritional and metabolic diseases | 5 310 | 1.61 |
| 2017 | IV | Endocrine, nutritional and metabolic diseases | 5 184 | 1.57 |
| 2017 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 5 060 | 1.53 |
| 2016 | XI | Diseases of the digestive system | 4 979 | 1.51 |
| 2018 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 4 943 | 1.50 |
| 2017 | XI | Diseases of the digestive system | 4 871 | 1.48 |
| 2016 | XX | External causes of morbidity and mortality | 4 832 | 1.46 |
| 2018 | V | Mental and behavioural disorders | 4 737 | 1.44 |
| 2018 | XI | Diseases of the digestive system | 4 721 | 1.43 |
| 2017 | XX | External causes of morbidity and mortality | 4 585 | 1.39 |
| 2018 | XX | External causes of morbidity and mortality | 4 431 | 1.34 |
| 2018 | VI | Diseases of the nervous system | 3 969 | 1.20 |
| 2017 | V | Mental and behavioural disorders | 3 947 | 1.20 |
| 2016 | VI | Diseases of the nervous system | 3 841 | 1.16 |
| 2017 | VI | Diseases of the nervous system | 3 748 | 1.14 |
| 2016 | V | Mental and behavioural disorders | 3 688 | 1.12 |
| 2016 | XIV | Diseases of the genitourinary system | 3 437 | 1.04 |
| 2018 | XIV | Diseases of the genitourinary system | 3 334 | 1.01 |
| 2017 | XIV | Diseases of the genitourinary system | 3 306 | 1.00 |
| 2019 | IX | Diseases of the circulatory system | 2 282 | 0.69 |
| 2017 | I | Certain infectious and parasitic diseases | 2 012 | 0.61 |
| 2018 | I | Certain infectious and parasitic diseases | 2 007 | 0.61 |
| 2016 | I | Certain infectious and parasitic diseases | 2 003 | 0.61 |
| 2019 | II | Neoplasms | 1 691 | 0.51 |
| 2019 | X | Diseases of the respiratory system | 965 | 0.29 |
| 2018 | XIII | Diseases of the musculoskeletal system and connective tissue | 479 | 0.15 |
| 2016 | XIII | Diseases of the musculoskeletal system and connective tissue | 458 | 0.14 |
| 2017 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 452 | 0.14 |
| 2016 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 438 | 0.13 |
| 2017 | XIII | Diseases of the musculoskeletal system and connective tissue | 426 | 0.13 |
| 2018 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 417 | 0.13 |
| 2019 | V | Mental and behavioural disorders | 370 | 0.11 |

Supplementary Table 8 - Distribution of death certificates, according to year of death and ICD-10 chapter (cont.)

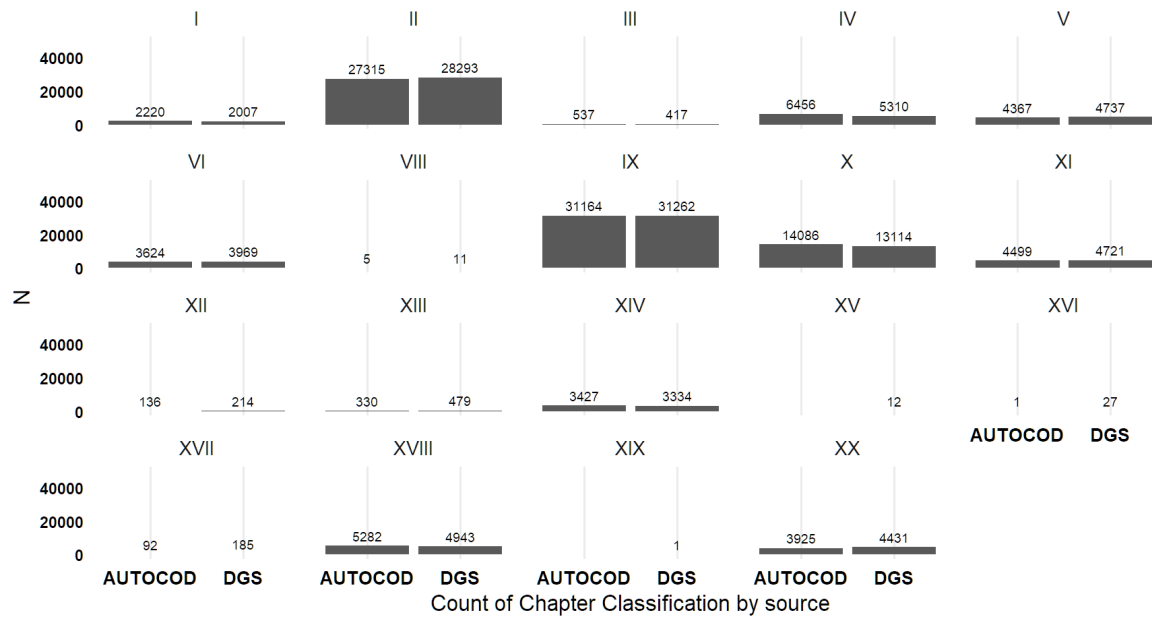
| Year of death | Chapter | Chapter Description | N | % |
|---------------|---------|--|----------------|---------------|
| 2019 | IV | Endocrine, nutritional and metabolic diseases | 352 | 0.11 |
| 2019 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 350 | 0.11 |
| 2019 | XI | Diseases of the digestive system | 321 | 0.10 |
| 2019 | XX | External causes of morbidity and mortality | 280 | 0.08 |
| 2019 | VI | Diseases of the nervous system | 252 | 0.08 |
| 2018 | XII | Diseases of the skin and subcutaneous tissue | 214 | 0.06 |
| 2016 | XII | Diseases of the skin and subcutaneous tissue | 209 | 0.06 |
| 2019 | XIV | Diseases of the genitourinary system | 200 | 0.06 |
| 2018 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 185 | 0.06 |
| 2017 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 152 | 0.05 |
| 2016 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 144 | 0.04 |
| 2019 | I | Certain infectious and parasitic diseases | 134 | 0.04 |
| 2017 | XII | Diseases of the skin and subcutaneous tissue | 125 | 0.04 |
| 2019 | XII | Diseases of the skin and subcutaneous tissue | 35 | 0.01 |
| 2019 | XIII | Diseases of the musculoskeletal system and connective tissue | 34 | 0.01 |
| 2018 | XVI | Certain conditions originating in the perinatal period | 27 | 0.01 |
| 2019 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 27 | 0.01 |
| 2016 | XVI | Certain conditions originating in the perinatal period | 21 | 0.01 |
| 2019 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 13 | 0.00 |
| 2017 | VIII | Diseases of the ear and mastoid process | 12 | 0.00 |
| 2018 | XV | Pregnancy, childbirth and the puerperium | 12 | 0.00 |
| 2017 | XV | Pregnancy, childbirth and the puerperium | 11 | 0.00 |
| 2018 | VIII | Diseases of the ear and mastoid process | 11 | 0.00 |
| 2017 | XVI | Certain conditions originating in the perinatal period | 10 | 0.00 |
| 2016 | VIII | Diseases of the ear and mastoid process | 7 | 0.00 |
| 2016 | XV | Pregnancy, childbirth and the puerperium | 7 | 0.00 |
| 2019 | XV | Pregnancy, childbirth and the puerperium | 5 | 0.00 |
| 2016 | VII | Diseases of the eye and adnexa | 2 | 0.00 |
| 2018 | XIX | Injury, poisoning and certain other consequences of external causes | 1 | 0.00 |
| 2019 | XIX | Injury, poisoning and certain other consequences of external causes | 1 | 0.00 |
| Total | | | 330 098 | 100.00 |



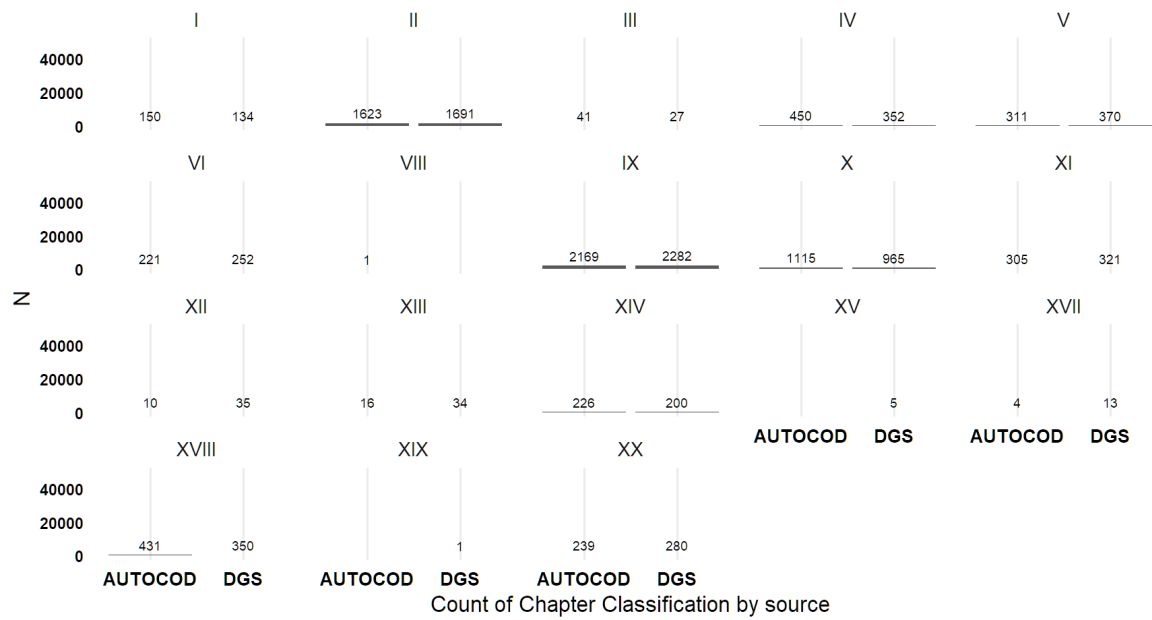
Supplementary Figure 1 - Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for the year 2016



Supplementary Figure 2 - Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for the year 2017



Supplementary Figure 3 - Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for the year 2018

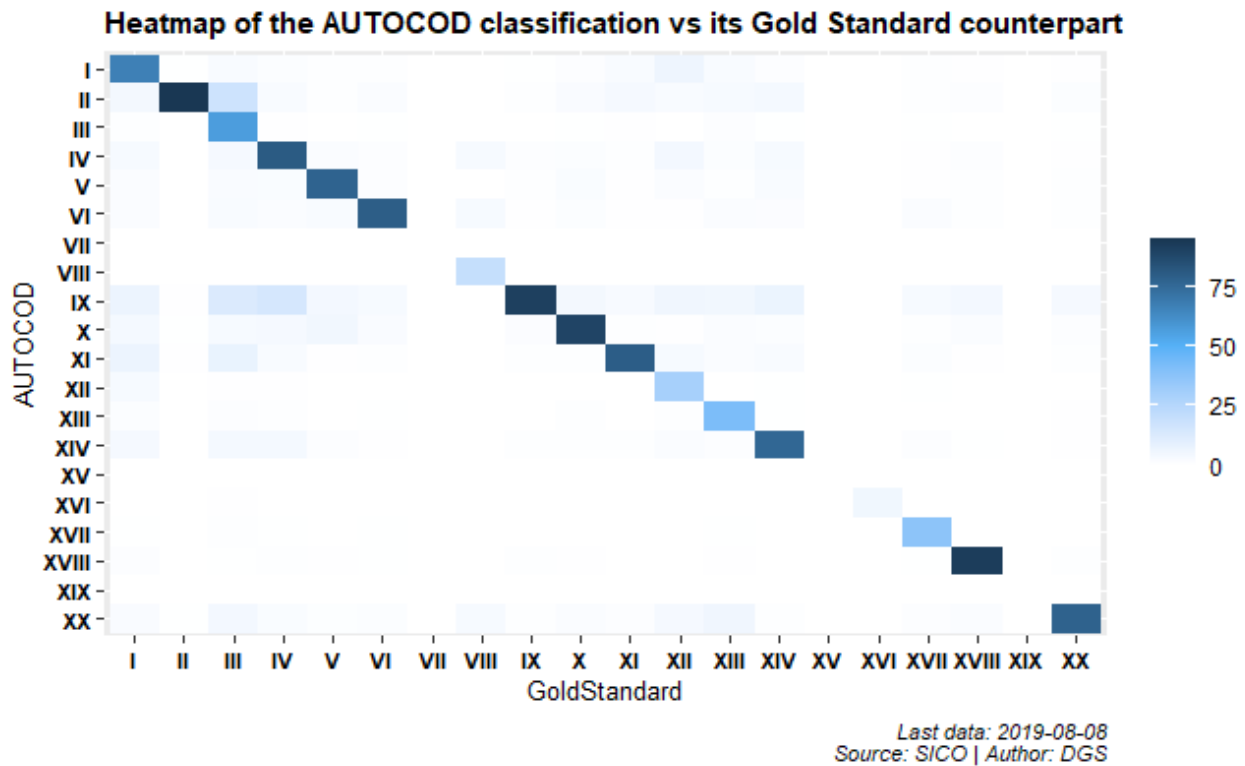


Supplementary Figure 4 - Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for the year 2019

Supplementary Table 9 - Confusion Matrix for all the period analysed

| | | Human Coders (gold-standard) | | | | | | | | | | | | | | | | | | | |
|---------|-------|------------------------------|------------|-----|------------|-----------|-----|-----|------|------------|------------|-----|-----|------|-----------|----|-----|------|------------|-----|------------|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX | XX |
| AUTOCOD | I | 4,11 9 | 271 | 48 | 192 | 116 | 115 | 0 | 2 | 406 | 235 | 414 | 189 | 78 | 229 | 0 | 6 | 17 | 70 | 0 | 142 |
| | II | 188 | 81,4 76 | 49 | 118 | 105 | 101 | 0 | 2 | 424 | 219 | 378 | 11 | 33 | 112 | 2 | 2 | 18 | 40 | 0 | 184 |
| | III | 31 | 234 | 757 | 47 | 29 | 33 | 0 | 2 | 171 | 44 | 102 | 6 | 15 | 53 | 2 | 7 | 8 | 4 | 0 | 57 |
| | IV | 233 | 436 | 58 | 13,2 79 | 325 | 291 | 0 | 6 | 2,41 3 | 595 | 412 | 54 | 131 | 656 | 5 | 8 | 41 | 103 | 0 | 336 |
| | V | 88 | 113 | 15 | 213 | 9,88 0 | 332 | 0 | 1 | 535 | 617 | 58 | 12 | 21 | 120 | 0 | 0 | 3 | 49 | 0 | 115 |
| | VI | 88 | 198 | 24 | 132 | 110 | 8 | 1 | 2 | 387 | 265 | 82 | 6 | 26 | 52 | 0 | 4 | 26 | 33 | 0 | 153 |
| | VII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VIII | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | IX | 254 | 838 | 138 | 1,18 3 | 788 | 469 | 0 | 4 | 88,8 83 | 1,56 5 | 741 | 58 | 157 | 674 | 19 | 3 | 97 | 564 | 0 | 817 |
| | X | 490 | 908 | 100 | 521 | 854 | 618 | 0 | 2 | 1,75 1 | 35,9 62 | 312 | 26 | 242 | 335 | 4 | 9 | 45 | 215 | 1 | 662 |
| | XI | 384 | 521 | 58 | 132 | 52 | 46 | 0 | 0 | 445 | 100 | 84 | 6 | 19 | 100 | 1 | 3 | 16 | 19 | 0 | 181 |
| | XII | 35 | 15 | 1 | 24 | 10 | 3 | 0 | 0 | 31 | 2 | 18 | 173 | 5 | 10 | 0 | 0 | 0 | 1 | 0 | 20 |
| | XIII | 35 | 43 | 13 | 20 | 12 | 24 | 0 | 1 | 69 | 27 | 26 | 2 | 583 | 16 | 1 | 2 | 4 | 6 | 0 | 76 |
| | XIV | 99 | 399 | 31 | 345 | 244 | 164 | 0 | 0 | 718 | 158 | 248 | 23 | 23 | 7,82 3 | 0 | 1 | 15 | 15 | 0 | 83 |
| | XV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| | XVII | 3 | 4 | 1 | 2 | 2 | 9 | 0 | 0 | 16 | 4 | 7 | 1 | 0 | 6 | 0 | 0 | 184 | 1 | 0 | 6 |
| | XVIII | 61 | 169 | 13 | 158 | 135 | 89 | 1 | 2 | 667 | 271 | 85 | 10 | 14 | 46 | 0 | 1 | 9 | 15,0 64 | 0 | 280 |
| | XIX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XX | 48 | 212 | 28 | 63 | 80 | 107 | 0 | 0 | 504 | 138 | 125 | 6 | 50 | 45 | 1 | 9 | 10 | 85 | 1 | 11,0 15 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality



Supplementary Figure 5 - Heatmap of the AUTOCOD classification vs its Gold Standard counterpart. Values (%) on the diagonal represent correct classifications

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Supplementary Table 10 - Overall performance metrics of AUTOCOD during all periods

| | |
|-----------------------|------|
| Accuracy | 0.88 |
| Kappa | 0.85 |
| AccuracyLower | 0.88 |
| AccuracyUpper | 0.88 |
| AccuracyNull | 0.30 |
| AccuracyPValue | 0.00 |

Supplementary Table 11 - Performance Metrics of AUTOCOD, by chapter, for all the periods analysed

| Chapter | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|---------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| I | 0.67 | 0.99 | 0.62 | 0.99 | 0.64 | 0.02 | 0.01 | 0.02 | 0.83 |
| II | 0.95 | 0.99 | 0.98 | 0.98 | 0.96 | 0.26 | 0.25 | 0.25 | 0.97 |
| III | 0.57 | 1.00 | 0.47 | 1.00 | 0.52 | 0.00 | 0.00 | 0.01 | 0.78 |
| IV | 0.81 | 0.98 | 0.69 | 0.99 | 0.74 | 0.05 | 0.04 | 0.06 | 0.89 |
| V | 0.78 | 0.99 | 0.81 | 0.99 | 0.79 | 0.04 | 0.03 | 0.04 | 0.88 |
| VI | 0.80 | 1.00 | 0.86 | 0.99 | 0.83 | 0.04 | 0.03 | 0.03 | 0.90 |
| VII | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| VIII | 0.20 | 1.00 | 0.67 | 1.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.60 |
| IX | 0.91 | 0.96 | 0.91 | 0.96 | 0.91 | 0.30 | 0.27 | 0.30 | 0.94 |
| X | 0.90 | 0.98 | 0.84 | 0.99 | 0.86 | 0.12 | 0.11 | 0.13 | 0.94 |
| XI | 0.80 | 0.99 | 0.85 | 0.99 | 0.82 | 0.05 | 0.04 | 0.04 | 0.90 |
| XII | 0.30 | 1.00 | 0.50 | 1.00 | 0.37 | 0.00 | 0.00 | 0.00 | 0.65 |
| XIII | 0.42 | 1.00 | 0.61 | 1.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.71 |
| XIV | 0.76 | 0.99 | 0.75 | 0.99 | 0.76 | 0.03 | 0.02 | 0.03 | 0.88 |
| XV | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XVI | 0.05 | 1.00 | 1.00 | 1.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.53 |
| XVII | 0.37 | 1.00 | 0.75 | 1.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.69 |
| XVIII | 0.93 | 0.99 | 0.88 | 1.00 | 0.90 | 0.05 | 0.05 | 0.05 | 0.96 |
| XIX | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XX | 0.78 | 1.00 | 0.88 | 0.99 | 0.83 | 0.04 | 0.03 | 0.04 | 0.89 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Periods of excess mortality

Supplementary Table 12 - Distribution of death certificates in the dataset, according to source of classification, for the periods of excess mortality

| Source | N | % |
|----------------|----------------|---------------|
| AUTOCOD | 93 417 | 50.00 |
| DGS | 93 417 | 50.00 |
| Total | 186 834 | 100.00 |

Supplementary Table 13 - Distribution of death certificates in the dataset, according to ICD-10 chapter (descendent order), for the periods of excess mortality

| Chapter | Chapter Description | N | % |
|--------------|--|---------------|---------------|
| IX | Diseases of the circulatory system | 28 399 | 30.40 |
| II | Neoplasms | 21 136 | 22.63 |
| X | Diseases of the respiratory system | 13 466 | 14.41 |
| XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 5 197 | 5.56 |
| IV | Endocrine, nutritional and metabolic diseases | 4 793 | 5.13 |
| XI | Diseases of the digestive system | 3 893 | 4.17 |
| V | Mental and behavioural disorders | 3 756 | 4.02 |
| XX | External causes of morbidity and mortality | 3 631 | 3.89 |
| VI | Diseases of the nervous system | 3 456 | 3.70 |
| XIV | Diseases of the genitourinary system | 2 851 | 3.05 |
| I | Certain infectious and parasitic diseases | 1 696 | 1.82 |
| III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 418 | 0.45 |
| XIII | Diseases of the musculoskeletal system and connective tissue | 406 | 0.43 |
| XII | Diseases of the skin and subcutaneous tissue | 153 | 0.16 |
| XVII | Congenital malformations, deformations and chromosomal abnormalities | 137 | 0.15 |
| XVI | Certain conditions originating in the perinatal period | 12 | 0.01 |
| VIII | Diseases of the ear and mastoid process | 8 | 0.01 |
| XV | Pregnancy, childbirth and the puerperium | 6 | 0.01 |
| XIX | Injury, poisoning and certain other consequences of external causes | 2 | 0.00 |
| VII | Diseases of the eye and adnexa | 1 | 0.00 |
| Total | | 93 417 | 100.00 |

Supplementary Table 14 - Distribution of death certificates according to year of death, for the periods of excess mortality

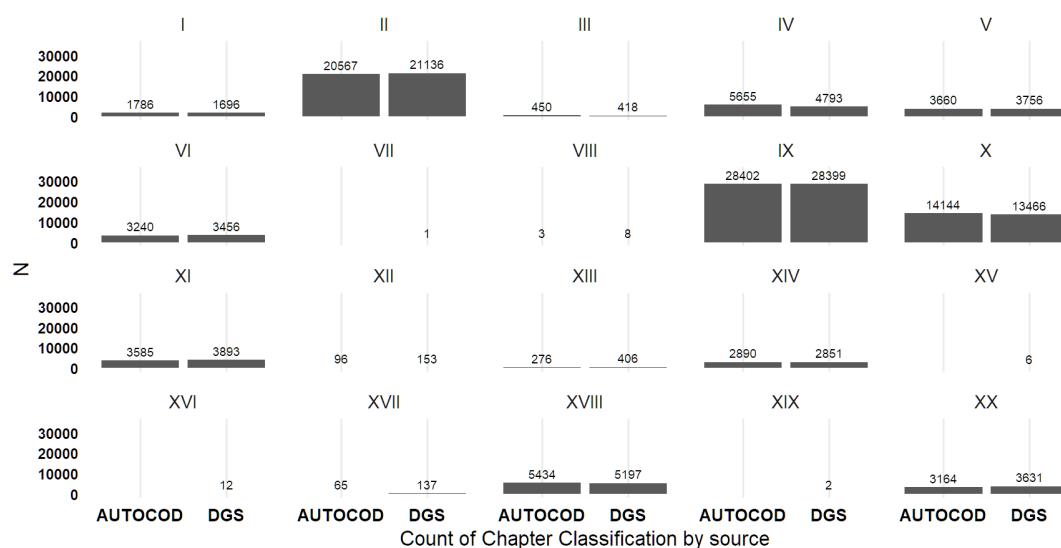
| Year of Death | N | % |
|---------------|---------------|---------------|
| 2016 | 29 381 | 31.45 |
| 2017 | 30 263 | 32.40 |
| 2018 | 29 624 | 31.71 |
| 2019 | 4 149 | 4.44 |
| Total | 93 417 | 100.00 |

Supplementary Table 15 - Distribution of death certificates, according to year of death and ICD-10 chapter, for the periods of excess mortality

| Year of Death | Chapter | Chapter Description | N | % |
|---------------|---------|--|-------|------|
| 2017 | IX | Diseases of the circulatory system | 9 294 | 9.95 |
| 2018 | IX | Diseases of the circulatory system | 8 975 | 9.61 |
| 2016 | IX | Diseases of the circulatory system | 8 786 | 9.41 |
| 2016 | II | Neoplasms | 7 048 | 7.54 |
| 2017 | II | Neoplasms | 6 611 | 7.08 |
| 2018 | II | Neoplasms | 6 569 | 7.03 |
| 2018 | X | Diseases of the respiratory system | 4 574 | 4.90 |
| 2017 | X | Diseases of the respiratory system | 4 358 | 4.67 |
| 2016 | X | Diseases of the respiratory system | 3 960 | 4.24 |
| 2016 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 1 730 | 1.85 |
| 2017 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 1 725 | 1.85 |
| 2018 | IV | Endocrine, nutritional and metabolic diseases | 1 573 | 1.68 |
| 2017 | IV | Endocrine, nutritional and metabolic diseases | 1 562 | 1.67 |
| 2018 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 1 540 | 1.65 |
| 2016 | IV | Endocrine, nutritional and metabolic diseases | 1 479 | 1.58 |
| 2019 | IX | Diseases of the circulatory system | 1 344 | 1.44 |
| 2016 | XI | Diseases of the digestive system | 1 310 | 1.40 |
| 2018 | V | Mental and behavioural disorders | 1 244 | 1.33 |
| 2017 | XI | Diseases of the digestive system | 1 241 | 1.33 |
| 2017 | V | Mental and behavioural disorders | 1 221 | 1.31 |
| 2017 | XX | External causes of morbidity and mortality | 1 192 | 1.28 |
| 2016 | XX | External causes of morbidity and mortality | 1 175 | 1.26 |
| 2017 | VI | Diseases of the nervous system | 1 171 | 1.25 |
| 2018 | XI | Diseases of the digestive system | 1 161 | 1.24 |
| 2018 | XX | External causes of morbidity and mortality | 1 119 | 1.20 |
| 2018 | VI | Diseases of the nervous system | 1 073 | 1.15 |
| 2016 | V | Mental and behavioural disorders | 1 071 | 1.15 |
| 2016 | VI | Diseases of the nervous system | 1 065 | 1.14 |
| 2017 | XIV | Diseases of the genitourinary system | 938 | 1.00 |
| 2018 | XIV | Diseases of the genitourinary system | 925 | 0.99 |
| 2019 | II | Neoplasms | 908 | 0.97 |
| 2016 | XIV | Diseases of the genitourinary system | 873 | 0.93 |
| 2017 | I | Certain infectious and parasitic diseases | 574 | 0.61 |
| 2019 | X | Diseases of the respiratory system | 574 | 0.61 |
| 2016 | I | Certain infectious and parasitic diseases | 528 | 0.57 |
| 2018 | I | Certain infectious and parasitic diseases | 520 | 0.56 |
| 2019 | V | Mental and behavioural disorders | 220 | 0.24 |
| 2019 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 202 | 0.22 |
| 2019 | XI | Diseases of the digestive system | 181 | 0.19 |
| 2019 | IV | Endocrine, nutritional and metabolic diseases | 179 | 0.19 |
| 2017 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 150 | 0.16 |
| 2019 | VI | Diseases of the nervous system | 147 | 0.16 |

Supplementary Table 16 - Distribution of death certificates, according to year of death and ICD-10 chapter, for the periods of excess mortality (cont.)

| Year of Death | Chapter | Chapter Description | N | % |
|---------------|---------|--|---------------|---------------|
| 2019 | XX | External causes of morbidity and mortality | 145 | 0.16 |
| 2017 | XIII | Diseases of the musculoskeletal system and connective tissue | 139 | 0.15 |
| 2016 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 130 | 0.14 |
| 2018 | XIII | Diseases of the musculoskeletal system and connective tissue | 128 | 0.14 |
| 2018 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 126 | 0.13 |
| 2016 | XIII | Diseases of the musculoskeletal system and connective tissue | 120 | 0.13 |
| 2019 | XIV | Diseases of the genitourinary system | 115 | 0.12 |
| 2019 | I | Certain infectious and parasitic diseases | 74 | 0.08 |
| 2016 | XII | Diseases of the skin and subcutaneous tissue | 52 | 0.06 |
| 2017 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 49 | 0.05 |
| 2018 | XII | Diseases of the skin and subcutaneous tissue | 48 | 0.05 |
| 2016 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 45 | 0.05 |
| 2018 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 37 | 0.04 |
| 2017 | XII | Diseases of the skin and subcutaneous tissue | 34 | 0.04 |
| 2019 | XII | Diseases of the skin and subcutaneous tissue | 19 | 0.02 |
| 2019 | XIII | Diseases of the musculoskeletal system and connective tissue | 19 | 0.02 |
| 2019 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 12 | 0.01 |
| 2016 | XVI | Certain conditions originating in the perinatal period | 6 | 0.01 |
| 2018 | XVI | Certain conditions originating in the perinatal period | 6 | 0.01 |
| 2019 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 6 | 0.01 |
| 2018 | VIII | Diseases of the ear and mastoid process | 5 | 0.01 |
| 2019 | XV | Pregnancy, childbirth and the puerperium | 3 | 0.00 |
| 2017 | VIII | Diseases of the ear and mastoid process | 2 | 0.00 |
| 2017 | XV | Pregnancy, childbirth and the puerperium | 2 | 0.00 |
| 2016 | VII | Diseases of the eye and adnexa | 1 | 0.00 |
| 2016 | VIII | Diseases of the ear and mastoid process | 1 | 0.00 |
| 2016 | XV | Pregnancy, childbirth and the puerperium | 1 | 0.00 |
| 2018 | XIX | Injury, poisoning and certain other consequences of external causes | 1 | 0.00 |
| 2019 | XIX | Injury, poisoning and certain other consequences of external causes | 1 | 0.00 |
| Total | | | 93 417 | 100.00 |

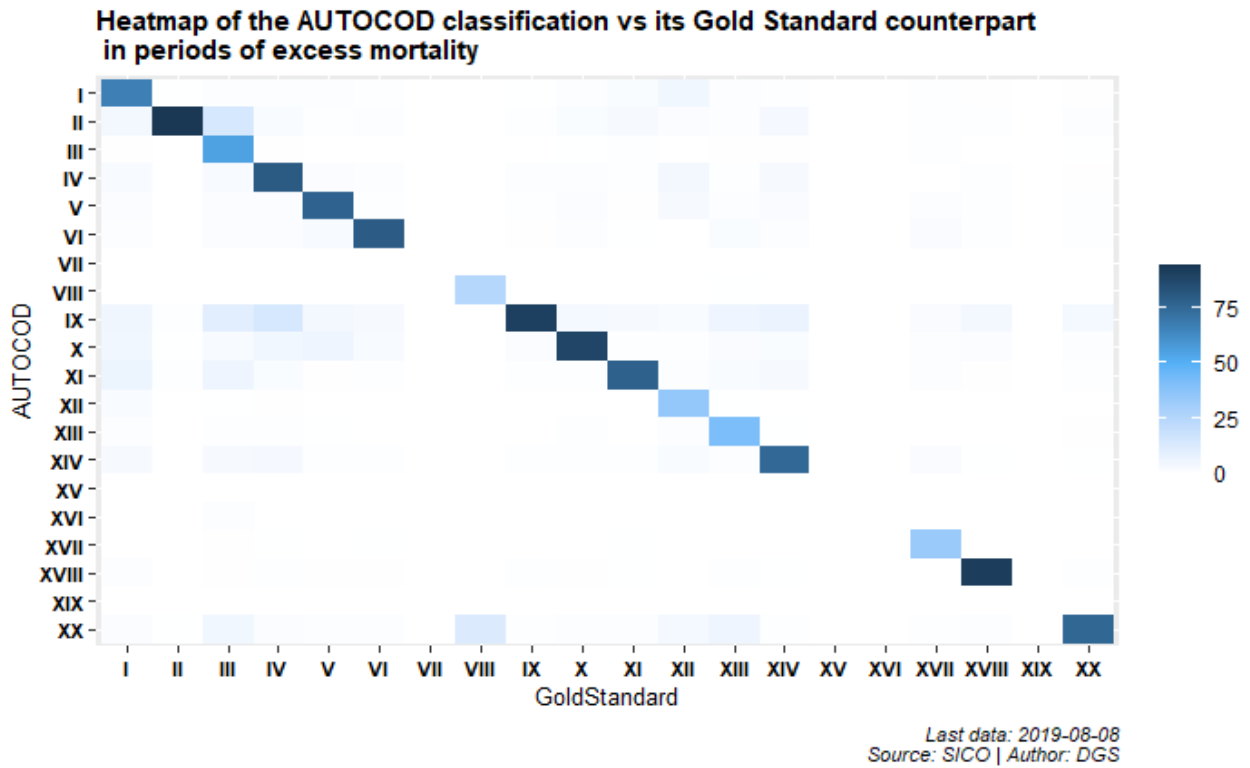


Supplementary Figure 6 – Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for periods of excess mortality

Supplementary Table 17 - Confusion Matrix for the excess mortality periods

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | |
|---------|-------|------------------------------|-----------|---------|----------|----------|----------|-----|------|-----------|-----------|----------|--------|---------|----------|----|-----|------|-------|-----|----------|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX | XX |
| AUTOCOD | I | 113 5 | 76 | 8 | 51 | 27 | 23 | 0 | 0 | 93 | 87 | 113 | 4 1 | 18 | 57 | 0 | 2 | 3 | 23 | 0 | 29 |
| | II | 38 | 1999 0 | 20 | 36 | 19 | 32 | 0 | 1 | 143 | 64 | 114 | 2 | 9 | 32 | 0 | 0 | 7 | 9 | 0 | 51 |
| | III | 4 | 61 | 23 1 | 12 | 8 | 8 | 0 | 0 | 43 | 12 | 25 | 1 | 3 | 13 | 0 | 4 | 2 | 2 | 0 | 21 |
| | IV | 70 | 120 | 23 | 388 0 | 94 | 82 | 0 | 2 | 698 | 231 | 99 | 2 1 | 33 | 171 | 0 | 0 | 10 | 31 | 0 | 90 |
| | V | 39 | 23 | 6 | 69 | 292 4 | 107 | 0 | 1 | 157 | 226 | 14 | 2 | 8 | 34 | 0 | 0 | 2 | 13 | 0 | 35 |
| | VI | 26 | 47 | 4 | 35 | 31 | 277 4 | 1 | 0 | 112 | 99 | 21 | 3 | 5 | 19 | 0 | 0 | 7 | 13 | 0 | 43 |
| | VII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VIII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | IX | 81 | 222 | 45 | 361 | 245 | 139 | 0 | 0 | 2588 2 | 517 | 205 | 1 6 | 43 | 207 | 4 | 0 | 32 | 183 | 0 | 220 |
| | X | 147 | 271 | 31 | 157 | 253 | 176 | 0 | 1 | 546 | 1199 3 | 96 | 4 | 85 | 94 | 2 | 4 | 12 | 72 | 1 | 199 |
| | XI | 80 | 120 | 23 | 27 | 15 | 9 | 0 | 0 | 125 | 29 | 305 8 | 0 | 4 | 29 | 0 | 1 | 8 | 9 | 0 | 48 |
| | XII | 8 | 3 | 0 | 7 | 5 | 0 | 0 | 0 | 4 | 1 | 2 | 5 4 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 6 |
| | XIII | 6 | 6 | 2 | 3 | 5 | 8 | 0 | 1 | 24 | 9 | 10 | 1 | 16 9 | 5 | 0 | 0 | 0 | 3 | 0 | 24 |
| | XIV | 22 | 106 | 10 | 96 | 62 | 39 | 0 | 0 | 216 | 57 | 88 | 3 | 7 | 215 8 | 0 | 0 | 3 | 6 | 0 | 17 |
| | XV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVII | 1 | 1 | 1 | 0 | 2 | 3 | 0 | 0 | 3 | 2 | 2 | 0 | 0 | 3 | 0 | 0 | 46 | 0 | 0 | 1 |
| | XVIII | 26 | 45 | 7 | 45 | 44 | 29 | 0 | 0 | 216 | 98 | 18 | 3 | 2 | 14 | 0 | 1 | 2 | 4806 | 0 | 78 |
| | XIX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XX | 13 | 45 | 7 | 14 | 22 | 27 | 0 | 0 | 137 | 41 | 28 | 2 | 18 | 11 | 0 | 0 | 3 | 27 | 1 | 276 8 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality



Supplementary Figure 7 - Heatmap of the AUTOCOD classification vs its Gold Standard counterpart in periods of excess mortality. Values on the diagonal represent correct classifications.

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Supplementary Table 18 - Overall performance metrics of AUTOCOD during excess mortality periods

| | |
|-----------------------|------|
| Accuracy | 0.88 |
| Kappa | 0.85 |
| AccuracyLower | 0.87 |
| AccuracyUpper | 0.88 |
| AccuracyNull | 0.30 |
| AccuracyPValue | 0.00 |

Supplementary Table 19 - Performance Metrics of AUTOCOD, by class, for the excess mortality periods

| Chapter | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|--------------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| I | 0.67 | 0.99 | 0.64 | 0.99 | 0.65 | 0.02 | 0.01 | 0.02 | 0.83 |
| II | 0.95 | 0.99 | 0.97 | 0.98 | 0.96 | 0.23 | 0.21 | 0.22 | 0.97 |
| III | 0.55 | 1.00 | 0.51 | 1.00 | 0.53 | 0.00 | 0.00 | 0.01 | 0.78 |
| IV | 0.81 | 0.98 | 0.69 | 0.99 | 0.74 | 0.05 | 0.04 | 0.06 | 0.90 |
| V | 0.78 | 0.99 | 0.80 | 0.99 | 0.79 | 0.04 | 0.03 | 0.04 | 0.89 |
| VI | 0.80 | 1.00 | 0.86 | 0.99 | 0.83 | 0.04 | 0.03 | 0.04 | 0.90 |
| VII | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| VIII | 0.25 | 1.00 | 0.67 | 1.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.63 |
| IX | 0.91 | 0.96 | 0.91 | 0.96 | 0.91 | 0.30 | 0.28 | 0.30 | 0.94 |
| X | 0.89 | 0.97 | 0.85 | 0.98 | 0.87 | 0.14 | 0.13 | 0.15 | 0.93 |
| XI | 0.79 | 0.99 | 0.85 | 0.99 | 0.82 | 0.04 | 0.03 | 0.04 | 0.89 |
| XII | 0.35 | 1 | 0.56 | 1 | 0.43 | 0 | 0 | 0 | 0.68 |
| XIII | 0.42 | 1 | 0.61 | 1 | 0.5 | 0 | 0 | 0 | 0.71 |
| XIV | 0.76 | 0.99 | 0.75 | 0.99 | 0.75 | 0.03 | 0.02 | 0.03 | 0.87 |
| XV | 0 | 1 | NaN | 1 | NA | 0 | 0 | 0 | 0.5 |
| XVI | 0 | 1 | NaN | 1 | NA | 0 | 0 | 0 | 0.5 |
| XVII | 0.34 | 1 | 0.71 | 1 | 0.46 | 0 | 0 | 0 | 0.67 |
| XVIII | 0.93 | 0.99 | 0.88 | 1 | 0.9 | 0.06 | 0.05 | 0.06 | 0.96 |
| XIX | 0 | 1 | NaN | 1 | NA | 0 | 0 | 0 | 0.5 |
| XX | 0.76 | 1 | 0.88 | 0.99 | 0.82 | 0.04 | 0.03 | 0.03 | 0.88 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Periods without excess mortality

Supplementary Table 20 - Distribution of death certificates in the dataset, according to source of classification, for the periods without excess mortality

| Source | N | % |
|----------------|----------------|---------------|
| AUTOCOD | 236 681 | 50.00 |
| DGS | 236 681 | 50.00 |
| Total | 473 362 | 100.00 |

Supplementary Table 21 - Distribution of death certificates in the dataset, according to ICD-10 chapter (descendent order), for the periods without excess mortality

| Chapter | Chapter Description | N | % |
|--------------|--|----------------|---------------|
| IX | Diseases of the circulatory system | 69 021 | 29.16 |
| II | Neoplasms | 64 701 | 27.34 |
| X | Diseases of the respiratory system | 26 736 | 11.30 |
| IV | Endocrine, nutritional and metabolic diseases | 11 637 | 4.92 |
| XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 11 072 | 4.68 |
| XI | Diseases of the digestive system | 10 999 | 4.65 |
| XX | External causes of morbidity and mortality | 10 497 | 4.44 |
| V | Mental and behavioural disorders | 8 986 | 3.80 |
| VI | Diseases of the nervous system | 8 354 | 3.53 |
| XIV | Diseases of the genitourinary system | 7 426 | 3.14 |
| I | Certain infectious and parasitic diseases | 4 460 | 1.88 |
| XIII | Diseases of the musculoskeletal system and connective tissue | 991 | 0.42 |
| III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 916 | 0.39 |
| XII | Diseases of the skin and subcutaneous tissue | 430 | 0.18 |
| XVII | Congenital malformations, deformations and chromosomal abnormalities | 357 | 0.15 |
| XVI | Certain conditions originating in the perinatal period | 46 | 0.02 |
| XV | Pregnancy, childbirth and the puerperium | 29 | 0.01 |
| VIII | Diseases of the ear and mastoid process | 22 | 0.01 |
| VII | Diseases of the eye and adnexa | 1 | 0.00 |
| Total | | 236 681 | 100.00 |

Supplementary Table 22 - Distribution of death certificates according to year of death, for the periods without excess mortality

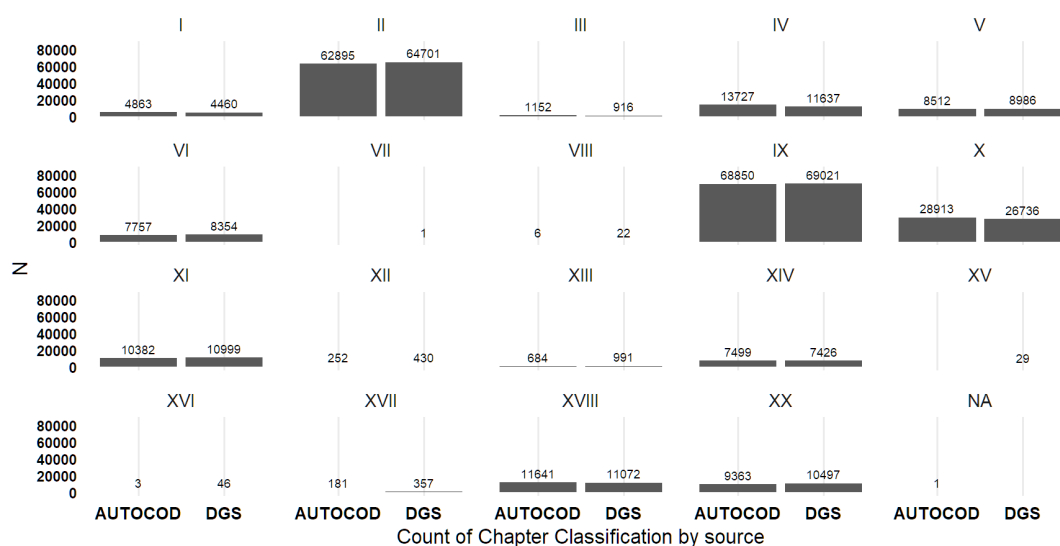
| Year of Death | N | % |
|---------------|----------------|---------------|
| 2016 | 80 404 | 33.97 |
| 2017 | 75 271 | 31.80 |
| 2018 | 77 843 | 32.89 |
| 2019 | 3 163 | 1.34 |
| Total | 236 681 | 100.00 |

Supplementary Table 23 - Distribution of death certificates, according to year of death and ICD-10 chapter, for the periods without excess mortality

| Year of Death | Chapter | Chapter Description | N | % |
|---------------|---------|--|--------|-------|
| 2016 | IX | Diseases of the circulatory system | 23 979 | 10.13 |
| 2018 | IX | Diseases of the circulatory system | 22 287 | 9.42 |
| 2017 | IX | Diseases of the circulatory system | 21 817 | 9.22 |
| 2018 | II | Neoplasms | 21 724 | 9.18 |
| 2017 | II | Neoplasms | 21 258 | 8.98 |
| 2016 | II | Neoplasms | 20 936 | 8.85 |
| 2016 | X | Diseases of the respiratory system | 9 510 | 4.02 |
| 2018 | X | Diseases of the respiratory system | 8 540 | 3.61 |
| 2017 | X | Diseases of the respiratory system | 8 295 | 3.50 |
| 2016 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 4 186 | 1.77 |
| 2016 | IV | Endocrine, nutritional and metabolic diseases | 4 105 | 1.73 |
| 2018 | IV | Endocrine, nutritional and metabolic diseases | 3 737 | 1.58 |
| 2016 | XI | Diseases of the digestive system | 3 669 | 1.55 |
| 2016 | XX | External causes of morbidity and mortality | 3 657 | 1.55 |
| 2017 | XI | Diseases of the digestive system | 3 630 | 1.53 |
| 2017 | IV | Endocrine, nutritional and metabolic diseases | 3 622 | 1.53 |
| 2018 | XI | Diseases of the digestive system | 3 560 | 1.50 |
| 2018 | V | Mental and behavioural disorders | 3 493 | 1.48 |
| 2018 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 3 403 | 1.44 |
| 2017 | XX | External causes of morbidity and mortality | 3 393 | 1.43 |
| 2017 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 3 335 | 1.41 |
| 2018 | XX | External causes of morbidity and mortality | 3 312 | 1.40 |
| 2018 | VI | Diseases of the nervous system | 2 896 | 1.22 |
| 2016 | VI | Diseases of the nervous system | 2 776 | 1.17 |
| 2017 | V | Mental and behavioural disorders | 2 726 | 1.15 |
| 2016 | V | Mental and behavioural disorders | 2 617 | 1.11 |
| 2017 | VI | Diseases of the nervous system | 2 577 | 1.09 |
| 2016 | XIV | Diseases of the genitourinary system | 2 564 | 1.08 |
| 2018 | XIV | Diseases of the genitourinary system | 2 409 | 1.02 |
| 2017 | XIV | Diseases of the genitourinary system | 2 368 | 1.00 |
| 2018 | I | Certain infectious and parasitic diseases | 1 487 | 0.63 |
| 2016 | I | Certain infectious and parasitic diseases | 1 475 | 0.62 |
| 2017 | I | Certain infectious and parasitic diseases | 1 438 | 0.61 |
| 2019 | IX | Diseases of the circulatory system | 938 | 0.40 |
| 2019 | II | Neoplasms | 783 | 0.33 |
| 2019 | X | Diseases of the respiratory system | 391 | 0.17 |
| 2018 | XIII | Diseases of the musculoskeletal system and connective tissue | 351 | 0.15 |
| 2016 | XIII | Diseases of the musculoskeletal system and connective tissue | 338 | 0.14 |
| 2016 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 308 | 0.13 |
| 2017 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 302 | 0.13 |
| 2018 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 291 | 0.12 |
| 2017 | XIII | Diseases of the musculoskeletal system and connective tissue | 287 | 0.12 |

Supplementary Table 24 - Distribution of death certificates, according to year of death and ICD-10 chapter, for the periods without excess mortality (cont.)

| Year of Death | Chapter | Chapter Description | N | % |
|---------------|---------|--|----------------|---------------|
| 2019 | IV | Endocrine, nutritional and metabolic diseases | 173 | 0.07 |
| 2018 | XII | Diseases of the skin and subcutaneous tissue | 166 | 0.07 |
| 2016 | XII | Diseases of the skin and subcutaneous tissue | 157 | 0.07 |
| 2019 | V | Mental and behavioural disorders | 150 | 0.06 |
| 2018 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 148 | 0.06 |
| 2019 | XVIII | Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified | 148 | 0.06 |
| 2019 | XI | Diseases of the digestive system | 140 | 0.06 |
| 2019 | XX | External causes of morbidity and mortality | 135 | 0.06 |
| 2019 | VI | Diseases of the nervous system | 105 | 0.04 |
| 2017 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 103 | 0.04 |
| 2016 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 99 | 0.04 |
| 2017 | XII | Diseases of the skin and subcutaneous tissue | 91 | 0.04 |
| 2019 | XIV | Diseases of the genitourinary system | 85 | 0.04 |
| 2019 | I | Certain infectious and parasitic diseases | 60 | 0.03 |
| 2018 | XVI | Certain conditions originating in the perinatal period | 21 | 0.01 |
| 2019 | XII | Diseases of the skin and subcutaneous tissue | 16 | 0.01 |
| 2016 | XVI | Certain conditions originating in the perinatal period | 15 | 0.01 |
| 2019 | III | Diseases of the blood and blood-forming organs and certain disorders involving the immune system | 15 | 0.01 |
| 2019 | XIII | Diseases of the musculoskeletal system and connective tissue | 15 | 0.01 |
| 2018 | XV | Pregnancy, childbirth and the puerperium | 12 | 0.01 |
| 2017 | VIII | Diseases of the ear and mastoid process | 10 | 0.00 |
| 2017 | XVI | Certain conditions originating in the perinatal period | 10 | 0.00 |
| 2017 | XV | Pregnancy, childbirth and the puerperium | 9 | 0.00 |
| 2019 | XVII | Congenital malformations, deformations and chromosomal abnormalities | 7 | 0.00 |
| 2016 | VIII | Diseases of the ear and mastoid process | 6 | 0.00 |
| 2016 | XV | Pregnancy, childbirth and the puerperium | 6 | 0.00 |
| 2018 | VIII | Diseases of the ear and mastoid process | 6 | 0.00 |
| 2019 | XV | Pregnancy, childbirth and the puerperium | 2 | 0.00 |
| 2016 | VII | Diseases of the eye and adnexa | 1 | 0.00 |
| Total | | | 236 681 | 100.00 |

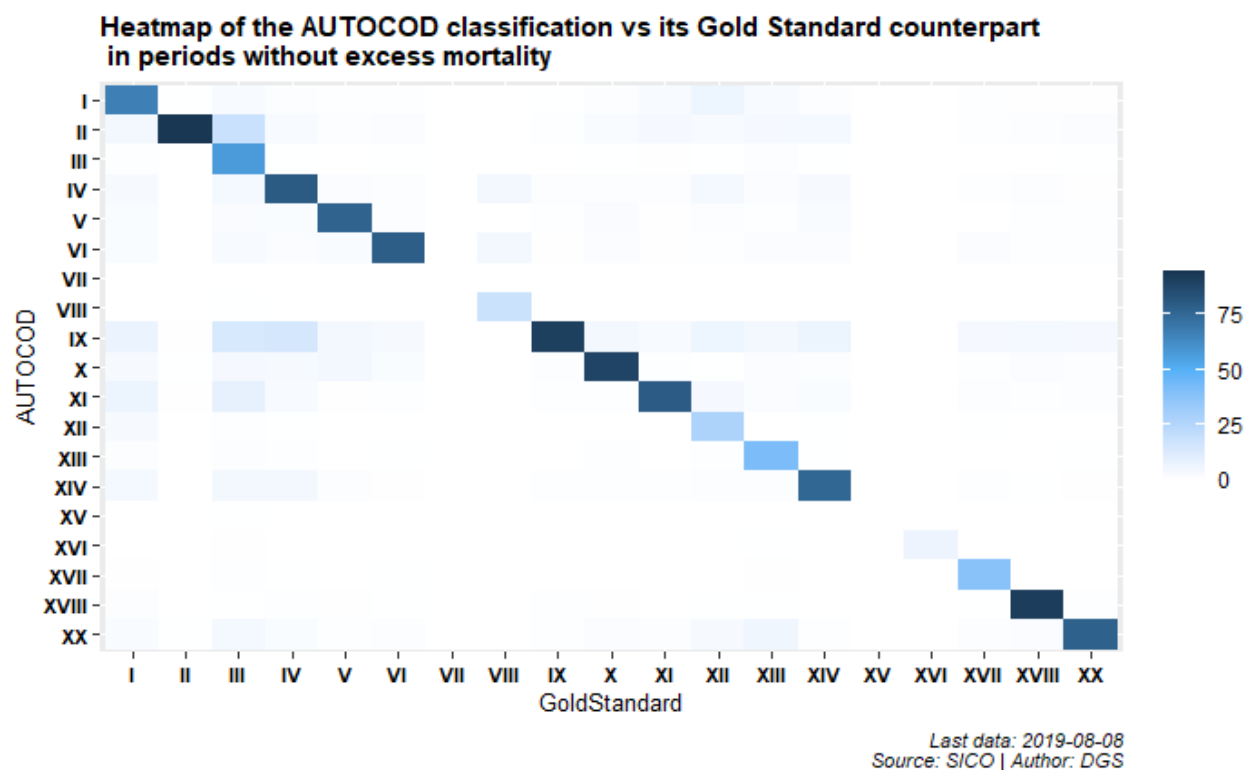


Supplementary Figure 8 - Count of death certificates classified either by human coders (DGS) or by AUTOCOD, for periods without excess mortality

Supplementary Table 25 - Confusion Matrix for the periods without excess mortality

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | |
|---------|-------|------------------------------|-----------|---------|----------|----------|----------|-----|------|-----------|-----------|----------|---------|---------|----------|--------|-----|------|-----------|----------|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XX |
| AUTOCOD | I | 298 4 | 195 | 40 | 141 | 89 | 92 | 0 | 2 | 313 | 148 | 301 | 14 8 | 60 | 172 | 0 | 4 | 14 | 47 | 113 |
| | II | 150 | 6148 6 | 29 | 82 | 86 | 69 | 0 | 1 | 281 | 155 | 264 | 9 | 24 | 80 | 2 | 2 | 11 | 31 | 133 |
| | III | 27 | 173 | 52 6 | 35 | 21 | 25 | 0 | 2 | 128 | 32 | 77 | 5 | 12 | 40 | 2 | 3 | 6 | 2 | 36 |
| | IV | 163 | 316 | 35 | 939 9 | 231 | 209 | 0 | 4 | 1715 | 364 | 313 | 33 | 98 | 485 | 5 | 8 | 31 | 72 | 246 |
| | V | 49 | 90 | 9 | 144 | 695 6 | 225 | 0 | 0 | 378 | 391 | 44 | 10 | 13 | 86 | 0 | 0 | 1 | 36 | 80 |
| | VI | 62 | 151 | 20 | 97 | 79 | 663 4 | 0 | 2 | 275 | 166 | 61 | 3 | 21 | 33 | 0 | 4 | 19 | 20 | 110 |
| | VII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VIII | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | IX | 173 | 616 | 93 | 822 | 543 | 330 | 0 | 4 | 6300 1 | 1048 | 536 | 42 | 11 4 | 467 | 1 5 | 3 | 65 | 381 | 597 |
| | X | 343 | 637 | 69 | 364 | 601 | 442 | 0 | 1 | 1205 | 2396 9 | 216 | 22 | 15 7 | 241 | 2 | 5 | 33 | 143 | 463 |
| | XI | 304 | 401 | 35 | 105 | 37 | 37 | 0 | 0 | 320 | 71 | 882 6 | 6 | 15 | 71 | 1 | 2 | 8 | 10 | 133 |
| | XII | 27 | 12 | 1 | 17 | 5 | 3 | 0 | 0 | 27 | 1 | 16 | 11 9 | 3 | 6 | 0 | 0 | 0 | 1 | 14 |
| | XIII | 29 | 37 | 11 | 17 | 7 | 16 | 0 | 0 | 45 | 18 | 16 | 1 | 41 4 | 11 | 1 | 2 | 4 | 3 | 52 |
| | XIV | 77 | 293 | 21 | 249 | 182 | 125 | 0 | 0 | 502 | 101 | 160 | 20 | 16 | 566 5 | 0 | 1 | 12 | 9 | 66 |
| | XV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | XVII | 2 | 3 | 0 | 2 | 0 | 6 | 0 | 0 | 13 | 2 | 5 | 1 | 0 | 3 | 0 | 0 | 138 | 1 | 5 |
| | XVIII | 35 | 124 | 6 | 113 | 91 | 60 | 1 | 2 | 451 | 173 | 67 | 7 | 12 | 32 | 0 | 0 | 7 | 1025 8 | 202 |
| | XX | 35 | 167 | 21 | 49 | 58 | 80 | 0 | 0 | 367 | 97 | 97 | 4 | 32 | 34 | 1 | 9 | 7 | 58 | 824 7 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality



Supplementary Figure 9 - Heatmap of the AUTOCOD classification vs its Gold Standard counterpart in periods without excess mortality. Values on the diagonal represent correct classifications.

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Supplementary Table 26 - Overall performance metrics of AUTOCOD during periods without excess mortality

| | |
|-----------------------|------|
| Accuracy | 0.88 |
| Kappa | 0.86 |
| AccuracyLower | 0.88 |
| AccuracyUpper | 0.88 |
| AccuracyNull | 0.29 |
| AccuracyPValue | 0.00 |

Supplementary Table 27 - Performance Metrics of AUTOCOD, by class, for the periods without excess mortality

| Chapter | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|--------------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| I | 0.67 | 0.99 | 0.61 | 0.99 | 0.64 | 0.02 | 0.01 | 0.02 | 0.83 |
| II | 0.95 | 0.99 | 0.98 | 0.98 | 0.96 | 0.27 | 0.26 | 0.27 | 0.97 |
| III | 0.57 | 1.00 | 0.46 | 1.00 | 0.51 | 0.00 | 0.00 | 0.01 | 0.79 |
| IV | 0.81 | 0.98 | 0.69 | 0.99 | 0.74 | 0.05 | 0.04 | 0.06 | 0.89 |
| V | 0.77 | 0.99 | 0.82 | 0.99 | 0.80 | 0.04 | 0.03 | 0.04 | 0.88 |
| VI | 0.79 | 1.00 | 0.86 | 0.99 | 0.82 | 0.04 | 0.03 | 0.03 | 0.90 |
| VII | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| VIII | 0.18 | 1.00 | 0.67 | 1.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.59 |
| IX | 0.91 | 0.97 | 0.92 | 0.96 | 0.91 | 0.29 | 0.27 | 0.29 | 0.94 |
| X | 0.90 | 0.98 | 0.83 | 0.99 | 0.86 | 0.11 | 0.10 | 0.12 | 0.94 |
| XI | 0.80 | 0.99 | 0.85 | 0.99 | 0.83 | 0.05 | 0.04 | 0.04 | 0.90 |
| XII | 0.28 | 1.00 | 0.47 | 1.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.64 |
| XIII | 0.42 | 1.00 | 0.61 | 1.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.71 |
| XIV | 0.76 | 0.99 | 0.76 | 0.99 | 0.76 | 0.03 | 0.02 | 0.03 | 0.88 |
| XV | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XVI | 0.07 | 1.00 | 1.00 | 1.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.53 |
| XVII | 0.39 | 1.00 | 0.76 | 1.00 | 0.51 | 0.00 | 0.00 | 0.00 | 0.69 |
| XVIII | 0.93 | 0.99 | 0.88 | 1.00 | 0.90 | 0.05 | 0.04 | 0.05 | 0.96 |
| XX | 0.79 | 1.00 | 0.88 | 0.99 | 0.83 | 0.04 | 0.04 | 0.04 | 0.89 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

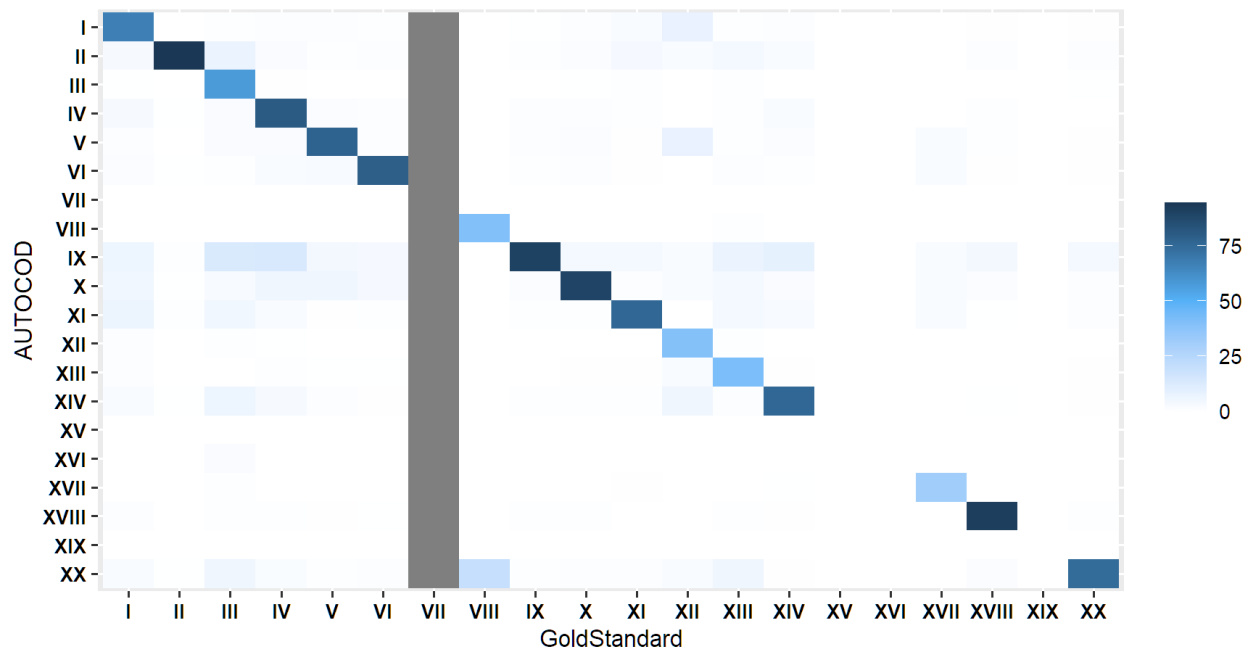
Periods with severe excess mortality (>4 SDs)

Supplementary Table 28 - Confusion Matrix for the periods with severe excess mortality (>4 SDs)

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | |
|---------|-------|------------------------------|----------|--------|----------|---------|---------|-----|------|----------|----------|---------|-----|------|-----|----|-----|------|-------|-----|---------|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX | XX |
| AUTOCOD | I | 36 6 | 18 | 1 | 17 | 7 | 10 | 0 | 0 | 35 | 27 | 36 | 8 | 6 | 14 | 0 | 0 | 0 | 7 | 0 | 14 |
| | II | 10 | 574 6 | 8 | 14 | 6 | 12 | 0 | 1 | 56 | 17 | 37 | 1 | 3 | 11 | 0 | 0 | 1 | 3 | 0 | 15 |
| | III | 1 | 10 | 8 0 | 3 | 3 | 1 | 0 | 0 | 18 | 4 | 7 | 1 | 0 | 9 | 0 | 3 | 1 | 1 | 0 | 8 |
| | IV | 24 | 35 | 5 | 128 7 | 36 | 38 | 0 | 0 | 218 | 87 | 38 | 4 | 11 | 52 | 0 | 0 | 2 | 11 | 0 | 32 |
| | V | 16 | 8 | 1 | 21 | 98 1 | 37 | 0 | 0 | 52 | 67 | 4 | 0 | 3 | 14 | 0 | 0 | 0 | 6 | 0 | 11 |
| | VI | 7 | 12 | 0 | 11 | 16 | 86 7 | 0 | 0 | 38 | 39 | 6 | 1 | 2 | 5 | 0 | 0 | 1 | 3 | 0 | 16 |
| | VII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VIII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | IX | 19 | 77 | 1 4 | 132 | 92 | 52 | 0 | 0 | 841 6 | 167 | 78 | 3 | 14 | 67 | 2 | 0 | 10 | 71 | 0 | 82 |
| | X | 52 | 76 | 1 3 | 56 | 76 | 49 | 0 | 1 | 188 | 423 7 | 32 | 2 | 24 | 27 | 0 | 0 | 4 | 27 | 1 | 69 |
| | XI | 28 | 44 | 9 | 10 | 5 | 6 | 0 | 0 | 45 | 14 | 91 4 | 0 | 4 | 9 | 0 | 1 | 4 | 2 | 0 | 13 |
| | XII | 3 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 15 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| | XIII | 1 | 5 | 1 | 1 | 1 | 2 | 0 | 1 | 9 | 5 | 5 | 1 | 54 | 2 | 0 | 0 | 0 | 1 | 0 | 7 |
| | XIV | 9 | 24 | 1 | 24 | 16 | 7 | 0 | 0 | 81 | 21 | 27 | 0 | 4 | 704 | 0 | 0 | 2 | 3 | 0 | 4 |
| | XV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XVII | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| | XVIII | 6 | 20 | 3 | 16 | 16 | 9 | 0 | 0 | 80 | 30 | 4 | 0 | 0 | 4 | 0 | 1 | 0 | 1657 | 0 | 33 |
| | XIX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | XX | 4 | 12 | 3 | 2 | 5 | 6 | 0 | 0 | 49 | 17 | 12 | 2 | 4 | 4 | 0 | 0 | 1 | 10 | 1 | 90 8 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Heatmap of the AUTOCOD classification vs its Gold Standard counterpart severe excess mortality >4 SD



Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 10 - Heatmap of the AUTOCOD classification vs its Gold Standard counterpart in periods with severe excess mortality (> 4SDs). Values on the diagonal represent correct classifications.

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Supplementary Table 29 - Overall performance metrics of AUTOCOD during periods with severe excess mortality (>4 SDs)

| | |
|-----------------------|------|
| Accuracy | 0.87 |
| Kappa | 0.84 |
| AccuracyLower | 0.87 |
| AccuracyUpper | 0.88 |
| AccuracyNull | 0.31 |
| AccuracyPValue | 0.00 |

Table 1 - Performance Metrics of AUTOCOD, by class, during periods with severe excess mortality (>4 SDs)

| Chapter | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|---------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| I | 0.67 | 0.99 | 0.65 | 0.99 | 0.66 | 0.02 | 0.01 | 0.02 | 0.83 |
| II | 0.94 | 0.99 | 0.97 | 0.99 | 0.96 | 0.20 | 0.19 | 0.20 | 0.97 |
| III | 0.58 | 1.00 | 0.53 | 1.00 | 0.55 | 0.01 | 0.00 | 0.01 | 0.79 |
| IV | 0.81 | 0.98 | 0.69 | 0.99 | 0.74 | 0.05 | 0.04 | 0.06 | 0.89 |
| V | 0.78 | 0.99 | 0.80 | 0.99 | 0.79 | 0.04 | 0.03 | 0.04 | 0.88 |
| VI | 0.79 | 1.00 | 0.85 | 0.99 | 0.82 | 0.04 | 0.03 | 0.03 | 0.89 |
| VII | NA | 1.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | NA |
| VIII | 0.40 | 1.00 | 0.67 | 1.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.70 |
| IX | 0.91 | 0.96 | 0.91 | 0.96 | 0.91 | 0.31 | 0.28 | 0.31 | 0.93 |
| X | 0.90 | 0.97 | 0.86 | 0.98 | 0.88 | 0.16 | 0.14 | 0.16 | 0.93 |
| XI | 0.76 | 0.99 | 0.83 | 0.99 | 0.79 | 0.04 | 0.03 | 0.04 | 0.88 |
| XII | 0.40 | 1.00 | 0.54 | 1.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.70 |
| XIII | 0.42 | 1.00 | 0.56 | 1.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.71 |
| XIV | 0.76 | 0.99 | 0.76 | 0.99 | 0.76 | 0.03 | 0.02 | 0.03 | 0.88 |
| XV | 0.00 | 1.00 | NA | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XVI | 0.00 | 1.00 | NA | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XVII | 0.32 | 1.00 | 0.71 | 1.00 | 0.44 | 0.00 | 0.00 | 0.00 | 0.66 |
| XVIII | 0.92 | 0.99 | 0.88 | 1.00 | 0.90 | 0.06 | 0.06 | 0.06 | 0.96 |
| XIX | 0.00 | 1.00 | NA | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XX | 0.75 | 1.00 | 0.87 | 0.99 | 0.81 | 0.04 | 0.03 | 0.04 | 0.87 |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

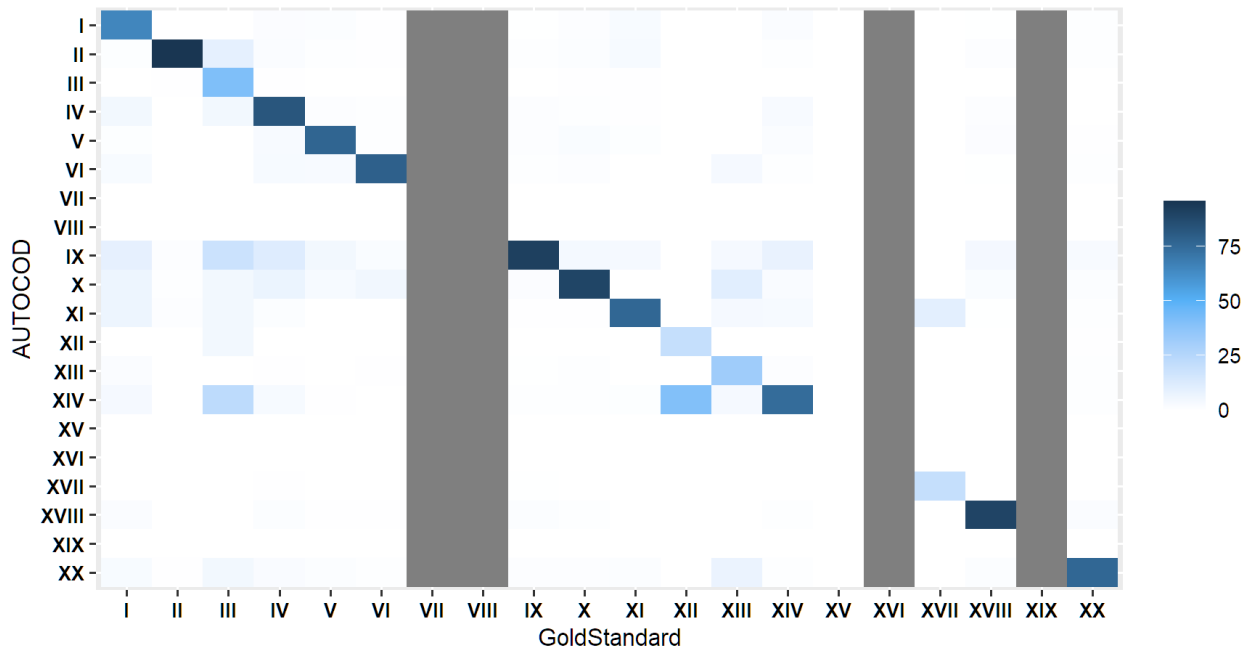
Periods with extreme excess mortality (>6 SDs)

Supplementary Table 30 - Confusion Matrix for the periods with extreme excess mortality (>6 SDs)

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | | |
|---------|------|------------------------------|-----|-----|-----|----|----|-----|------|----|----|----|-----|------|-----|----|-----|------|-------|-----|----|----|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX | XX | |
| AUTOCOD | I | 7 | | | | | | | | | | | | | | | | | | | | |
| | | 2 | 1 | 0 | 5 | 1 | 3 | 0 | 0 | 10 | 7 | 7 | 0 | 2 | 4 | 0 | 0 | 0 | 2 | 0 | 3 | |
| | II | | 111 | | | | | | | | | | | | | | | | | | | |
| | | 0 | 2 | 4 | 1 | 2 | 2 | 0 | 0 | 11 | 7 | 14 | 1 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 4 | |
| | III | | | | | | | | | | | | | | | | | | | | | |
| | | 0 | 2 | 9 | 1 | 0 | 0 | 0 | 0 | 4 | 1 | 1 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | |
| | IV | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | 6 | 1 | 25 | 8 | 9 | 10 | 0 | 0 | 36 | 22 | 4 | 0 | 1 | 10 | 0 | 0 | 1 | 4 | 0 | 7 |
| | V | | | | | | | | | | | | | | | | | | | | | |
| | | 4 | 2 | 0 | 21 | 3 | 6 | 8 | 0 | 0 | 13 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 4 |
| | VI | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 1 | 0 | 20 | 2 | 2 | 0 | 0 | 0 | 5 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| | VII | | | | | | | | | | | | | | | | | | | | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VIII | | | | | | | | | | | | | | | | | | | | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | IX | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | 13 | 3 | 175 | 23 | 18 | 15 | 0 | 0 | 0 | 30 | 10 | 1 | 4 | 11 | 1 | 0 | 5 | 27 | 0 | 21 |
| | X | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 14 | 4 | 90 | 9 | 20 | 11 | 0 | 0 | 40 | 5 | 5 | 0 | 6 | 6 | 0 | 0 | 1 | 6 | 0 | 11 |
| XI | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | 7 | 1 | 16 | 1 | 2 | 0 | 0 | 0 | 8 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | |
| XII | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | |
| XIII | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | |
| XIV | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | 1 | 0 | 133 | 5 | 3 | 1 | 0 | 0 | 14 | 4 | 6 | 0 | 2 | 133 | 0 | 0 | 0 | 1 | 0 | 1 | |
| XV | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| XVI | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| XVII | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | |
| XVIII | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | 5 | 0 | 401 | 5 | 7 | 1 | 0 | 0 | 18 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 401 | 0 | 6 | |
| XIX | | | | | | | | | | | | | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| XX | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | 2 | 0 | 20 | 0 | 1 | 2 | 0 | 0 | 8 | 4 | 2 | 1 | 2 | 2 | 0 | 0 | 0 | 5 | 0 | 8 | |

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Heatmap of the AUTOCOD classification vs its Gold Standard counterpart extreme excess mortality >6 SD



Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 11 - Heatmap of the AUTOCOD classification vs its Gold Standard counterpart in periods with extreme excess mortality (>6 SDs). Values on the diagonal represent correct classifications.

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Supplementary Table 31 - Overall performance metrics of AUTOCOD during periods with extreme excess mortality (>6 SDs)

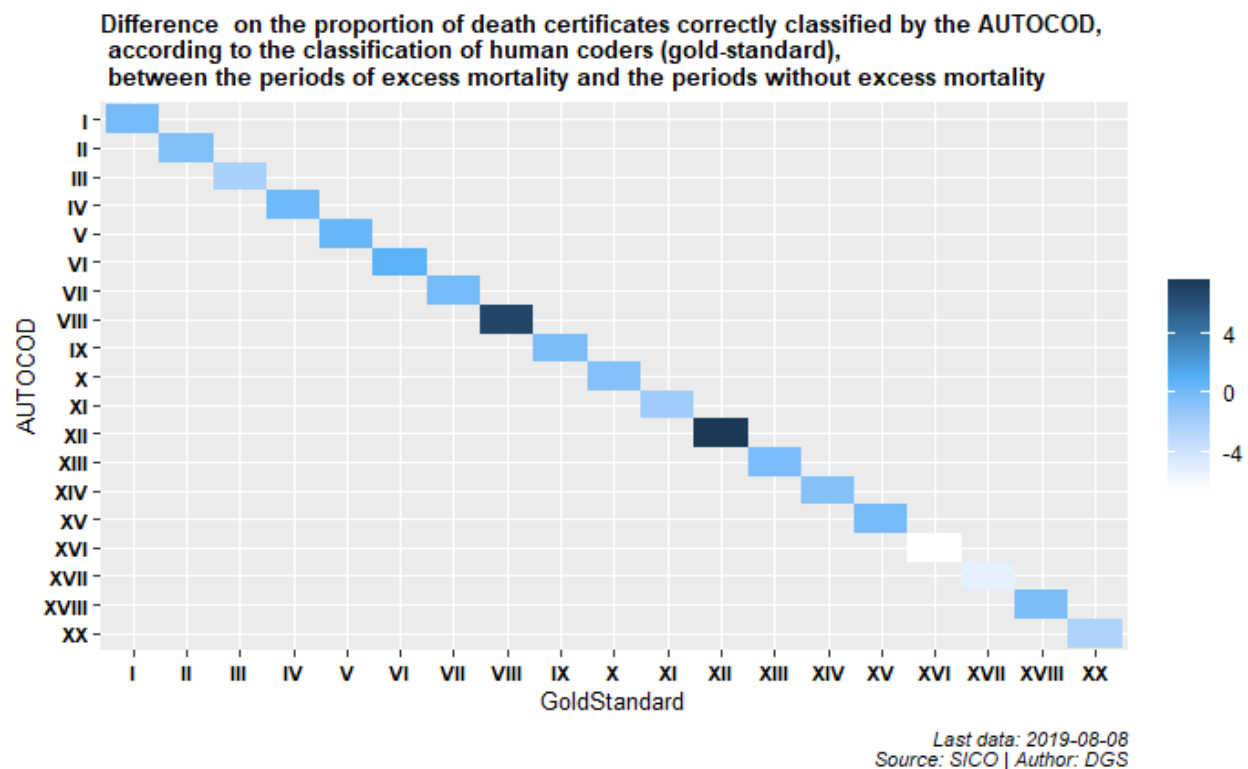
| | |
|-----------------------|------|
| Accuracy | 0.87 |
| Kappa | 0.85 |
| AccuracyLower | 0.86 |
| AccuracyUpper | 0.88 |
| AccuracyNull | 0.31 |
| AccuracyPValue | 0.00 |

Supplementary Table 32 - Performance Metrics of AUTOCOD, by class, during periods with extreme excess mortality (>6 SDs)

| Chapter | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|---------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| I | 0.65 | 0.99 | 0.62 | 0.99 | 0.63 | 0.02 | 0.01 | 0.02 | 0.82 |
| II | 0.95 | 0.99 | 0.96 | 0.99 | 0.96 | 0.19 | 0.18 | 0.19 | 0.97 |
| III | 0.41 | 1.00 | 0.36 | 1.00 | 0.38 | 0.00 | 0.00 | 0.00 | 0.70 |
| IV | 0.82 | 0.98 | 0.69 | 0.99 | 0.75 | 0.05 | 0.04 | 0.06 | 0.90 |
| V | 0.77 | 0.99 | 0.83 | 0.99 | 0.80 | 0.05 | 0.04 | 0.04 | 0.88 |
| VI | 0.79 | 1.00 | 0.88 | 0.99 | 0.83 | 0.04 | 0.03 | 0.04 | 0.89 |
| VII | NA | 1.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | NA |
| VIII | NA | 1.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | NA |
| IX | 0.91 | 0.96 | 0.96 | 0.96 | 0.91 | 0.31 | 0.28 | 0.31 | 0.94 |
| X | 0.89 | 0.97 | 0.86 | 0.98 | 0.88 | 0.16 | 0.15 | 0.17 | 0.93 |
| XI | 0.76 | 1.00 | 0.85 | 0.99 | 0.80 | 0.04 | 0.03 | 0.03 | 0.88 |
| XII | 0.20 | 1.00 | 0.33 | 1.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.60 |
| XIII | 0.32 | 1.00 | 0.50 | 1.00 | 0.39 | 0.00 | 0.00 | 0.00 | 0.66 |
| XIV | 0.74 | 0.99 | 0.76 | 0.99 | 0.75 | 0.03 | 0.02 | 0.03 | 0.87 |
| XV | 0.00 | 1.00 | NA | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| XVI | NA | 1.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | NA |
| XVII | 0.20 | 1.00 | 0.67 | 1.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.60 |
| XVIII | 0.90 | 0.99 | 0.88 | 0.99 | 0.89 | 0.07 | 0.06 | 0.07 | 0.94 |
| XIX | NA | 1.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | NA |
| XX | 0.76 | 1.00 | 0.87 | 0.99 | 0.81 | 0.04 | 0.03 | 0.04 | 0.88 |

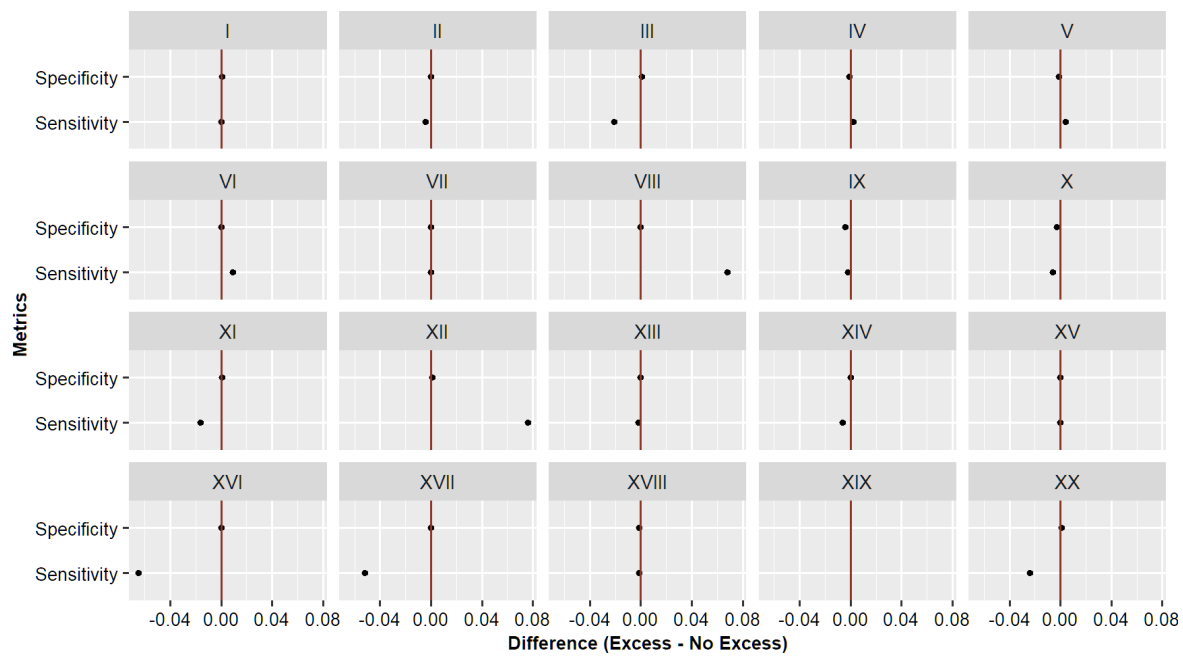
Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Difference between excess mortality periods and periods without excess mortality

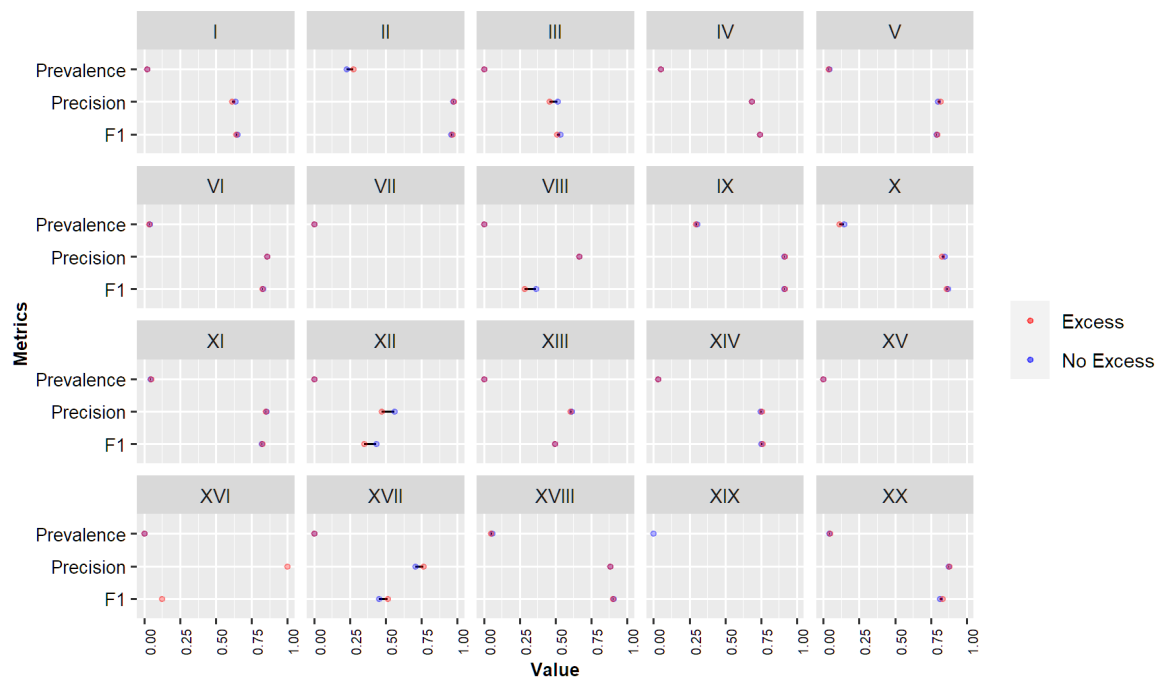


Supplementary Figure 12 - Difference on the proportion of death certificates correctly classified by the AUTOCOD, according to the classification of human coders (gold-standard), between the periods of excess mortality and the periods without excess mortality

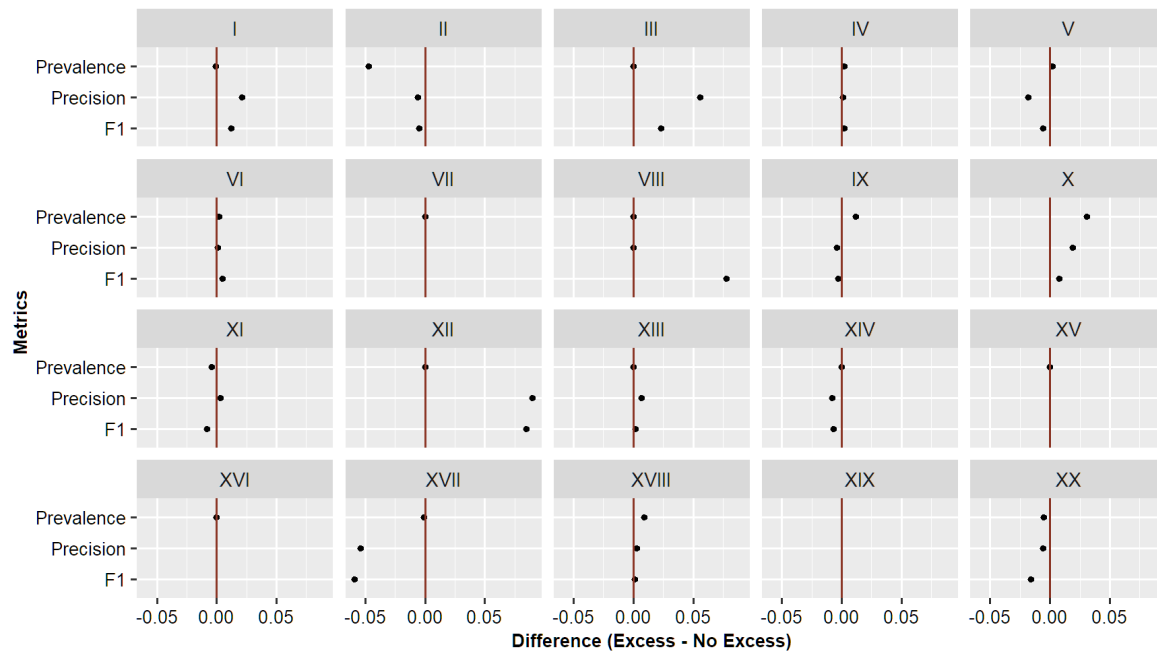
Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality



Supplementary Figure 13 - Difference on performance metrics of AUTOCOD, by chapter, between periods of excess mortality and periods without excess mortality

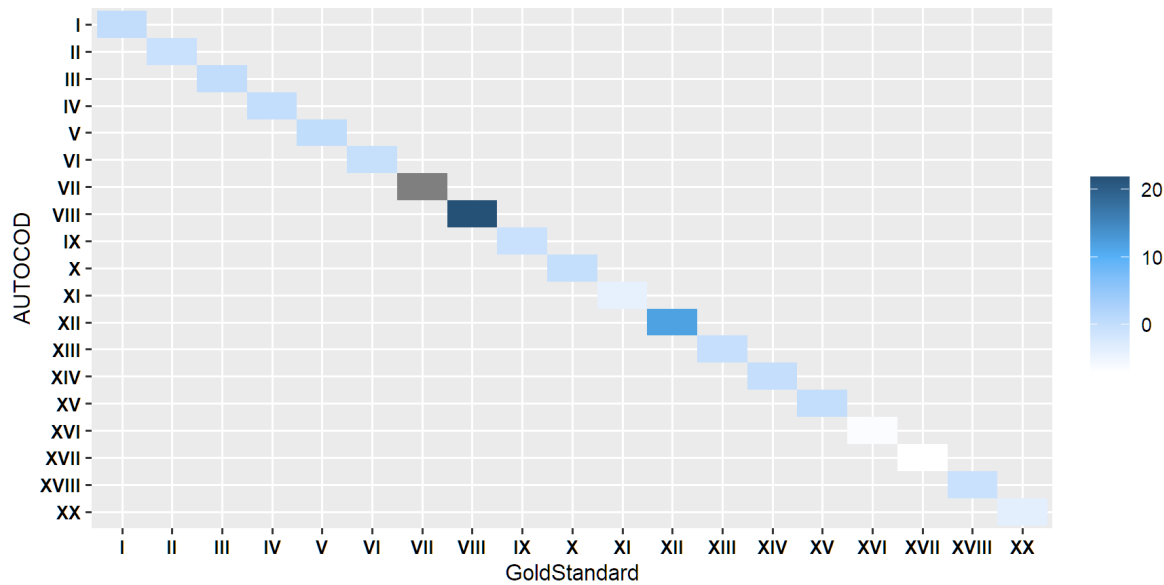


Supplementary Figure 14 - Comparison between other performance metrics of AUTOCOD during periods of excess mortality and periods without excess mortality



Supplementary Figure 15 - Difference on other performance metrics of AUTOCOD, by chapter, between periods of excess mortality and periods without excess mortality

Difference on the proportion of death certificates correctly classified by the AUTOCOD, according to the classification of human coders (gold-standard), between the periods of severe excess mortality (>4 SD) and the periods without excess mortality

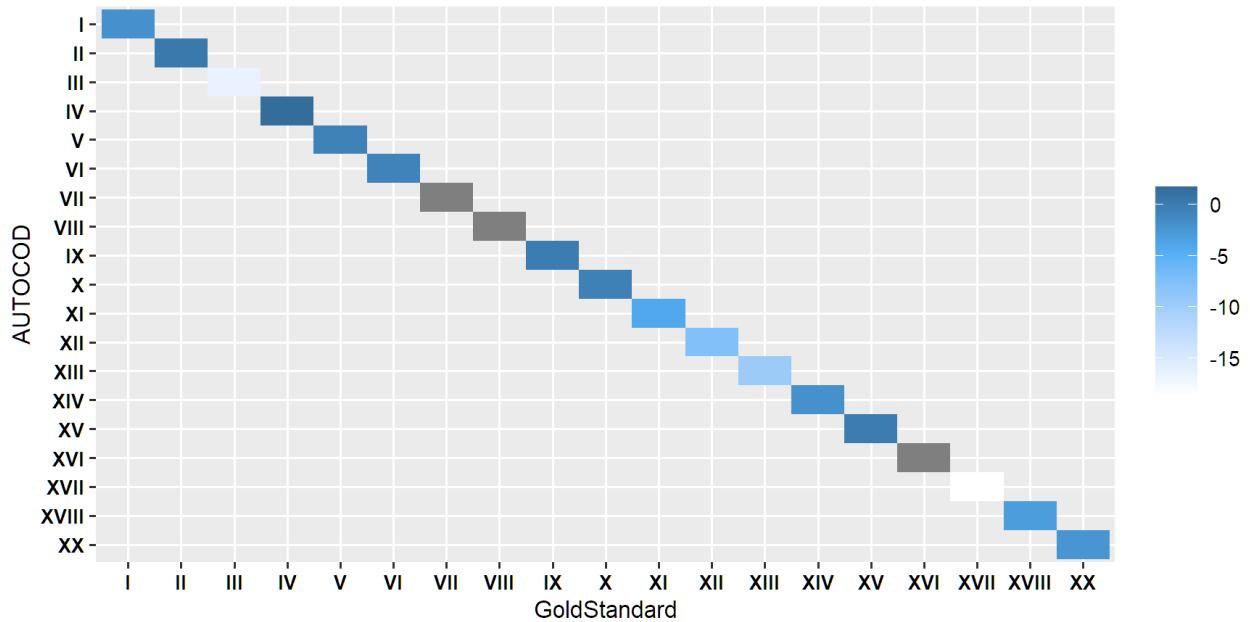


Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 16 - Difference on the proportion of death certificates correctly classified by the AUTOCOD, according to the classification of human coders (gold-standard), between the periods of severe excess mortality (>4 SDs) and the periods without excess mortality

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Difference on the proportion of death certificates correctly classified by the AUTOCOD, according to the classification of human coders (gold-standard), between the periods of extreme excess mortality (>6 SD) and the periods without excess mortality

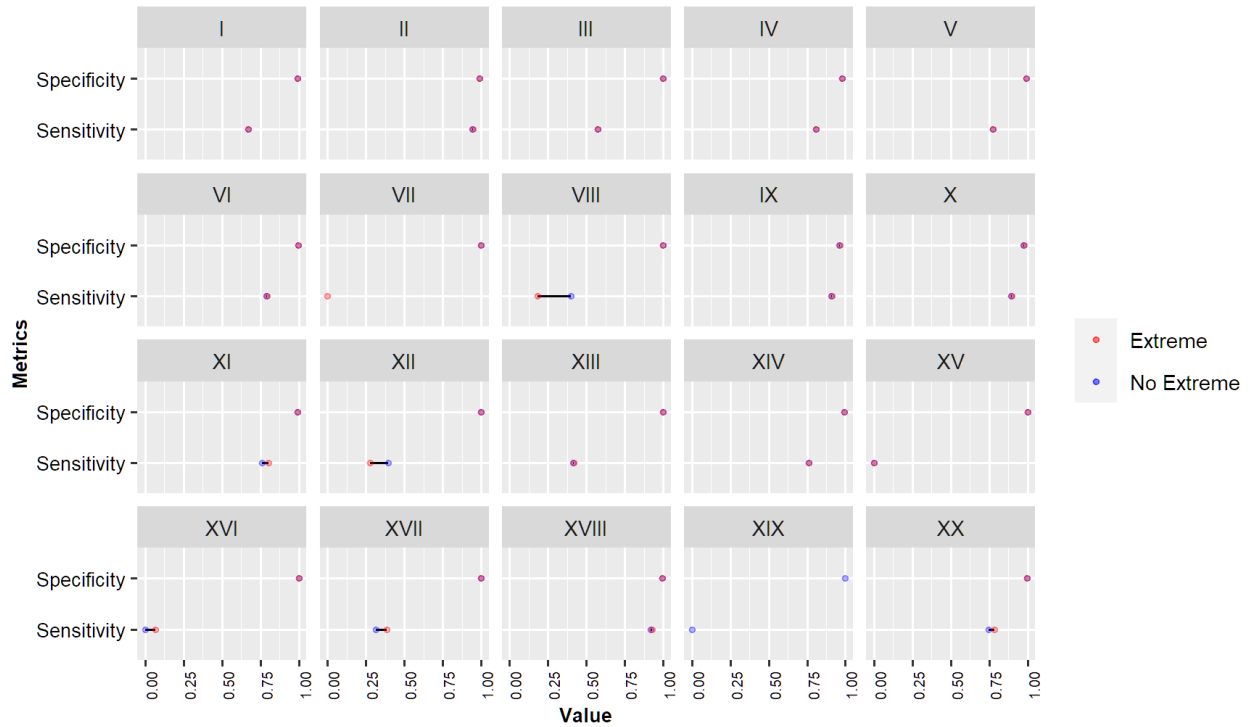


Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 17 - Difference on the proportion of death certificates correctly classified by the AUTOCOD, according to the classification of human coders (gold-standard), between the periods of extreme excess mortality (> 6 SDs) and the periods without excess mortality.

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

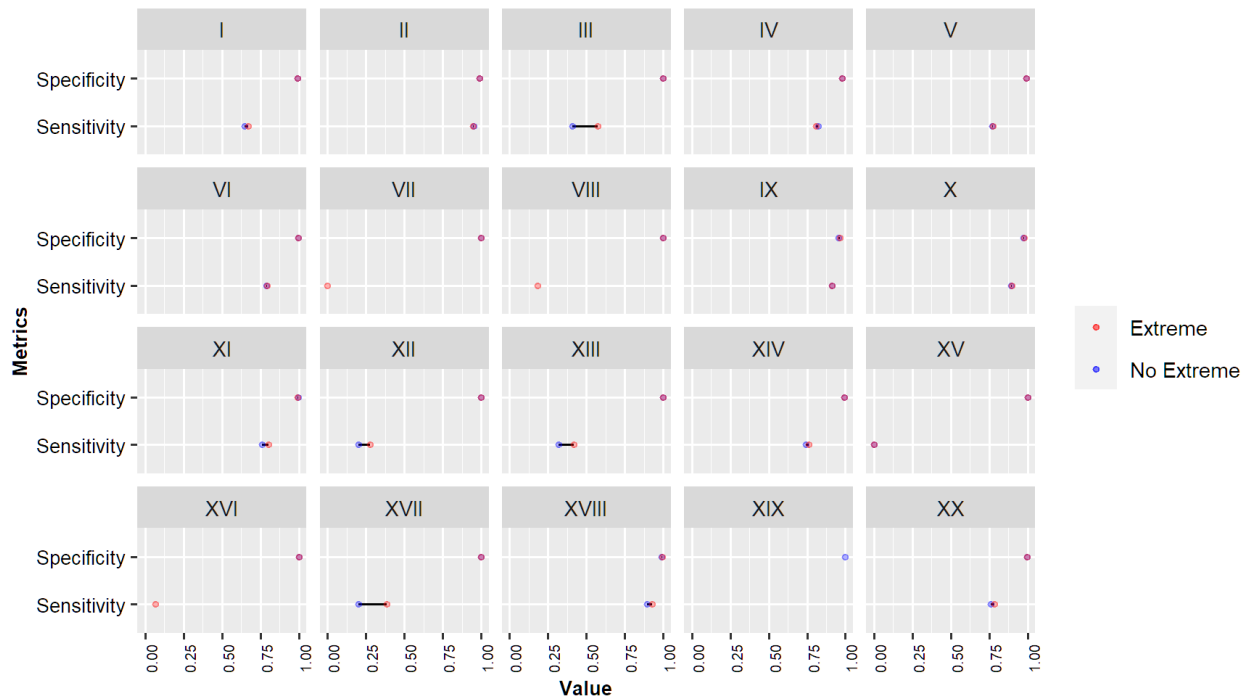
Metrics in periods of severe excess mortality >4 SD and periods without excess mortality



Supplementary Figure 18 - Comparison between performance metrics of AUTOCOD during periods of severe excess mortality (>4 SDs) and periods without excess mortality

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

Metrics in periods of extreme excess mortality >6 SD and periods without excess mortality



Supplementary Figure 19 - Comparison between performance metrics of AUTOCOD during periods of extreme excess mortality (>6 SDs) and periods without excess mortality

Caption: I - Certain infectious and parasitic diseases; II - Neoplasms; III - Diseases of the blood and blood-forming organs and certain disorders involving the immune system; IV - Endocrine, nutritional and metabolic diseases; V - Mental and behavioural disorders; VI - Diseases of the nervous system; VII - Diseases of the eye and adnexa; VIII - Diseases of the ear and mastoid process; IX - Diseases of the circulatory system; X - Diseases of the respiratory system; XI - Diseases of the digestive system; XII - Diseases of the skin and subcutaneous tissue; XIII - Diseases of the musculoskeletal system and connective tissue; XIV - Diseases of the genitourinary system; XV - Pregnancy, childbirth and the puerperium; XVI - Certain conditions originating in the perinatal period; XVII - Congenital malformations, deformations and chromosomal abnormalities; XVIII - Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere specified; XIX - Injury, poisoning and certain other consequences of external causes; XX - External causes of morbidity and mortality

ICD-10 block analysis

Performance metrics – global overview

Supplementary Table 33 - Performance Metrics of AUTOCOD, by block, for all the periods analysed

| | C00-C97 | | | | D00-D09 | | | | D10-D36 | | | | D37-D48 | | | | I05-I09 | | | |
|-----|------------|--------------|--------------|---------------|------------|--------------|--------------|---------------|------------|--------------|--------------|---------------|------------|--------------|--------------|---------------|------------|--------------|--------------|---------------|
| | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD |
| Sen | 0.98 | 0.98 | 0.97 | 0.97 | 0.00 | NA | NA | NA | 0.70 | 0.69 | 0.72 | 0.80 | 0.74 | 0.73 | 0.74 | 0.77 | 0.41 | 0.49 | 0.63 | 0.67 |
| Spe | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| PPV | 0.99 | 0.99 | 0.99 | 0.99 | NaN | NA | NA | NA | 0.76 | 0.84 | 0.93 | 1.00 | 0.83 | 0.82 | 0.76 | 0.54 | 0.51 | 0.53 | 0.57 | 0.50 |
| NPV | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | NA | NA | NA | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.99 | 0.98 | 0.98 | 0.98 | NA | NA | NA | NA | 0.73 | 0.76 | 0.81 | 0.89 | 0.78 | 0.77 | 0.75 | 0.63 | 0.45 | 0.51 | 0.60 | 0.57 |
| Pre | 0.40 | 0.34 | 0.30 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DR | 0.40 | 0.33 | 0.30 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DP | 0.40 | 0.33 | 0.30 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| BA | 0.99 | 0.99 | 0.98 | 0.98 | 0.50 | NA | NA | NA | 0.85 | 0.84 | 0.86 | 0.90 | 0.87 | 0.86 | 0.87 | 0.88 | 0.70 | 0.75 | 0.82 | 0.83 |
| | I10-I15 | | | | I20-I25 | | | | I26-I28 | | | | I30-I52 | | | | I60-I69 | | | |
| | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD |
| Sen | 0.85 | 0.86 | 0.87 | 0.87 | 0.93 | 0.92 | 0.92 | 0.92 | 0.80 | 0.79 | 0.77 | 0.80 | 0.91 | 0.92 | 0.92 | 0.92 | 0.94 | 0.94 | 0.93 | 0.93 |
| Spe | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| PPV | 0.76 | 0.76 | 0.78 | 0.78 | 0.94 | 0.93 | 0.95 | 0.93 | 0.81 | 0.82 | 0.80 | 0.78 | 0.90 | 0.90 | 0.89 | 0.90 | 0.95 | 0.95 | 0.96 | 0.96 |
| NPV | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| F1 | 0.80 | 0.81 | 0.82 | 0.82 | 0.93 | 0.93 | 0.94 | 0.93 | 0.80 | 0.80 | 0.78 | 0.79 | 0.90 | 0.91 | 0.91 | 0.91 | 0.95 | 0.95 | 0.95 | 0.94 |
| Pre | 0.03 | 0.04 | 0.04 | 0.03 | 0.09 | 0.10 | 0.11 | 0.12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.11 | 0.12 | 0.12 | 0.13 | 0.15 | 0.15 | 0.16 | 0.15 |
| DR | 0.03 | 0.03 | 0.03 | 0.03 | 0.09 | 0.09 | 0.10 | 0.11 | 0.01 | 0.01 | 0.01 | 0.01 | 0.10 | 0.11 | 0.11 | 0.12 | 0.14 | 0.14 | 0.15 | 0.14 |
| DP | 0.04 | 0.04 | 0.04 | 0.04 | 0.09 | 0.10 | 0.10 | 0.11 | 0.01 | 0.01 | 0.01 | 0.01 | 0.11 | 0.13 | 0.13 | 0.13 | 0.15 | 0.15 | 0.15 | 0.15 |
| BA | 0.92 | 0.92 | 0.93 | 0.93 | 0.96 | 0.96 | 0.96 | 0.96 | 0.90 | 0.89 | 0.88 | 0.90 | 0.95 | 0.95 | 0.95 | 0.95 | 0.97 | 0.97 | 0.96 | 0.96 |
| | I70-I79 | | | | I80-I89 | | | | I95-I99 | | | | J00-J06 | | | | J09-J18 | | | |
| | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD |
| Sen | 0.82 | 0.82 | 0.85 | 0.84 | 0.55 | 0.54 | 0.58 | 0.50 | 0.08 | 0.00 | 0.00 | NA | 0.41 | 0.07 | 0.00 | 0.00 | 0.94 | 0.93 | 0.93 | 0.93 |
| Spe | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 |
| PPV | 0.89 | 0.88 | 0.88 | 0.91 | 0.75 | 0.76 | 0.83 | 1.00 | 0.20 | NaN | NA | NA | 0.70 | 0.33 | 0.00 | NA | 0.93 | 0.94 | 0.94 | 0.95 |
| NPV | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 |
| F1 | 0.85 | 0.85 | 0.86 | 0.87 | 0.64 | 0.63 | 0.68 | 0.67 | 0.11 | NA | NA | NA | 0.52 | 0.12 | NA | NA | 0.94 | 0.94 | 0.93 | 0.94 |
| Pre | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.10 | 0.11 | 0.12 |
| DR | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.09 | 0.10 | 0.11 |
| DP | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.10 | 0.11 | 0.11 |
| BA | 0.91 | 0.91 | 0.92 | 0.92 | 0.78 | 0.77 | 0.79 | 0.75 | 0.54 | 0.50 | 0.50 | NA | 0.71 | 0.54 | 0.50 | 0.50 | 0.97 | 0.96 | 0.96 | 0.96 |
| | J20-J22 | | | | J30-J39 | | | | J40-J47 | | | | J60-J70 | | | | J80-J84 | | | |
| | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD |
| Sen | 0.83 | 0.83 | 0.85 | 0.90 | 0.45 | 0.17 | 0.25 | NA | 0.89 | 0.89 | 0.90 | 0.89 | 0.87 | 0.84 | 0.84 | 0.82 | 0.82 | 0.81 | 0.79 | 0.88 |
| Spe | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| PPV | 0.87 | 0.86 | 0.89 | 0.93 | 0.53 | 0.25 | 0.50 | NA | 0.83 | 0.83 | 0.83 | 0.82 | 0.91 | 0.93 | 0.91 | 0.94 | 0.89 | 0.85 | 0.83 | 0.78 |
| NPV | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | NA | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.85 | 0.85 | 0.87 | 0.91 | 0.49 | 0.20 | 0.33 | NA | 0.86 | 0.86 | 0.86 | 0.86 | 0.89 | 0.88 | 0.88 | 0.87 | 0.85 | 0.83 | 0.81 | 0.82 |
| Pre | 0.01 | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.05 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| DR | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| DP | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.06 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| BA | 0.92 | 0.92 | 0.92 | 0.95 | 0.73 | 0.58 | 0.63 | NA | 0.94 | 0.94 | 0.95 | 0.94 | 0.93 | 0.92 | 0.92 | 0.91 | 0.91 | 0.91 | 0.89 | 0.94 |
| | J85-J86 | | | | J90-J94 | | | | J95-J99 | | | | | | | | | | | |
| | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | No Excess. | Excess Mort. | Severe >4 SD | Extreme >6 SD | | | | | | | | |
| Sen | 0.31 | 0.35 | 0.08 | 0.00 | 0.66 | 0.69 | 0.71 | 0.50 | 0.92 | 0.92 | 0.92 | 0.91 | | | | | | | | |
| Spe | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | | | | | | | | |
| PPV | 0.83 | 0.90 | 0.50 | NA | 0.63 | 0.59 | 0.71 | 0.67 | 0.85 | 0.84 | 0.85 | 0.83 | | | | | | | | |
| NPV | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | | | | | | | | |
| F1 | 0.46 | 0.51 | 0.14 | NA | 0.65 | 0.64 | 0.71 | 0.57 | 0.88 | 0.88 | 0.88 | 0.87 | | | | | | | | |
| Pre | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.04 | | | | | | | | |
| DR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.03 | 0.03 | | | | | | | | |
| DP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.04 | 0.04 | | | | | | | | |
| BA | 0.66 | 0.68 | 0.54 | 0.50 | 0.83 | 0.84 | 0.85 | 0.75 | 0.96 | 0.96 | 0.96 | 0.95 | | | | | | | | |

Caption: Sen – Sensitivity; Spe – Specificity; PPV – Positive Predictive Value; NPV – Negative Predictive Value; F1 – F1-score; Pre – Prevalence; DR – Detection Rate; DP – Detection Prevalence; BA – Balanced Accuracy; C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally

affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Supplementary Table 34 - Weighted-averages for performance metrics for different periods, for ICD-10's block classification of AUTOCOD

| Block | Period | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|-------------------------|-----------------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| Weighted-average | No Excess Mort. | 0.94 | 0.99 | 0.93 | 0.99 | 0.93 | 0.20 | 0.20 | 0.20 | 0.96 |
| | Excess Mort. | 0.94 | 0.99 | 0.94 | 0.99 | 0.94 | 0.21 | 0.21 | 0.21 | 0.97 |
| | Severe +4SD | 0.93 | 0.99 | 0.93 | 0.99 | 0.93 | 0.17 | 0.17 | 0.17 | 0.96 |
| | Extreme +6SD | 0.93 | 0.99 | 0.93 | 0.99 | 0.93 | 0.16 | 0.15 | 0.16 | 0.96 |

All periods

Supplementary Table 35 - Distribution of death certificates in the dataset, according to year of death and to ICD-10 block (descendent order, 50 most common blocks), for all periods

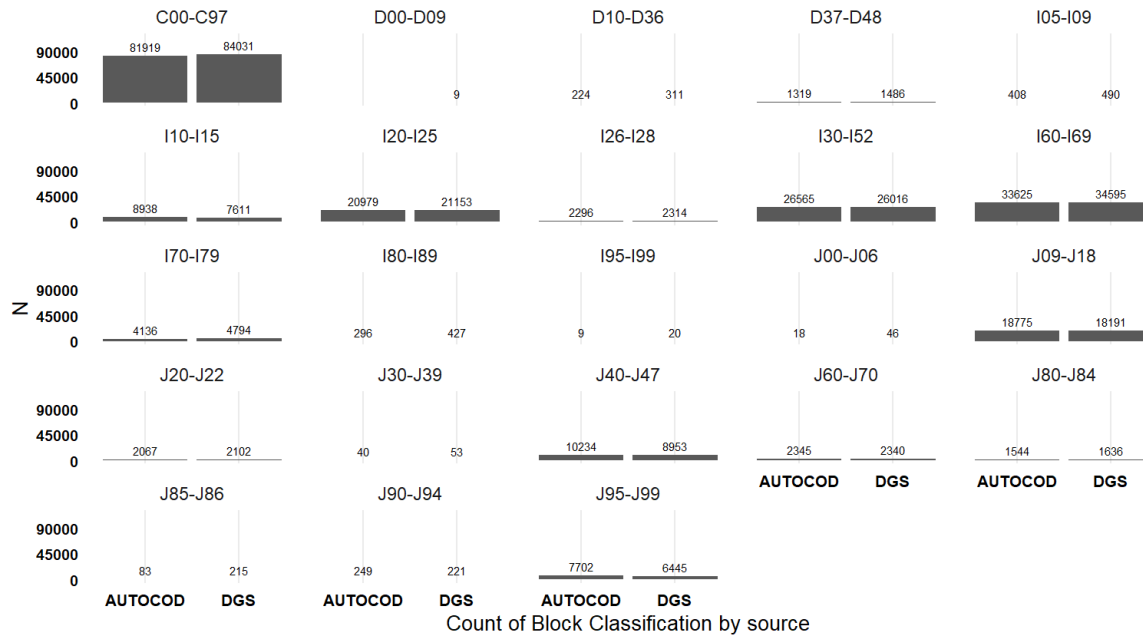
| Chapter | Block | Block Description | N | % |
|---------|---------|--|--------|-------|
| II | C00-C97 | Malignant neoplasms | 84 031 | 25.46 |
| IX | I60-I69 | Cerebrovascular diseases | 34 595 | 10.48 |
| IX | I30-I52 | Other forms of heart disease | 26 016 | 7.88 |
| IX | I20-I25 | Ischaemic heart diseases | 21 153 | 6.41 |
| X | J09-J18 | Influenza and pneumonia | 18 191 | 5.51 |
| IV | E10-E14 | Diabetes mellitus | 12 731 | 3.86 |
| V | F00-F09 | Organic, including symptomatic, mental disorders | 12 150 | 3.68 |
| X | J40-J47 | Chronic lower respiratory diseases | 8 953 | 2.71 |
| XX | V01-X59 | Accidents | 8 509 | 2.58 |
| IX | I10-I15 | Hypertensive diseases | 7 611 | 2.31 |
| X | J95-J99 | Other diseases of the respiratory system | 6 445 | 1.95 |
| XVIII | R50-R69 | General symptoms and signs | 6 022 | 1.82 |
| XVIII | R00-R09 | Symptoms and signs involving the circulatory and respiratory systems | 5 799 | 1.76 |
| VI | G30-G32 | Other degenerative diseases of the nervous system | 5 428 | 1.64 |
| IX | I70-I79 | Diseases of arteries, arterioles and capillaries | 4 794 | 1.45 |
| XI | K70-K77 | Diseases of liver | 4 574 | 1.39 |
| XIV | N30-N39 | Other diseases of the urinary system | 4 461 | 1.35 |
| XVIII | R95-R99 | Ill-defined and unknown cause of mortality | 4 385 | 1.33 |
| XI | K55-K64 | Other diseases of intestines | 4 218 | 1.28 |
| XIV | N17-N19 | Acute kidney failure and chronic kidney disease | 3 998 | 1.21 |
| I | A30-A49 | Other bacterial diseases | 3 066 | 0.93 |
| VI | G20-G26 | Extrapyramidal and movement disorders | 2 862 | 0.87 |
| XX | X60-X84 | Intentional self-harm | 2 808 | 0.85 |
| XI | K80-K87 | Disorders of gallbladder, biliary tract and pancreas | 2 345 | 0.71 |
| X | J60-J70 | Lung diseases due to external agents | 2 340 | 0.71 |
| IX | I26-I28 | Pulmonary heart disease and diseases of pulmonary circulation | 2 314 | 0.70 |
| IV | E70-E90 | Metabolic disorders | 2 302 | 0.70 |
| X | J20-J22 | Other acute lower respiratory infections | 2 102 | 0.64 |
| XX | Y10-Y34 | Event of undetermined intent | 1 819 | 0.55 |
| X | J80-J84 | Other respiratory diseases principally affecting the interstitium | 1 636 | 0.50 |
| II | D37-D48 | Neoplasms of uncertain or unknown behaviour | 1 486 | 0.45 |
| VI | G40-G47 | Episodic and paroxysmal disorders | 1 105 | 0.33 |
| XI | K90-K93 | Other diseases of the digestive system | 1 049 | 0.32 |
| XIV | N10-N16 | Renal tubulo-interstitial diseases | 1 032 | 0.31 |
| I | B20-B24 | Human immunodeficiency virus [HIV] disease | 961 | 0.29 |
| VI | G10-G14 | Systemic atrophies primarily affecting the central nervous system | 942 | 0.29 |
| XI | K20-K31 | Diseases of oesophagus, stomach and duodenum | 921 | 0.28 |
| IV | E65-E68 | Obesity and other hyperalimentation | 758 | 0.23 |
| I | A00-A09 | Intestinal infectious diseases | 682 | 0.21 |
| NA | D60-D64 | Aplastic and other anaemias | 644 | 0.20 |
| XI | K50-K52 | Noninfective enteritis and colitis | 634 | 0.19 |
| XI | K65-K67 | Diseases of peritoneum | 605 | 0.18 |
| IX | I05-I09 | Chronic rheumatic heart diseases | 490 | 0.15 |
| XI | K40-K46 | Hernia | 477 | 0.14 |
| XX | Y40-Y84 | Complications of medical and surgical care | 475 | 0.14 |
| XIII | M00-M25 | Arthropathies | 434 | 0.13 |
| IX | I80-I89 | Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified | 427 | 0.13 |
| VI | G90-G99 | Other disorders of the nervous system | 398 | 0.12 |
| XIII | M30-M36 | Systemic connective tissue disorders | 359 | 0.11 |
| I | A15-A19 | Tuberculosis | 345 | 0.10 |

Supplementary Table 36 - Distribution of death certificates in the dataset, according to ICD-10 block (descendent order, for the three most common chapters – II, IX and X), for all periods

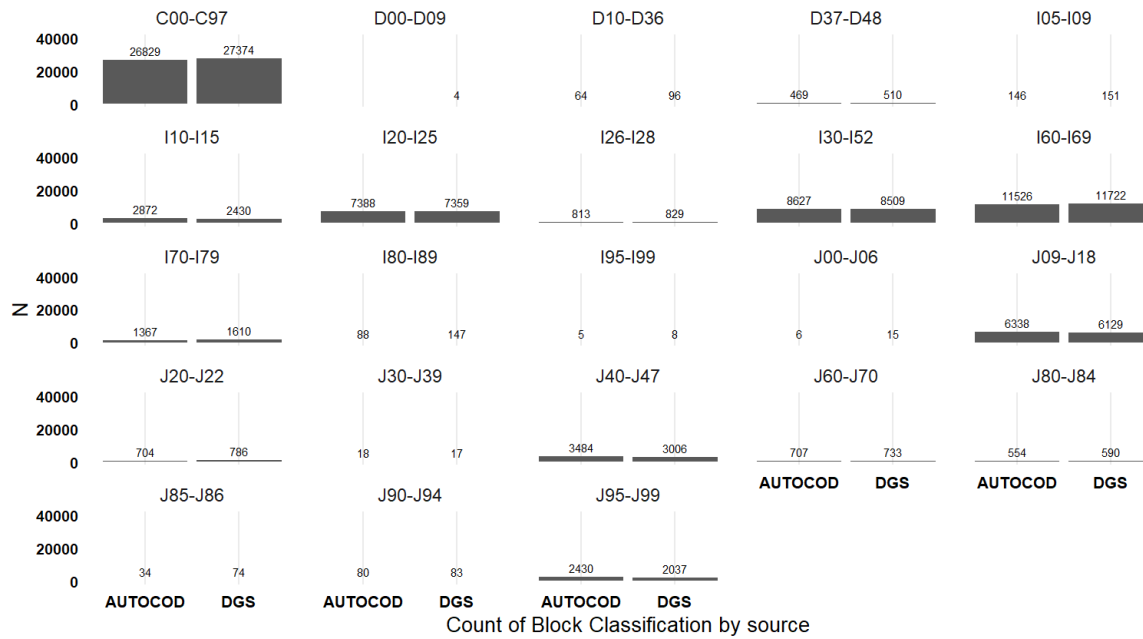
| Chapter | Block | Block Description | N | % |
|-----------|-------------|--|--------|-------|
| II | C00- C97 | Malignant neoplasms | 84 031 | 37.60 |
| IX | I60-I69 | Cerebrovascular diseases | 34 595 | 15.48 |
| IX | I30-I52 | Other forms of heart disease | 26 016 | 11.64 |
| IX | I20-I25 | Ischaemic heart diseases | 21 153 | 9.47 |
| X | J09-J18 | Influenza and pneumonia | 18 191 | 8.14 |
| X | J40-J47 | Chronic lower respiratory diseases | 8 953 | 4.01 |
| IX | I10-I15 | Hypertensive diseases | 7 611 | 3.41 |
| X | J95-J99 | Other diseases of the respiratory system | 6 445 | 2.88 |
| IX | I70-I79 | Diseases of arteries, arterioles and capillaries | 4 794 | 2.15 |
| X | J60-J70 | Lung diseases due to external agents | 2 340 | 1.05 |
| IX | I26-I28 | Pulmonary heart disease and diseases of pulmonary circulation | 2 314 | 1.04 |
| X | J20-J22 | Other acute lower respiratory infections | 2 102 | 0.94 |
| X | J80-J84 | Other respiratory diseases principally affecting the interstitium | 1 636 | 0.73 |
| II | D37- D48 | Neoplasms of uncertain or unknown behaviour | 1 486 | 0.66 |
| IX | I05-I09 | Chronic rheumatic heart diseases | 490 | 0.22 |
| IX | I80-I89 | Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified | 427 | 0.19 |
| II | D10- D36 | Benign neoplasms | 311 | 0.14 |
| X | J90-J94 | Other diseases of pleura | 221 | 0.10 |
| X | J85-J86 | Suppurative and necrotic conditions of lower respiratory tract | 215 | 0.10 |
| X | J30-J39 | Other diseases of upper respiratory tract | 53 | 0.02 |
| X | J00-J06 | Acute upper respiratory infections | 46 | 0.02 |
| IX | I95-I99 | Other and unspecified disorders of the circulatory system | 20 | 0.01 |
| II | D00- D09 | In situ neoplasms | 9 | 0.00 |

Supplementary Table 37 - Distribution of death certificates in the dataset, according to ICD-10 block (descendent order, for the three most common chapters – II, IX and X), for all periods

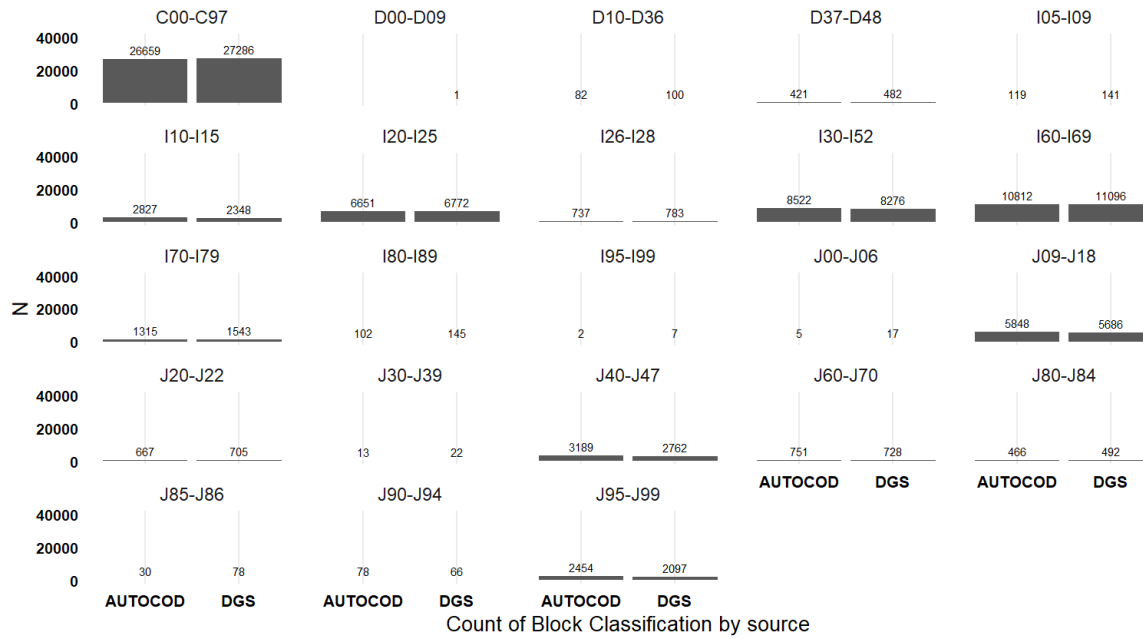
| Year of Death | Chapter | Block | Block Description | N | % |
|---------------|---------|---------|---|--------|-------|
| 2018 | II | C00-C97 | Malignant neoplasms | 27 710 | 12.40 |
| 2016 | II | C00-C97 | Malignant neoplasms | 27 374 | 12.25 |
| 2017 | II | C00-C97 | Malignant neoplasms | 27 286 | 12.21 |
| 2016 | IX | I60-I69 | Cerebrovascular diseases | 11 722 | 5.25 |
| 2017 | IX | I60-I69 | Cerebrovascular diseases | 11 096 | 4.97 |
| 2018 | IX | I60-I69 | Cerebrovascular diseases | 11 019 | 4.93 |
| 2018 | IX | I30-I52 | Other forms of heart disease | 8 564 | 3.83 |
| 2016 | IX | I30-I52 | Other forms of heart disease | 8 509 | 3.81 |
| 2017 | IX | I30-I52 | Other forms of heart disease | 8 276 | 3.70 |
| 2016 | IX | I20-I25 | Ischaemic heart diseases | 7 359 | 3.29 |
| 2017 | IX | I20-I25 | Ischaemic heart diseases | 6 772 | 3.03 |
| 2018 | IX | I20-I25 | Ischaemic heart diseases | 6 513 | 2.91 |
| 2016 | X | J09-J18 | Influenza and pneumonia | 6 129 | 2.74 |
| 2018 | X | J09-J18 | Influenza and pneumonia | 5 915 | 2.65 |
| 2017 | X | J09-J18 | Influenza and pneumonia | 5 686 | 2.54 |
| 2016 | X | J40-J47 | Chronic lower respiratory diseases | 3 006 | 1.35 |
| 2018 | X | J40-J47 | Chronic lower respiratory diseases | 2 977 | 1.33 |
| 2017 | X | J40-J47 | Chronic lower respiratory diseases | 2 762 | 1.24 |
| 2018 | IX | I10-I15 | Hypertensive diseases | 2 631 | 1.18 |
| 2016 | IX | I10-I15 | Hypertensive diseases | 2 430 | 1.09 |
| 2017 | IX | I10-I15 | Hypertensive diseases | 2 348 | 1.05 |
| 2018 | X | J95-J99 | Other diseases of the respiratory system | 2 148 | 0.96 |
| 2017 | X | J95-J99 | Other diseases of the respiratory system | 2 097 | 0.94 |
| 2016 | X | J95-J99 | Other diseases of the respiratory system | 2 037 | 0.91 |
| 2019 | II | C00-C97 | Malignant neoplasms | 1 661 | 0.74 |
| 2016 | IX | I70-I79 | Diseases of arteries, arterioles and capillaries | 1 610 | 0.72 |
| 2018 | IX | I70-I79 | Diseases of arteries, arterioles and capillaries | 1 558 | 0.70 |
| 2017 | IX | I70-I79 | Diseases of arteries, arterioles and capillaries | 1 543 | 0.69 |
| 2018 | X | J60-J70 | Lung diseases due to external agents | 830 | 0.37 |
| 2016 | X | I26-I28 | Pulmonary heart disease and diseases of pulmonary circulation | 829 | 0.37 |
| 2016 | X | J20-J22 | Other acute lower respiratory infections | 786 | 0.35 |
| 2017 | X | I26-I28 | Pulmonary heart disease and diseases of pulmonary circulation | 783 | 0.35 |
| 2019 | IX | I60-I69 | Cerebrovascular diseases | 758 | 0.34 |
| 2016 | X | J60-J70 | Lung diseases due to external agents | 733 | 0.33 |
| 2017 | X | J60-J70 | Lung diseases due to external agents | 728 | 0.33 |
| 2017 | X | J20-J22 | Other acute lower respiratory infections | 705 | 0.32 |
| 2019 | IX | I30-I52 | Other forms of heart disease | 667 | 0.30 |
| 2018 | X | I26-I28 | Pulmonary heart disease and diseases of pulmonary circulation | 661 | 0.30 |
| 2016 | X | J80-J84 | Other respiratory diseases principally affecting the interstitium | 590 | 0.26 |
| 2018 | X | J20-J22 | Other acute lower respiratory infections | 587 | 0.26 |
| 2016 | II | D37-D48 | Neoplasms of uncertain or unknown behaviour | 510 | 0.23 |
| 2019 | IX | I20-I25 | Ischaemic heart diseases | 509 | 0.23 |
| 2018 | X | J80-J84 | Other respiratory diseases principally affecting the interstitium | 504 | 0.23 |



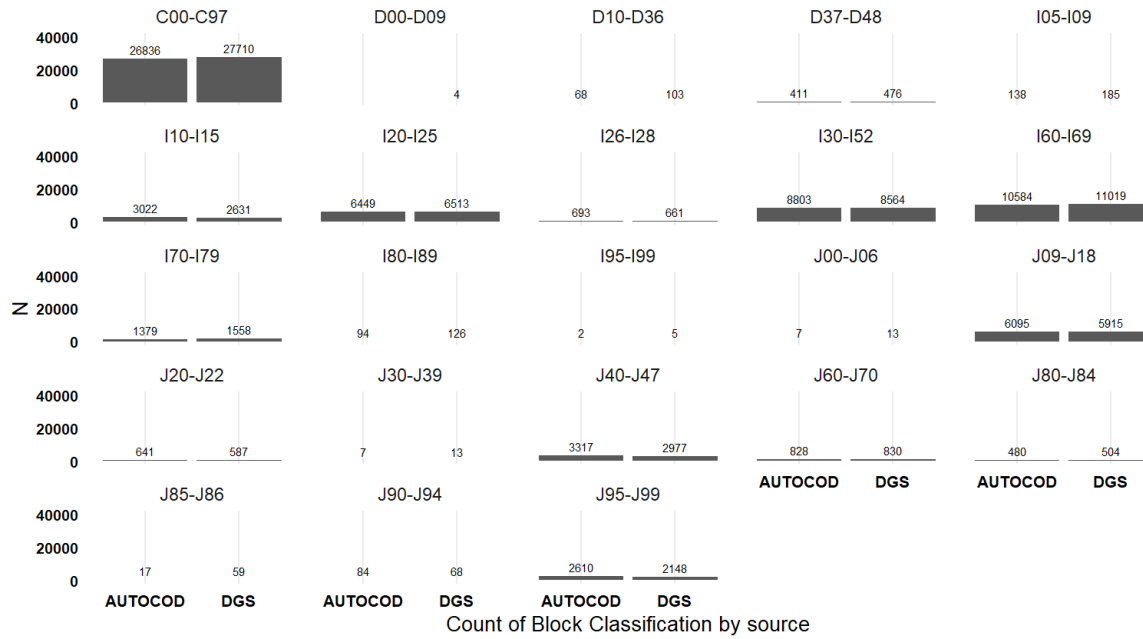
Supplementary Figure 20 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in all periods



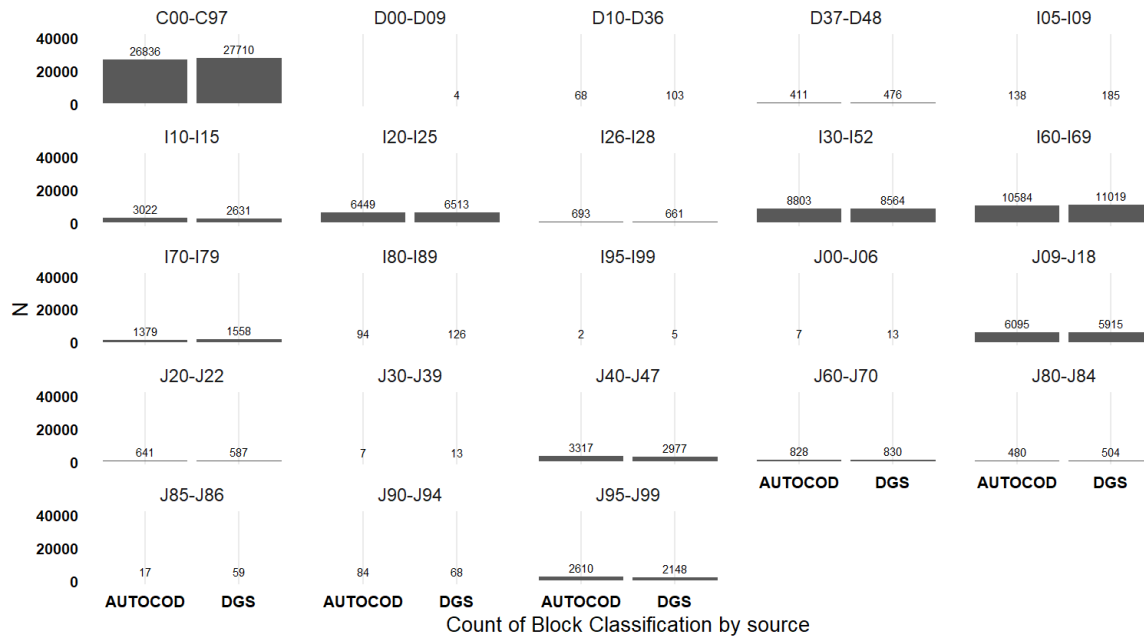
Supplementary Figure 21 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in 2016



Supplementary Figure 22 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in 2017



Supplementary Figure 23 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in 2018

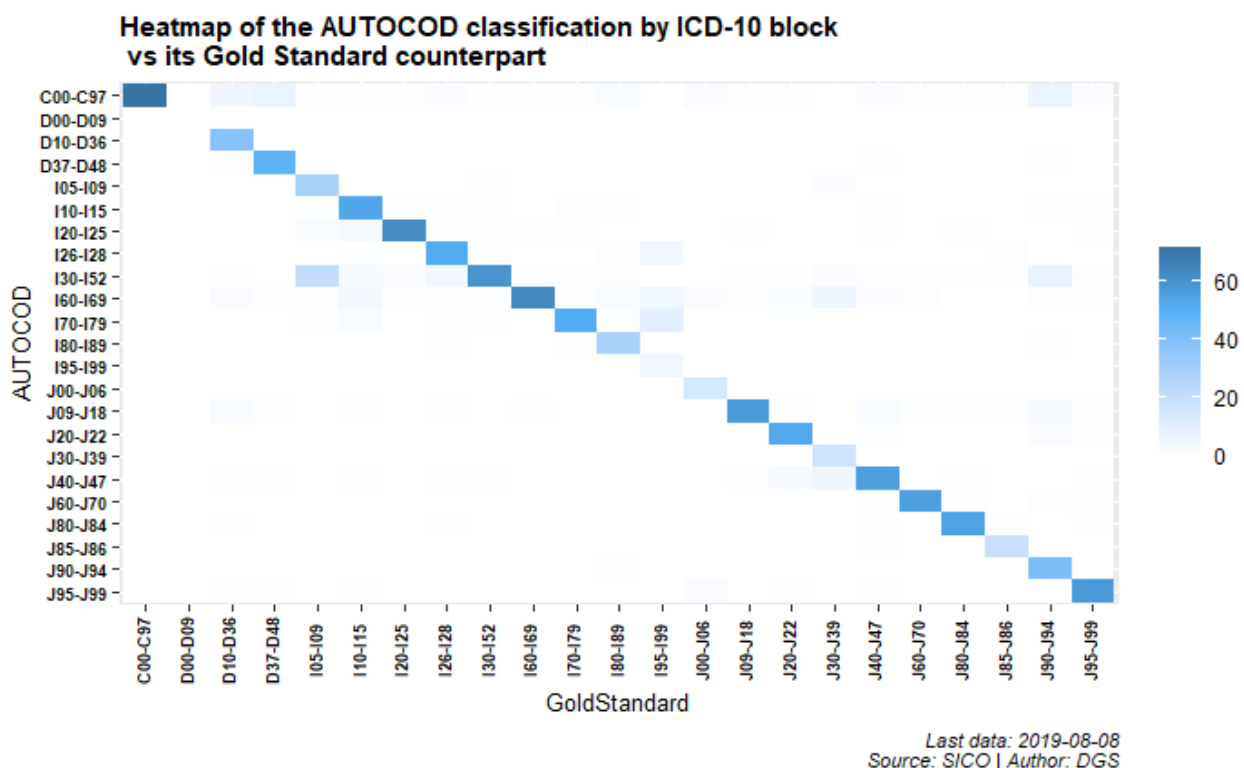


Supplementary Figure 24 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in 2019

Supplementary Table 38 - Confusion matrix for ICD-10 block classification, all periods

| | C00-C97 | D00-D09 | D10-D36 | D37-D48 | I05-I09 | I10-I15 | I20-I25 | I26-I28 | I30-I52 | I60-I69 | I70-I79 | I80-I89 | I95-I99 | J00-J06 | J09-J18 | J20-J22 | J30-J39 | J40-J47 | J60-J70 | J80-J84 | J85-J86 | J90-J94 | J95-J99 |
|---------|-----------|---------|---------|---------|---------|----------|-----------|----------|-----------|-----------|----------|---------|---------|---------|-----------|----------|---------|----------|----------|----------|---------|---------|----------|
| C00-C97 | 79 941 | 3 | 29 | 181 | 3 | 44 | 67 | 15 | 110 | 112 | 23 | 17 | 0 | 1 | 63 | 15 | 1 | 42 | 17 | 12 | 1 | 4 | 17 |
| D00-D09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| D10-D36 | 23 | 0 | 162 | 3 | 0 | 0 | 0 | 0 | 1 | 8 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| D37-D48 | 151 | 0 | 0 | 983 | 2 | 3 | 2 | 0 | 5 | 11 | 1 | 0 | 0 | 0 | 11 | 0 | 1 | 9 | 0 | 4 | 0 | 1 | 8 |
| I05-I09 | 5 | 0 | 0 | 0 | 191 | 9 | 15 | 0 | 135 | 8 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 |
| I10-I15 | 104 | 0 | 5 | 8 | 12 | 5 830 | 368 | 83 | 301 | 470 | 227 | 13 | 0 | 0 | 55 | 1 | 0 | 89 | 29 | 24 | 0 | 4 | 54 |
| I20-I25 | 105 | 1 | 4 | 10 | 18 | 94 | 18 661 | 72 | 504 | 203 | 82 | 18 | 2 | 0 | 43 | 9 | 1 | 75 | 3 | 9 | 2 | 4 | 31 |
| I26-I28 | 50 | 0 | 1 | 5 | 8 | 29 | 36 | 1 718 | 148 | 14 | 21 | 16 | 0 | 0 | 8 | 0 | 0 | 28 | 2 | 14 | 0 | 5 | 11 |
| I30-I52 | 201 | 0 | 0 | 14 | 198 | 461 | 532 | 121 | 22 399 | 313 | 250 | 21 | 3 | 0 | 78 | 19 | 0 | 181 | 13 | 30 | 11 | 19 | 85 |
| I60-I69 | 191 | 0 | 17 | 30 | 8 | 127 | 177 | 23 | 413 | 30 518 | 94 | 14 | 2 | 2 | 193 | 131 | 5 | 106 | 43 | 15 | 8 | 5 | 83 |
| I70-I79 | 70 | 0 | 0 | 2 | 1 | 76 | 54 | 16 | 59 | 77 | 3 363 | 28 | 6 | 0 | 10 | 2 | 0 | 2 | 1 | 0 | 2 | 0 | 8 |
| I80-I89 | 14 | 0 | 1 | 0 | 0 | 2 | 3 | 9 | 8 | 10 | 5 | 177 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 |
| I95-I99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| J00-J06 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| J09-J18 | 289 | 0 | 6 | 30 | 3 | 38 | 101 | 32 | 108 | 215 | 25 | 1 | 1 | 2 | 16 062 | 11 | 1 | 134 | 40 | 30 | 43 | 9 | 49 |
| J20-J22 | 32 | 0 | 0 | 1 | 1 | 3 | 3 | 0 | 12 | 52 | 5 | 0 | 0 | 1 | 12 | 1 660 | 0 | 103 | 2 | 1 | 1 | 0 | 21 |
| J30-J39 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 3 | 0 | 0 | 0 | 0 | 0 |
| J40-J47 | 233 | 0 | 1 | 52 | 0 | 58 | 80 | 36 | 177 | 186 | 7 | 4 | 0 | 3 | 372 | 99 | 3 | 7 633 | 64 | 71 | 42 | 5 | 94 |
| J60-J70 | 27 | 1 | 0 | 3 | 0 | 7 | 2 | 1 | 10 | 53 | 3 | 0 | 0 | 0 | 36 | 0 | 2 | 8 | 1 842 | 5 | 0 | 1 | 6 |
| J80-J84 | 26 | 0 | 1 | 1 | 0 | 8 | 16 | 10 | 33 | 1 | 0 | 2 | 0 | 0 | 24 | 4 | 1 | 14 | 25 | 1 245 | 1 | 0 | 9 |
| J85-J86 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 60 | 0 | 0 |
| J90-J94 | 21 | 0 | 0 | 3 | 0 | 1 | 1 | 0 | 25 | 3 | 0 | 1 | 0 | 0 | 12 | 5 | 0 | 0 | 4 | 1 | 0 | 126 | 0 |
| J95-J99 | 164 | 0 | 5 | 5 | 0 | 39 | 56 | 21 | 139 | 134 | 14 | 10 | 1 | 14 | 119 | 42 | 1 | 128 | 55 | 54 | 13 | 3 | 5 508 |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system



Supplementary Figure 25 - Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart. Values on the diagonal represent correct classifications, during all period

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Supplementary Table 39 - Overall performance metrics of AUTOCOD when classifying by ICD-10 block, all periods

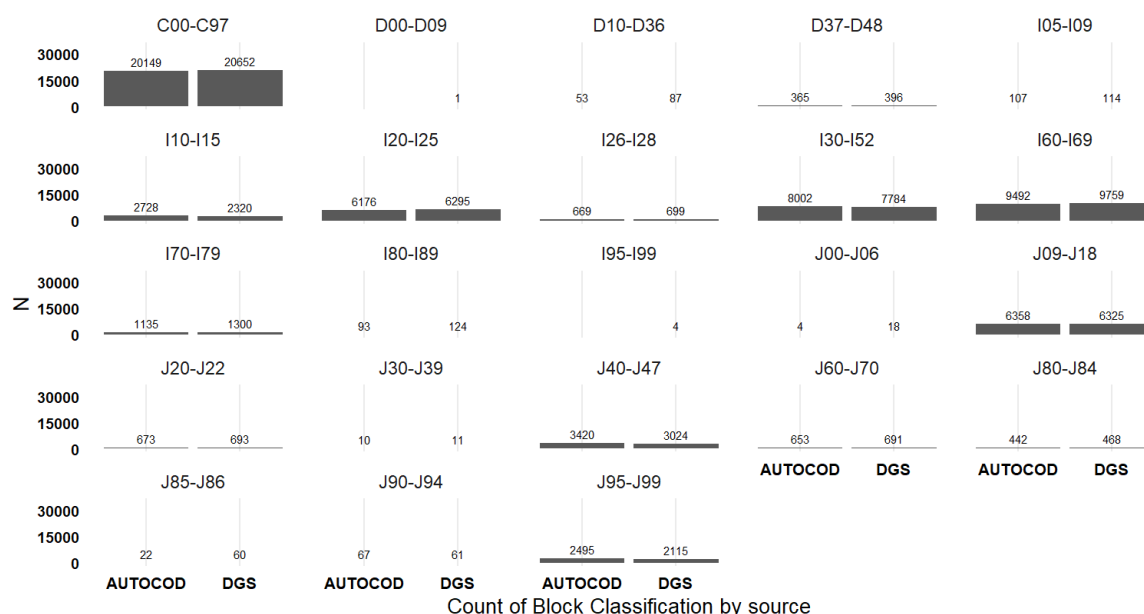
| | |
|-----------------------|------|
| Accuracy | 0.93 |
| Kappa | 0.92 |
| AccuracyLower | 0.93 |
| AccuracyUpper | 0.94 |
| AccuracyNull | 0.39 |
| AccuracyPValue | 0.00 |

Supplementary Table 40 - Performance Metrics of AUTOCOD by ICD-10 block, all periods

| Block | Sensitivity | Specificity | Pos Pred Value | Neg Pred Value | F1 | Prevalence | Detection Rate | Detection Prevalence | Balanced Accuracy |
|---------|-------------|-------------|----------------|----------------|------|------------|----------------|----------------------|-------------------|
| C00-C97 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.39 | 0.38 | 0.38 | 0.99 |
| D00-D09 | 0.00 | 1.00 | NaN | 1.00 | NA | 0.00 | 0.00 | 0.00 | 0.50 |
| D10-D36 | 0.70 | 1.00 | 0.78 | 1.00 | 0.74 | 0.00 | 0.00 | 0.00 | 0.85 |
| D37-D48 | 0.74 | 1.00 | 0.83 | 1.00 | 0.78 | 0.01 | 0.01 | 0.01 | 0.87 |
| I05-I09 | 0.43 | 1.00 | 0.51 | 1.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.71 |
| I10-I15 | 0.85 | 0.99 | 0.76 | 1.00 | 0.80 | 0.03 | 0.03 | 0.04 | 0.92 |
| I20-I25 | 0.93 | 0.99 | 0.94 | 0.99 | 0.93 | 0.10 | 0.09 | 0.09 | 0.96 |
| I26-I28 | 0.80 | 1.00 | 0.81 | 1.00 | 0.80 | 0.01 | 0.01 | 0.01 | 0.90 |
| I30-I52 | 0.91 | 0.99 | 0.90 | 0.99 | 0.90 | 0.12 | 0.11 | 0.12 | 0.95 |
| I60-I69 | 0.94 | 0.99 | 0.95 | 0.99 | 0.95 | 0.15 | 0.14 | 0.15 | 0.97 |
| I70-I79 | 0.82 | 1.00 | 0.89 | 1.00 | 0.85 | 0.02 | 0.02 | 0.02 | 0.91 |
| I80-I89 | 0.55 | 1.00 | 0.75 | 1.00 | 0.63 | 0.00 | 0.00 | 0.00 | 0.77 |
| I95-I99 | 0.06 | 1.00 | 0.20 | 1.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.53 |
| J00-J06 | 0.26 | 1.00 | 0.62 | 1.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.63 |
| J09-J18 | 0.94 | 0.99 | 0.93 | 1.00 | 0.94 | 0.08 | 0.08 | 0.08 | 0.97 |
| J20-J22 | 0.83 | 1.00 | 0.87 | 1.00 | 0.85 | 0.01 | 0.01 | 0.01 | 0.92 |
| J30-J39 | 0.39 | 1.00 | 0.48 | 1.00 | 0.43 | 0.00 | 0.00 | 0.00 | 0.69 |
| J40-J47 | 0.89 | 0.99 | 0.83 | 1.00 | 0.86 | 0.04 | 0.04 | 0.04 | 0.94 |
| J60-J70 | 0.86 | 1.00 | 0.92 | 1.00 | 0.89 | 0.01 | 0.01 | 0.01 | 0.93 |
| J80-J84 | 0.82 | 1.00 | 0.88 | 1.00 | 0.85 | 0.01 | 0.01 | 0.01 | 0.91 |
| J85-J86 | 0.32 | 1.00 | 0.85 | 1.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.66 |
| J90-J94 | 0.67 | 1.00 | 0.62 | 1.00 | 0.65 | 0.00 | 0.00 | 0.00 | 0.84 |
| J95-J99 | 0.92 | 1.00 | 0.84 | 1.00 | 0.88 | 0.03 | 0.03 | 0.03 | 0.96 |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Periods of excess mortality

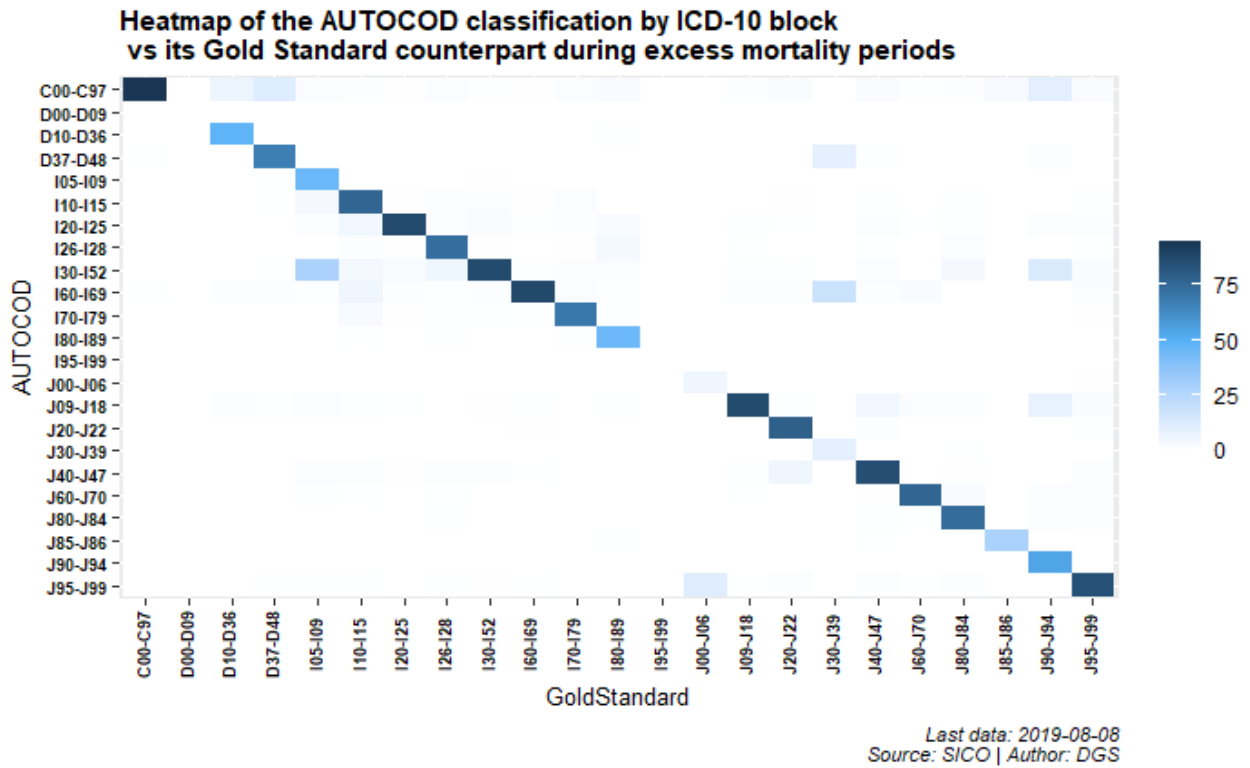


Supplementary Figure 26 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in periods of excess mortality

Supplementary Table 41 - Confusion matrix for ICD-10 block classification, excess mortality periods

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | | | | | |
|---------|-------------|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| | | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 | |
| AUTOCOD | C00- C97 | ##### | 0 | 9 | 53 | 0 | 12 | 27 | 5 | 35 | 41 | 9 | 6 | 0 | 0 | 26 | 5 | 1 | 13 | 6 | 1 | 0 | 1 | 4 | |
| | D00- D09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | D10- D36 | 6 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | D37- D48 | 47 | 0 | 0 | 267 | 1 | 1 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | I05- I09 | 2 | 0 | 0 | 0 | 52 | 4 | 2 | 0 | 32 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| | I10- I15 | 34 | 0 | 1 | 1 | 4 | 1,775 | 117 | 27 | 88 | 135 | 70 | 6 | 0 | 0 | 18 | 1 | 0 | 28 | 7 | 4 | 0 | 1 | 18 | |
| | I20- I25 | 28 | 0 | 0 | 3 | 4 | 28 | 5,493 | 22 | 144 | 68 | 23 | 5 | 1 | 0 | 18 | 3 | 1 | 31 | 1 | 1 | 2 | 0 | 6 | |
| | I26- I28 | 12 | 0 | 0 | 0 | 1 | 9 | 12 | 513 | 41 | 4 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 10 | 2 | 5 | 0 | 1 | 5 | |
| | I30- I52 | 52 | 0 | 0 | 4 | 41 | 132 | 161 | 39 | 6,761 | 104 | 56 | 10 | 0 | 0 | 26 | 8 | 0 | 73 | 5 | 10 | 3 | 7 | 32 | |
| | I60- I69 | 47 | 0 | 4 | 7 | 1 | 32 | 56 | 3 | 90 | 8,602 | 29 | 3 | 1 | 1 | 68 | 38 | 1 | 27 | 13 | 5 | 2 | 3 | 18 | |
| | I70- I79 | 23 | 0 | 0 | 0 | 1 | 24 | 14 | 6 | 17 | 22 | 908 | 8 | 2 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| | I80- I89 | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 5 | 2 | 1 | 1 | 56 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | I95- I99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J00- J06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | J09- J18 | 89 | 0 | 2 | 10 | 1 | 11 | 34 | 12 | 37 | 64 | 5 | 0 | 0 | 1 | 5,506 | 5 | 0 | 43 | 14 | 7 | 11 | 2 | 13 | |
| | J20- J22 | 14 | 0 | 0 | 1 | 0 | 3 | 2 | 0 | 5 | 9 | 1 | 0 | 0 | 0 | 5 | 546 | 0 | 40 | 1 | 0 | 0 | 0 | 7 | |
| | J30- J39 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| | J40- J47 | 66 | 0 | 0 | 17 | 0 | 22 | 33 | 9 | 58 | 39 | 0 | 2 | 0 | 2 | 149 | 35 | 1 | 2,594 | 16 | 23 | 9 | 0 | 35 | |
| | J60- J70 | 4 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 17 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 1 | 530 | 2 | 0 | 0 | 2 | |
| | J80- J84 | 5 | 0 | 0 | 0 | 0 | 3 | 3 | 5 | 16 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 1 | 2 | 11 | 349 | 0 | 0 | 5 | |
| | J85- J86 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | |
| | J90- J94 | 6 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 1 | 0 | 33 | 0 | |
| | J95- J99 | 49 | 0 | 2 | 2 | 0 | 15 | 25 | 5 | 44 | 41 | 7 | 3 | 0 | 9 | 47 | 15 | 0 | 37 | 21 | 22 | 3 | 0 | 1,790 | |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system



Supplementary Figure 27 - Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart. Values on the diagonal represent correct classifications, during excess mortality periods

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Supplementary Table 42 - Overall performance metrics of AUTOCOD when classifying by ICD-10 block, excess mortality periods

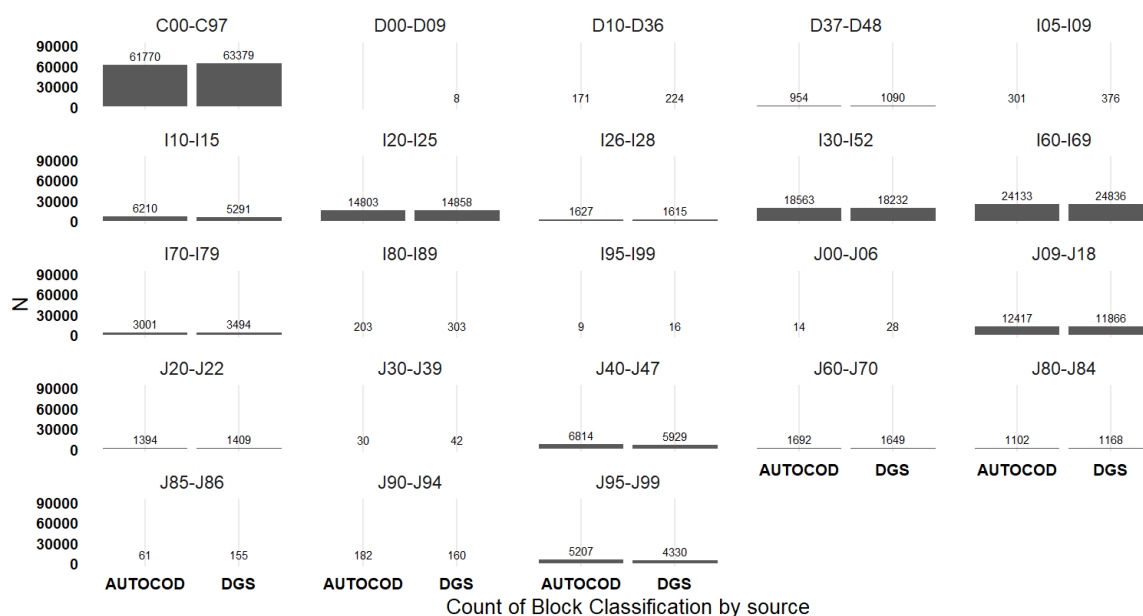
| | |
|-----------------------|------|
| Accuracy | 0.93 |
| Kappa | 0.91 |
| AccuracyLower | 0.93 |
| AccuracyUpper | 0.93 |
| AccuracyNull | 0.34 |
| AccuracyPValue | 0.00 |

Supplementary Table 43 - Performance Metrics of AUTOCOD by ICD-10 block, excess mortality periods

| | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Sensitivity | 0.98 | NA | 0.69 | 0.73 | 0.49 | 0.86 | 0.92 | 0.79 | 0.92 | 0.94 | 0.82 | 0.54 | 0.00 | 0.07 | 0.93 | 0.83 | 0.17 | 0.89 | 0.84 | 0.81 | 0.35 | 0.69 | 0.92 |
| Specificity | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| Pos Pred Value | 0.99 | NA | 0.84 | 0.82 | 0.53 | 0.76 | 0.93 | 0.82 | 0.90 | 0.95 | 0.88 | 0.76 | NaN | 0.33 | 0.94 | 0.86 | 0.25 | 0.83 | 0.93 | 0.85 | 0.90 | 0.59 | 0.84 |
| Neg Pred Value | 0.99 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.98 | NA | 0.76 | 0.77 | 0.51 | 0.81 | 0.93 | 0.80 | 0.91 | 0.95 | 0.85 | 0.63 | NA | 0.12 | 0.94 | 0.85 | 0.20 | 0.86 | 0.88 | 0.83 | 0.51 | 0.64 | 0.88 |
| Prevalence | 0.34 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.10 | 0.01 | 0.12 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.10 | 0.01 | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Detection Rate | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.09 | 0.01 | 0.11 | 0.14 | 0.02 | 0.00 | 0.00 | 0.00 | 0.09 | 0.01 | 0.00 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Detection Prevalence | 0.33 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.10 | 0.01 | 0.13 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.10 | 0.01 | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 |
| Balanced Accuracy | 0.99 | NA | 0.84 | 0.86 | 0.75 | 0.92 | 0.96 | 0.89 | 0.95 | 0.97 | 0.91 | 0.77 | 0.50 | 0.54 | 0.96 | 0.92 | 0.58 | 0.94 | 0.92 | 0.91 | 0.68 | 0.84 | 0.96 |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Periods without excess mortality

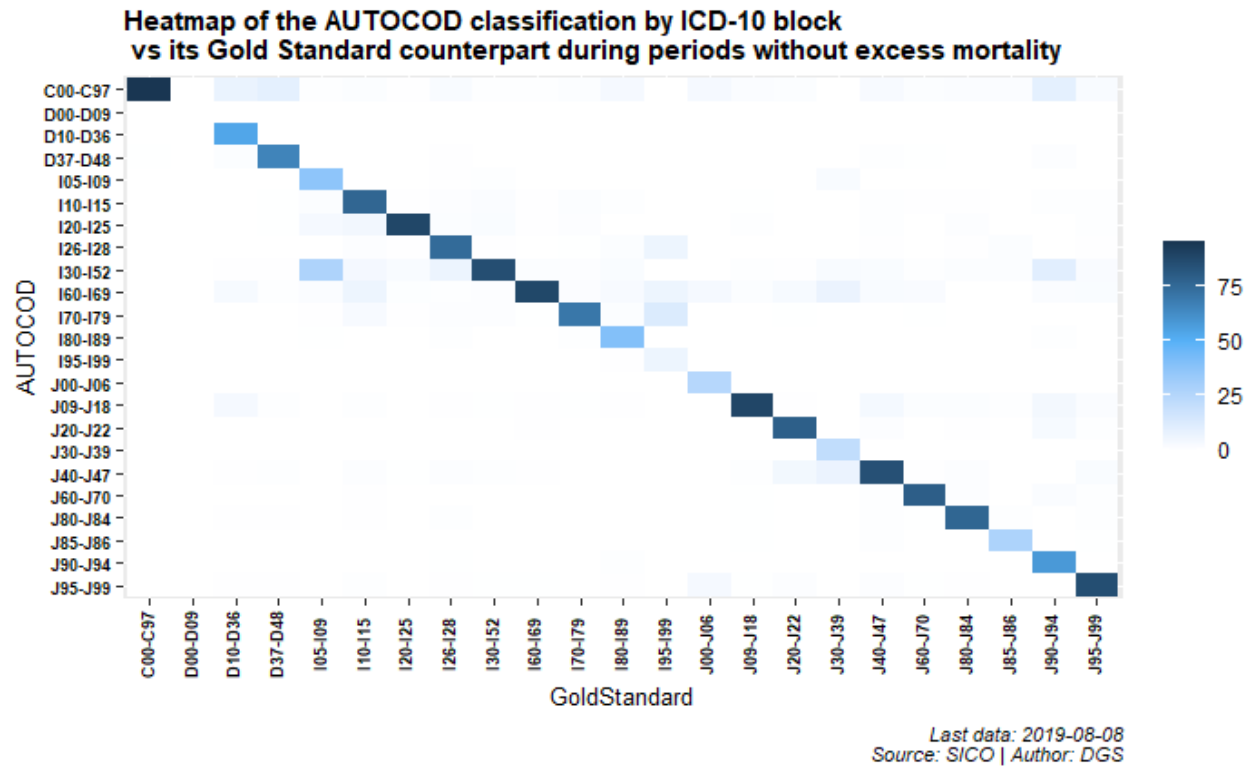


Supplementary Figure 28 - Count of death certificates classified by ICD-10 block either by human coders (DGS) or by AUTOCOD, in periods without excess mortality

Supplementary Table 44 - Confusion matrix for ICD-10 block classification, periods without excess mortality

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | | | | | |
|---------|-------------|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| | | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 | |
| AUTOCOD | C00- C97 | ##### | 3 | 20 | 128 | 3 | 32 | 40 | 10 | 75 | 71 | 14 | 11 | 0 | 1 | 37 | 10 | 0 | 29 | 11 | 11 | 1 | 3 | 13 | |
| | D00- D09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | D10- D36 | 17 | 0 | 120 | 3 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | |
| | D37- D48 | 104 | 0 | 0 | 716 | 1 | 2 | 2 | 0 | 4 | 7 | 1 | 0 | 0 | 0 | 8 | 0 | 1 | 9 | 0 | 4 | 0 | 1 | 5 | |
| | I05- I09 | 3 | 0 | 0 | 0 | 139 | 5 | 13 | 0 | 103 | 7 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | I10- I15 | 70 | 0 | 4 | 7 | 8 | 4,055 | 251 | 56 | 213 | 335 | 157 | 7 | 0 | 0 | 37 | 0 | 0 | 61 | 22 | 20 | 0 | 3 | 36 | |
| | I20- I25 | 77 | 1 | 4 | 7 | 14 | 66 | 13,168 | 50 | 360 | 135 | 59 | 13 | 1 | 0 | 25 | 6 | 0 | 44 | 2 | 8 | 0 | 4 | 25 | |
| | I26- I28 | 38 | 0 | 1 | 5 | 7 | 20 | 24 | 1,205 | 107 | 10 | 16 | 11 | 0 | 0 | 8 | 0 | 0 | 18 | 0 | 9 | 0 | 4 | 6 | |
| | I30- I52 | 149 | 0 | 0 | 10 | 157 | 329 | 371 | 82 | 15,638 | 209 | 194 | 11 | 3 | 0 | 52 | 11 | 0 | 108 | 8 | 20 | 8 | 12 | 53 | |
| | I60- I69 | 144 | 0 | 13 | 23 | 7 | 95 | 121 | 20 | 323 | 21,916 | 65 | 11 | 1 | 1 | 125 | 93 | 4 | 79 | 30 | 10 | 6 | 2 | 65 | |
| | I70- I79 | 47 | 0 | 0 | 2 | 0 | 52 | 40 | 10 | 42 | 55 | 2,455 | 20 | 4 | 0 | 8 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 6 |
| | I80- I89 | 11 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 6 | 9 | 4 | 121 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| | I95- I99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J00- J06 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | J09- J18 | 200 | 0 | 4 | 20 | 2 | 27 | 67 | 20 | 71 | 151 | 20 | 1 | 1 | 1 | 10,556 | 6 | 1 | 91 | 26 | 23 | 32 | 7 | 36 | |
| | J20- J22 | 18 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 7 | 43 | 4 | 0 | 0 | 1 | 7 | 1,114 | 0 | 63 | 1 | 1 | 1 | 0 | 14 | |
| | J30- J39 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 0 | 0 | 0 | 0 | |
| | J40- J47 | 167 | 0 | 1 | 35 | 0 | 36 | 47 | 27 | 119 | 147 | 7 | 2 | 0 | 1 | 223 | 64 | 2 | 5,039 | 48 | 48 | 33 | 5 | 59 | |
| | J60- J70 | 23 | 1 | 0 | 3 | 0 | 6 | 0 | 1 | 9 | 36 | 3 | 0 | 0 | 0 | 25 | 0 | 2 | 7 | 1,312 | 3 | 0 | 1 | 4 | |
| | J80- J84 | 21 | 0 | 1 | 1 | 0 | 5 | 13 | 5 | 17 | 1 | 0 | 2 | 0 | 0 | 15 | 4 | 0 | 12 | 14 | 896 | 1 | 0 | 4 | |
| | J85- J86 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 43 | 0 | 0 | |
| | J90- J94 | 15 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 17 | 3 | 0 | 1 | 0 | 0 | 7 | 5 | 0 | 0 | 3 | 0 | 0 | 93 | 0 | |
| | J95- J99 | 115 | 0 | 3 | 3 | 0 | 24 | 31 | 16 | 95 | 93 | 7 | 7 | 1 | 5 | 72 | 27 | 1 | 91 | 34 | 32 | 10 | 3 | 3,718 | |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system



Supplementary Figure 29 - Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart. Values on the diagonal represent correct classifications, during periods without excess mortality

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Supplementary Table 45 - Overall performance metrics of AUTOCOD when classifying by ICD-10 block, periods without excess mortality

| | |
|-----------------------|------|
| Accuracy | 0.94 |
| Kappa | 0.92 |
| AccuracyLower | 0.94 |
| AccuracyUpper | 0.94 |
| AccuracyNull | 0.40 |
| AccuracyPValue | 0.00 |

Supplementary Table 46 - Performance Metrics of AUTOCOD by ICD-10 block, periods without excess mortality

| | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Sensitivity | 0.98 | 0.00 | 0.70 | 0.74 | 0.41 | 0.85 | 0.93 | 0.80 | 0.91 | 0.94 | 0.82 | 0.55 | 0.08 | 0.41 | 0.94 | 0.83 | 0.45 | 0.89 | 0.87 | 0.82 | 0.31 | 0.66 | 0.92 |
| Specificity | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Pos Pred Value | 0.99 | NaN | 0.76 | 0.83 | 0.51 | 0.76 | 0.94 | 0.81 | 0.90 | 0.95 | 0.89 | 0.75 | 0.20 | 0.70 | 0.93 | 0.87 | 0.53 | 0.83 | 0.91 | 0.89 | 0.83 | 0.63 | 0.85 |
| Neg Pred Value | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.99 | NA | 0.73 | 0.78 | 0.45 | 0.80 | 0.93 | 0.80 | 0.90 | 0.95 | 0.85 | 0.64 | 0.11 | 0.52 | 0.94 | 0.85 | 0.49 | 0.86 | 0.89 | 0.85 | 0.46 | 0.65 | 0.88 |
| Prevalence | 0.40 | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 | 0.09 | 0.01 | 0.11 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.07 | 0.01 | 0.00 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Detection Rate | 0.40 | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 | 0.09 | 0.01 | 0.10 | 0.14 | 0.02 | 0.00 | 0.00 | 0.00 | 0.07 | 0.01 | 0.00 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 |
| Detection Prevalence | 0.40 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.09 | 0.01 | 0.11 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.08 | 0.01 | 0.00 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Balanced Accuracy | 0.99 | 0.50 | 0.85 | 0.87 | 0.70 | 0.92 | 0.96 | 0.90 | 0.95 | 0.97 | 0.91 | 0.78 | 0.54 | 0.71 | 0.97 | 0.92 | 0.73 | 0.94 | 0.93 | 0.91 | 0.66 | 0.83 | 0.96 |

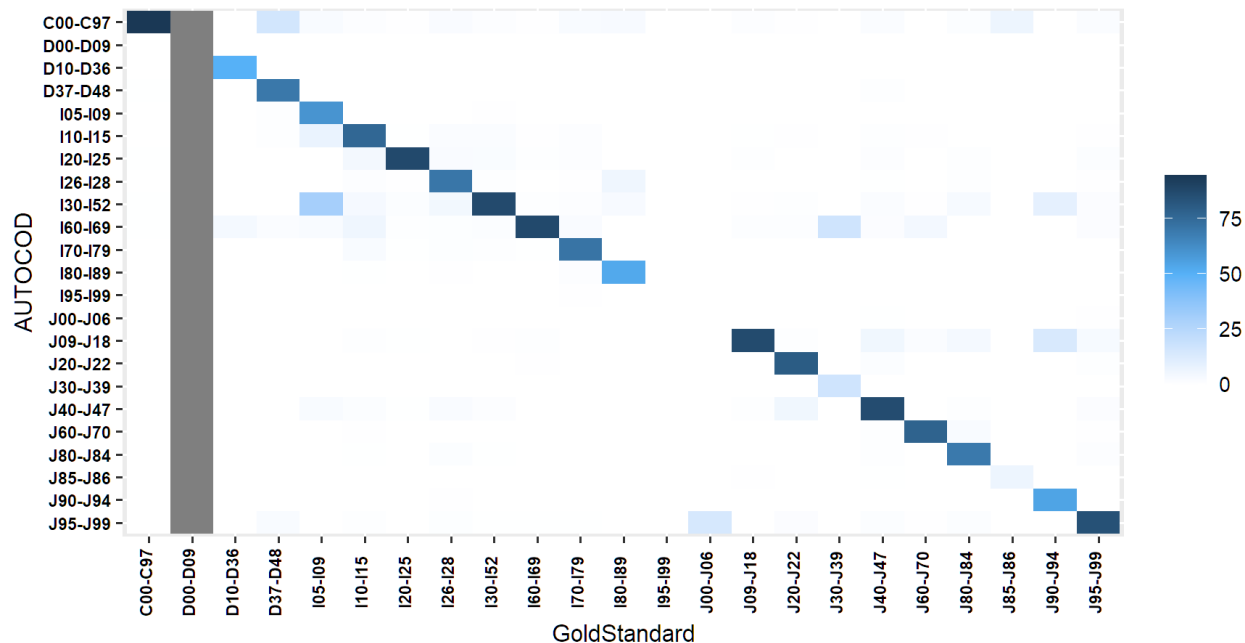
Periods with severe excess mortality (>4 SDs)

Supplementary Table 47 - Confusion matrix for ICD-10 block classification, severe excess mortality periods (>4 SDs)

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|-------------|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---|
| | | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 | |
| AUTOCOD | C00- C97 | 5,614 | 0 | 3 | 13 | 0 | 4 | 11 | 1 | 14 | 16 | 3 | 2 | 0 | 0 | 6 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 3 | |
| | D00- D09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | D10- D36 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | D37- D48 | 19 | 0 | 0 | 84 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | I05- I09 | 1 | 0 | 0 | 0 | 24 | 3 | 0 | 0 | 12 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | I10- I15 | 8 | 0 | 0 | 1 | 1 | 617 | 35 | 8 | 30 | 45 | 21 | 2 | 0 | 0 | 7 | 0 | 0 | 11 | 3 | 2 | 0 | 0 | 0 | 5 |
| | I20- I25 | 10 | 0 | 0 | 0 | 0 | 6 | 1,831 | 9 | 30 | 18 | 5 | 0 | 1 | 0 | 5 | 1 | 1 | 6 | 1 | 0 | 1 | 0 | 0 | 0 |
| | I26- I28 | 5 | 0 | 0 | 0 | 0 | 4 | 5 | 157 | 10 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 3 | 0 | 1 | 2 | 2 |
| | I30- I52 | 24 | 0 | 0 | 2 | 12 | 41 | 50 | 15 | 2,172 | 38 | 17 | 4 | 0 | 0 | 11 | 4 | 0 | 28 | 1 | 5 | 0 | 2 | 7 | 7 |
| | I60- I69 | 11 | 0 | 0 | 3 | 0 | 10 | 19 | 1 | 23 | 2,767 | 6 | 0 | 0 | 0 | 23 | 10 | 1 | 5 | 5 | 2 | 0 | 0 | 0 | 7 |
| | I70- I79 | 11 | 0 | 0 | 0 | 0 | 4 | 4 | 2 | 5 | 10 | 308 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | I80- I89 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | I95- I99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J00- J06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | J09- J18 | 28 | 0 | 1 | 3 | 0 | 6 | 13 | 2 | 11 | 24 | 1 | 0 | 0 | 1 | 1,954 | 1 | 0 | 19 | 4 | 1 | 8 | 1 | 4 | 4 |
| | J20- J22 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 202 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 4 |
| | J30- J39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J40- J47 | 18 | 0 | 0 | 7 | 0 | 8 | 12 | 2 | 21 | 17 | 0 | 0 | 0 | 2 | 56 | 14 | 1 | 924 | 8 | 7 | 2 | 0 | 14 | |
| | J60- J70 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 9 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 164 | 0 | 0 | 0 | 1 | |
| | J80- J84 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 1 | 4 | 109 | 0 | 0 | 2 | |
| | J85- J86 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | |
| | J90- J94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | |
| J95- J99 | 14 | 0 | 1 | 0 | 0 | 4 | 10 | 4 | 12 | 12 | 1 | 1 | 0 | 3 | 23 | 6 | 0 | 12 | 4 | 8 | 0 | 0 | 630 | | |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart, during severe excess mortality periods (>4 SD)



Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 30 - Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart. Values on the diagonal represent correct classifications

Supplementary Table 48 - Overall performance metrics of AUTOCOD when classifying by ICD-10 block, severe excess mortality periods (>4 SDs)

| | |
|-----------------------|------|
| Accuracy | 0.93 |
| Kappa | 0.91 |
| AccuracyLower | 0.92 |
| AccuracyUpper | 0.93 |
| AccuracyNull | 0.30 |
| AccuracyPValue | 0.00 |

Supplementary Table 49 - Performance Metrics of AUTOCOD by ICD-10 block, severe excess mortality periods (>4 SDs)

| | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Sensitivity | 0.97 | NA | 0.72 | 0.74 | 0.63 | 0.87 | 0.92 | 0.77 | 0.92 | 0.93 | 0.85 | 0.58 | 0.00 | 0.00 | 0.93 | 0.85 | 0.25 | 0.90 | 0.84 | 0.79 | 0.08 | 0.71 | 0.92 |
| Specificity | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 0.98 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| Pos Pred Value | 0.99 | NA | 0.93 | 0.76 | 0.57 | 0.78 | 0.95 | 0.80 | 0.89 | 0.96 | 0.88 | 0.83 | NA | 0.00 | 0.94 | 0.89 | 0.50 | 0.83 | 0.91 | 0.83 | 0.50 | 0.71 | 0.85 |
| Neg Pred Value | 0.99 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.98 | NA | 0.81 | 0.75 | 0.60 | 0.82 | 0.94 | 0.78 | 0.91 | 0.95 | 0.86 | 0.68 | NA | NA | 0.93 | 0.87 | 0.33 | 0.86 | 0.88 | 0.81 | 0.14 | 0.71 | 0.88 |
| Prevalence | 0.30 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.11 | 0.01 | 0.12 | 0.16 | 0.02 | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 |
| Detection Rate | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.10 | 0.01 | 0.11 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.10 | 0.01 | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Detection Prevalence | 0.30 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.10 | 0.01 | 0.13 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.06 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 |
| Balanced Accuracy | 0.98 | NA | 0.86 | 0.87 | 0.82 | 0.93 | 0.96 | 0.88 | 0.95 | 0.96 | 0.92 | 0.79 | 0.50 | 0.50 | 0.96 | 0.92 | 0.63 | 0.95 | 0.92 | 0.89 | 0.54 | 0.85 | 0.96 |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

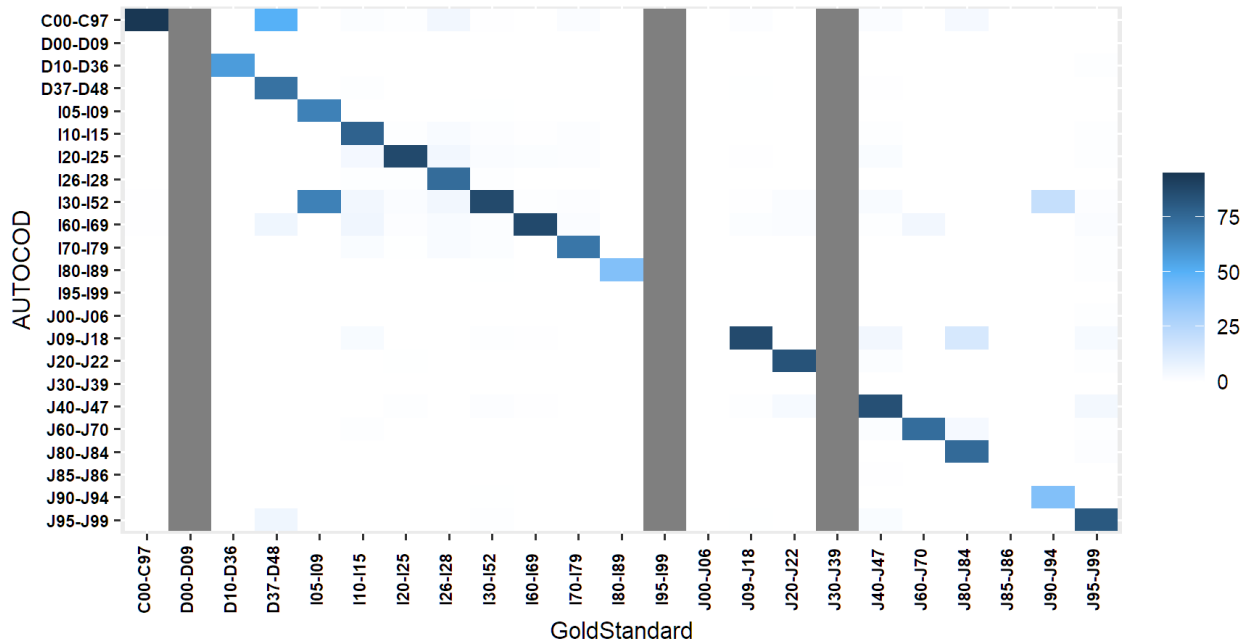
Periods with extreme excess mortality (>6 SDs)

Supplementary Table 50 - Confusion matrix for ICD-10 block classification, extreme excess mortality periods (>6 SDs)

| | | Human Coders (GOLD-STANDARD) | | | | | | | | | | | | | | | | | | | | | | |
|---------|-------------|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 |
| AUTOCOD | C00- C97 | 1,085 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | D00- D09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | D10- D36 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | D37- D48 | 9 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | I05- I09 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | I10- I15 | 2 | 0 | 0 | 1 | 0 | 116 | 6 | 1 | 7 | 8 | 3 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | I20- I25 | 3 | 0 | 0 | 0 | 0 | 3 | 412 | 3 | 9 | 5 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| | I26- I28 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 32 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | I30- I52 | 2 | 0 | 0 | 0 | 1 | 6 | 9 | 4 | 458 | 8 | 7 | 1 | 0 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 4 |
| | I60- I69 | 1 | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 5 | 544 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 1 |
| | I70- I79 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | I80- I89 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | I95- I99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J00- J06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J09- J18 | 6 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 2 | 7 | 0 | 0 | 0 | 0 | 419 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 |
| | J20- J22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| | J30- J39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J40- J47 | 4 | 0 | 0 | 1 | 0 | 2 | 5 | 0 | 6 | 2 | 0 | 0 | 0 | 0 | 11 | 3 | 0 | 197 | 3 | 0 | 1 | 0 | 5 |
| | J60- J70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 0 | 0 |
| | J80- J84 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 21 | 0 | 0 | 0 |
| | J85- J86 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | J90- J94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | J95- J99 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 3 | 1 | 1 | 0 | 1 | 5 | 1 | 0 | 7 | 1 | 2 | 0 | 0 | 133 |

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart during extreme excess mortality periods (>6 SD)



Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 31 - Heatmap of the AUTOCOD classification by ICD-10 block vs its Gold Standard counterpart. Values on the diagonal represent correct classifications, during extreme excess mortality periods (>6 SDs)

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Supplementary Table 51 - - Overall performance metrics of AUTOCOD when classifying by ICD-10 block, extreme excess mortality periods (>6 SDs)

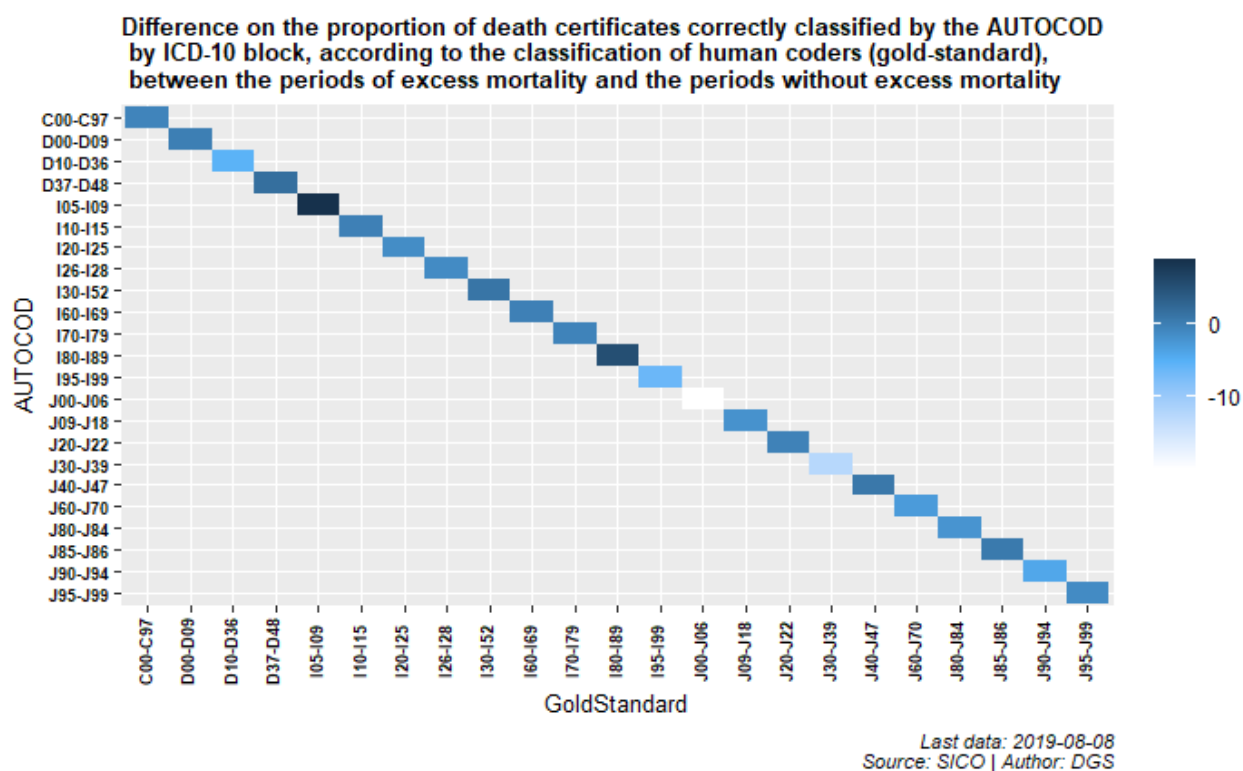
| | |
|-----------------------|------|
| Accuracy | 0.93 |
| Kappa | 0.91 |
| AccuracyLower | 0.92 |
| AccuracyUpper | 0.93 |
| AccuracyNull | 0.29 |
| AccuracyPValue | 0.00 |

Supplementary Table 52 - Performance Metrics of AUTOCOD by ICD-10 block, extreme excess mortality periods (>6 SDs)

| | Chapter II - Neoplasms | | | | Chapter IX - Diseases of the circulatory system | | | | | | | | | Chapter X - Diseases of the respiratory system | | | | | | | | | |
|----------------------|------------------------|-------------|-------------|-------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | C00- C97 | D00- D09 | D10- D36 | D37- D48 | I05- I09 | I10- I15 | I20- I25 | I26- I28 | I30- I52 | I60- I69 | I70- I79 | I80- I89 | I95- I99 | J00- J06 | J09- J18 | J20- J22 | J30- J39 | J40- J47 | J60- J70 | J80- J84 | J85- J86 | J90- J94 | J95- J99 |
| Sensitivity | 0.97 | NA | 0.80 | 0.77 | 0.67 | 0.87 | 0.92 | 0.80 | 0.92 | 0.93 | 0.84 | 0.50 | NA | 0.00 | 0.93 | 0.90 | NA | 0.89 | 0.82 | 0.88 | 0.00 | 0.50 | 0.91 |
| Specificity | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| Pos Pred Value | 0.99 | NA | 1.00 | 0.54 | 0.50 | 0.78 | 0.93 | 0.78 | 0.90 | 0.96 | 0.91 | 1.00 | NA | NA | 0.95 | 0.93 | NA | 0.82 | 0.94 | 0.78 | NA | 0.67 | 0.83 |
| Neg Pred Value | 0.99 | NA | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | NA | 1.00 | 0.99 | 1.00 | NA | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F1 | 0.98 | NA | 0.89 | 0.63 | 0.57 | 0.82 | 0.93 | 0.79 | 0.91 | 0.94 | 0.87 | 0.67 | NA | NA | 0.94 | 0.91 | NA | 0.86 | 0.87 | 0.82 | NA | 0.57 | 0.87 |
| Prevalence | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.12 | 0.01 | 0.13 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.12 | 0.02 | 0.00 | 0.06 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 |
| Detection Rate | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.11 | 0.01 | 0.12 | 0.14 | 0.02 | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.03 |
| Detection Prevalence | 0.28 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.11 | 0.01 | 0.13 | 0.15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.06 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 |
| Balanced Accuracy | 0.98 | NA | 0.90 | 0.88 | 0.83 | 0.93 | 0.96 | 0.90 | 0.95 | 0.96 | 0.92 | 0.75 | NA | 0.50 | 0.96 | 0.95 | NA | 0.94 | 0.91 | 0.94 | 0.50 | 0.75 | 0.95 |

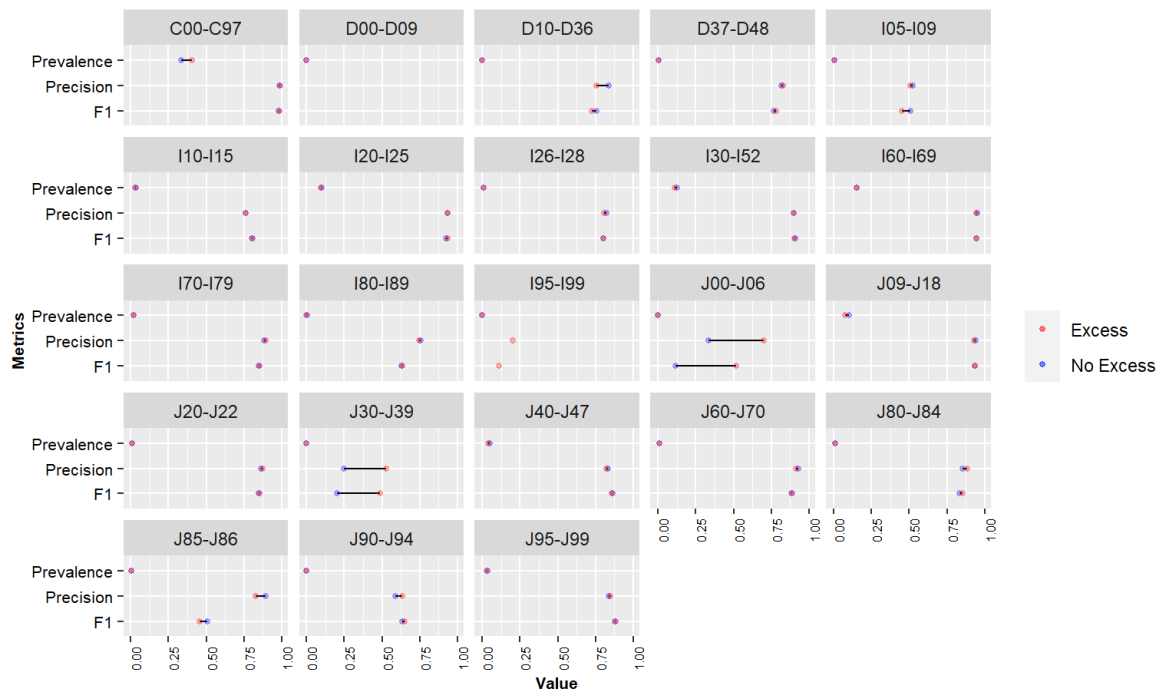
Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Difference between excess mortality periods and periods without excess mortality

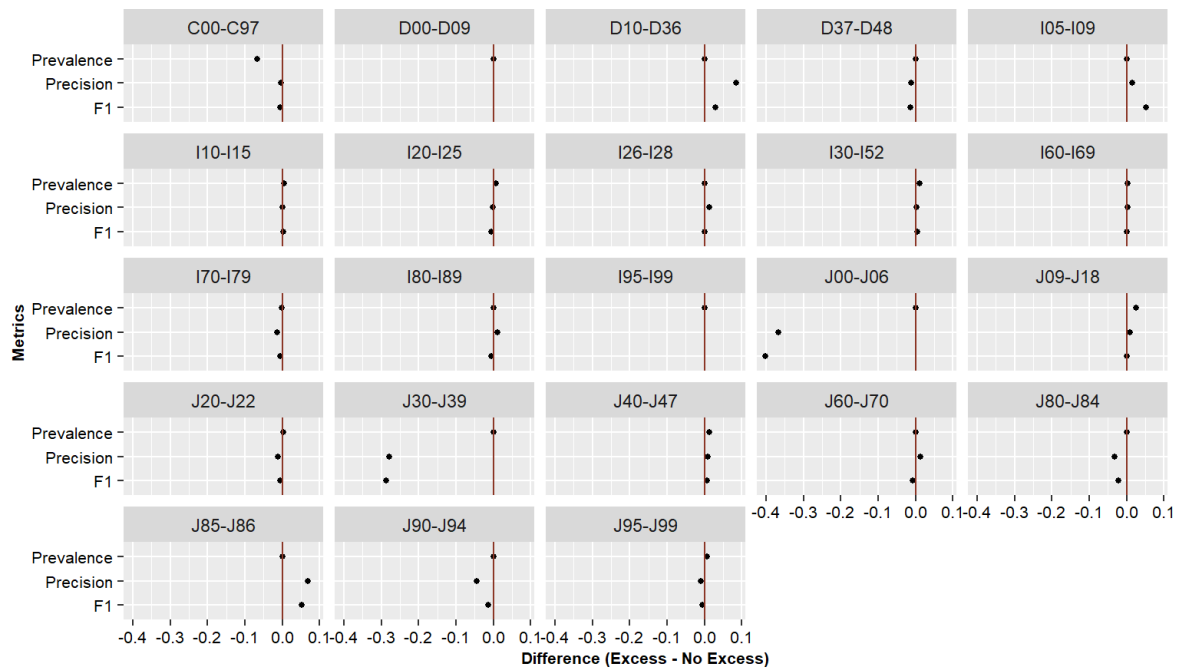


Supplementary Figure 32 - Difference on the proportion of death certificates correctly classified by the AUTOCOD by ICD-10 block, according to the classification of human coders (gold-standard), between the periods of excess mortality and the periods without excess mortality

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system



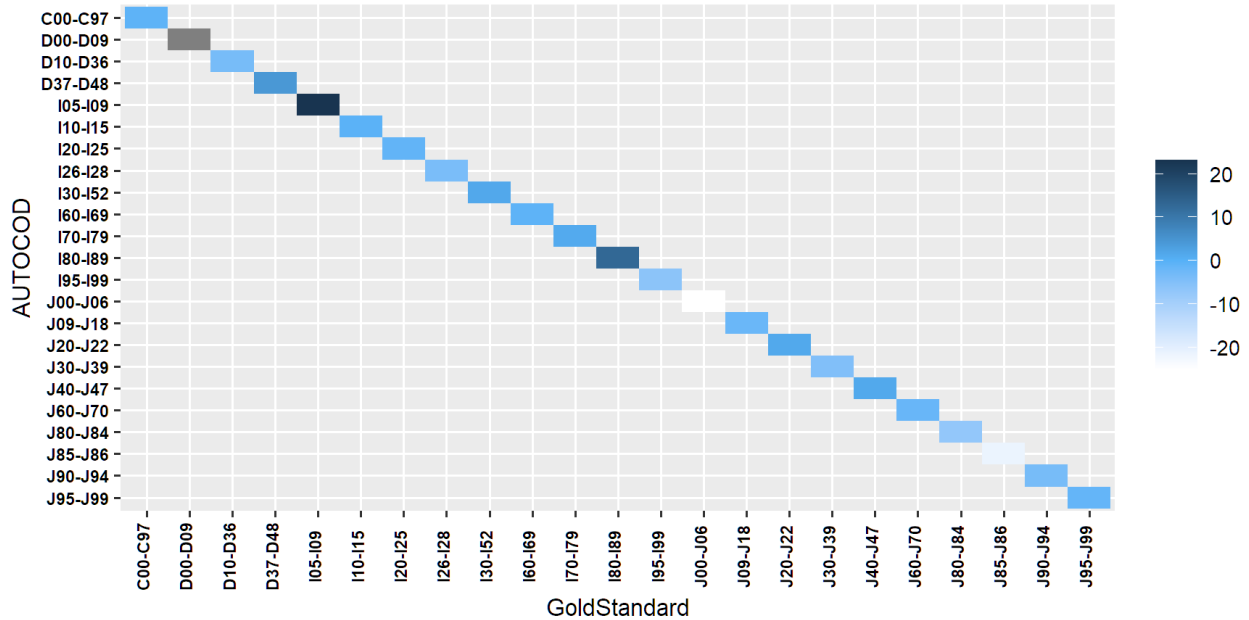
Supplementary Figure 33 - Comparison between other performance metrics of AUTOCOD during periods of excess mortality and periods without excess mortality, by ICD-10 block



Supplementary Figure 34 - Difference on other performance metrics of AUTOCOD, by block, between periods of Excess Mortality and periods without excess mortality

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Difference on the proportion of death certificates correctly classified by the AUTOCOD by ICD-10 block, according to the classification of human coders (gold-standard) between the periods of severe excess mortality (> 4SD) and the periods without excess mortality

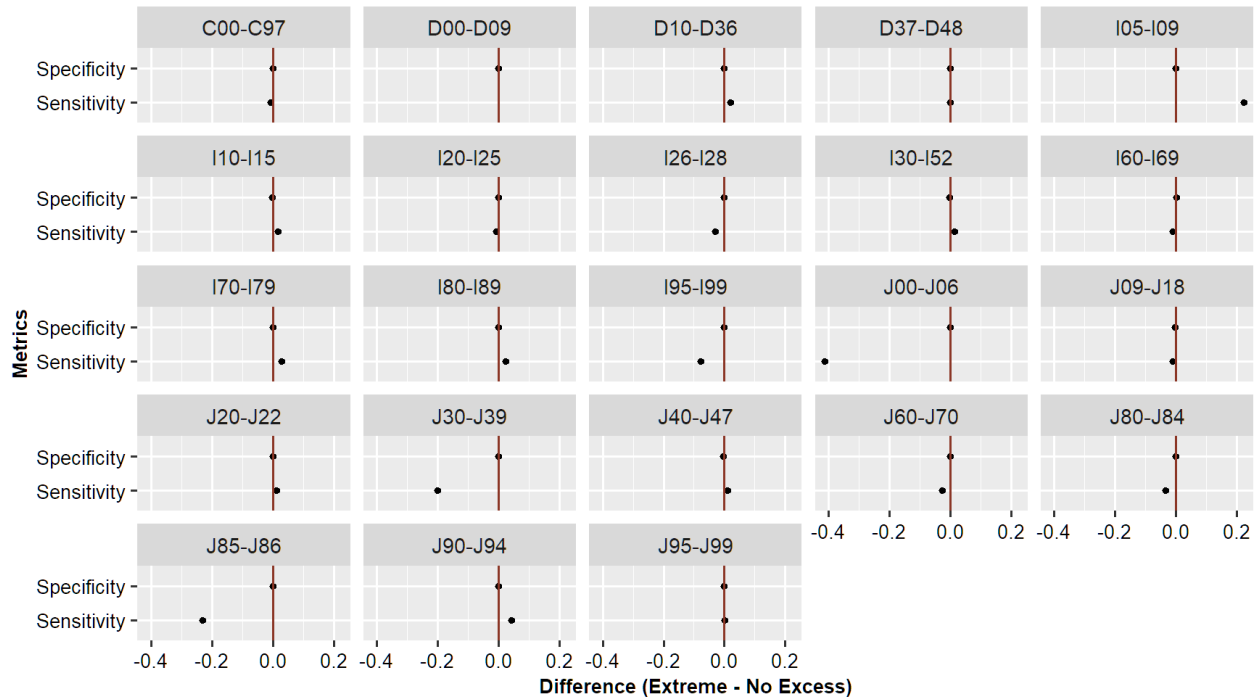


Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 35 - Difference on the proportion of death certificates correctly classified by the AUTOCOD by ICD-10 block, according to the classification of human coders (gold-standard), between the periods of extreme excess mortality (>4 SDs) and the periods without excess mortality

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

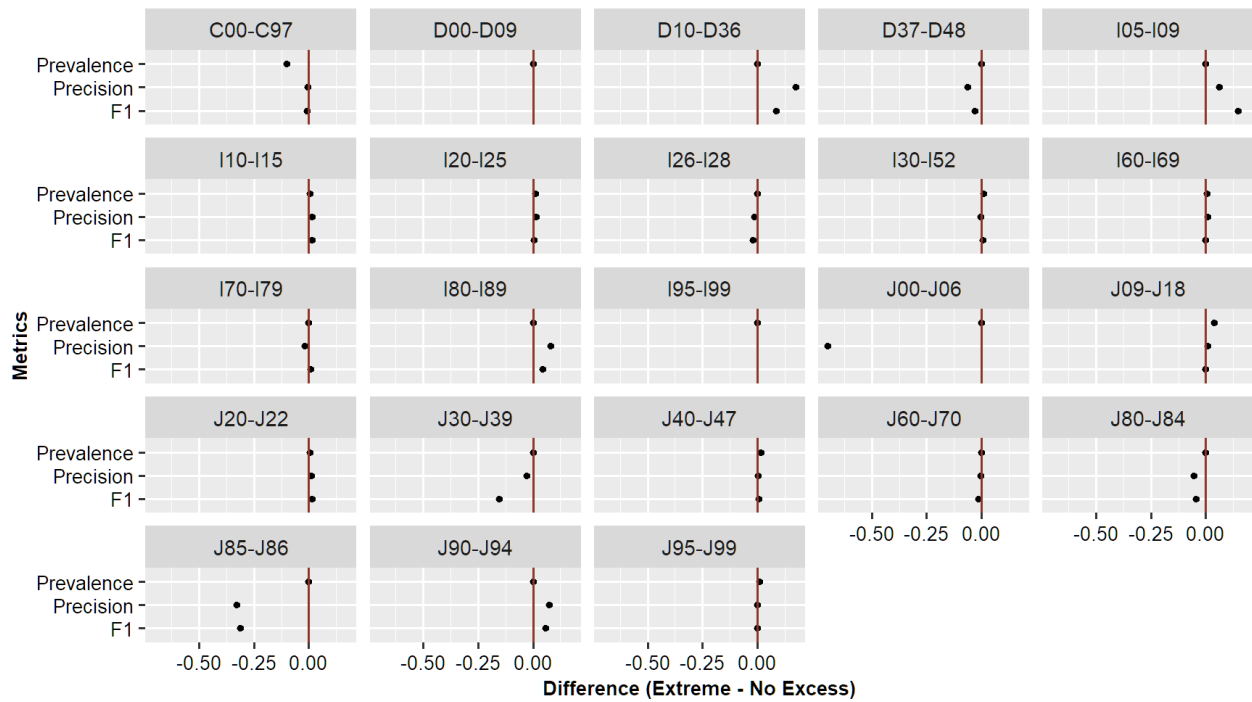
Metrics difference between periods of severe excess mortality >4 SD and periods without excess mortality by Block



Supplementary Figure 36 - Difference on other performance metrics of AUTOCOD, by block, between periods of severe excess mortality (>4 SDs) and periods without excess mortality

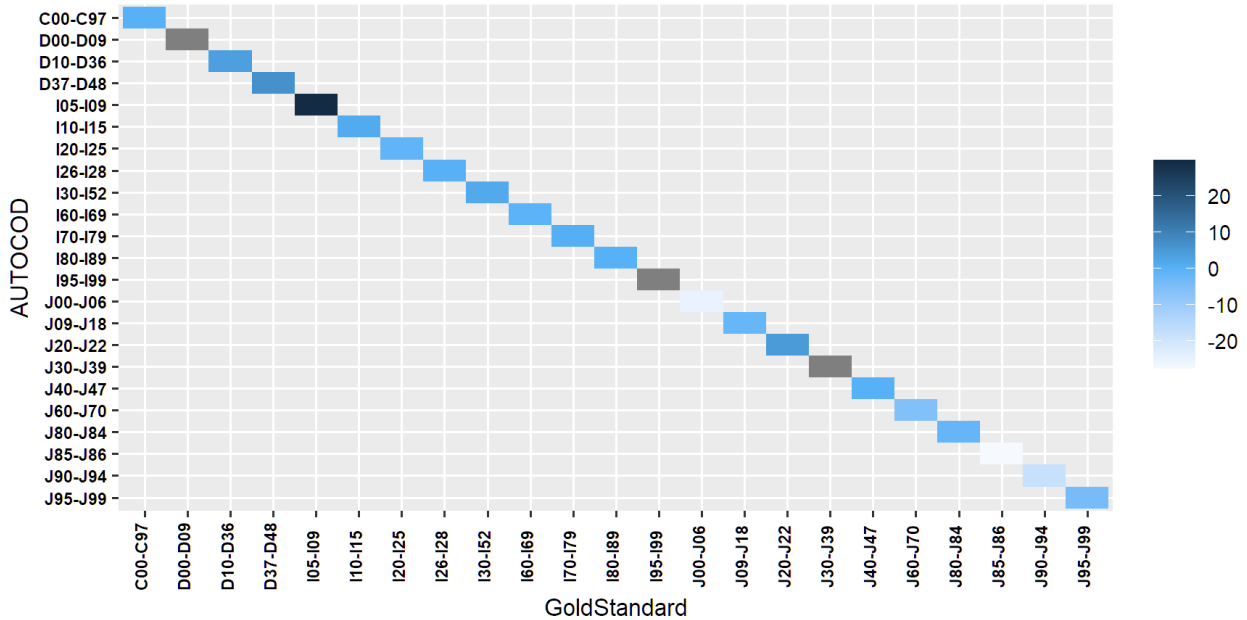
Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system

Metrics difference between periods of severe excess mortality >4 SD and periods without excess mortality by block



Supplementary Figure 37 - Difference on other performance metrics of AUTOCOD, by block, between periods of severe excess mortality (>4 SDs) and periods without excess mortality

Difference on the proportion of death certificates correctly classified by the AUTOCOD by ICD-10 block, according to the classification of human coders (gold-standard), between the periods of extreme excess mortality (>6 SD) and the periods without excess mortality



Last data: 2019-08-08
Source: SICO | Author: DGS

Supplementary Figure 38 - Difference on the proportion of death certificates correctly classified by the AUTOCOD by ICD-10 block, according to the classification of human coders (gold-standard), between the periods of extreme excess mortality (>6 SDs) and the periods without excess mortality

Caption: C00-C97 - Malignant neoplasms; D00-D09 - In situ neoplasms; D10-D36 - Benign neoplasms; D37-D48 - Neoplasms of uncertain or unknown behaviour; I05-I09 - Chronic rheumatic heart diseases; I10-I15 - Hypertensive diseases; I20-I25 - Ischaemic heart diseases; I26-I28 - Pulmonary heart disease and diseases of pulmonary circulation; I30-I52 - Other forms of heart disease; I60-I69 - Cerebrovascular diseases; I70-I79 - Diseases of arteries, arterioles and capillaries; I80-I89 - Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified; I95-I99 - Other and unspecified disorders of the circulatory system; J00-J06 - Acute upper respiratory infections; J09-J18 - Influenza and pneumonia; J20-J22 - Other acute lower respiratory infections; J30-J39 - Other diseases of upper respiratory tract; J40-J47 - Chronic lower respiratory diseases; J60-J70 - Lung diseases due to external agents; J80-J84 - Other respiratory diseases principally affecting the interstitium; J85-J86 - Suppurative and necrotic conditions of lower respiratory tract; J90-J94 - Other diseases of pleura; J95-J99 - Other diseases of the respiratory system