

# Análise Bayesiana para Inferência Causal na COVID-19

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## Análise Bayesiana para Inferência Causal na COVID-19

*Dataset* = <https://dados.gov.br/dataset/bd-srag-2019>

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**SRAG 2019** - Banco de Dados de Síndrome Respiratória Aguda Grave Vigilância de Síndrome Respiratória Aguda Grave (SRAG) O Ministério da Saúde, por meio da Secretaria de Vigilância em Saúde (SVS), desenvolve a vigilância da Síndrome Respiratória Aguda Grave (SRAG) no Brasil, desde 2009, devido a pandemia de Influenza A(H1N1)pdm09. A partir disso, a vigilância de SRAG foi implantada na rede de vigilância de Influenza e outros vírus respiratórios, que anteriormente atuava apenas com a vigilância sentinela de Síndrome Gripal (SG).

Recentemente (2020), a vigilância da COVID-19, a infecção humana causada pelo novo Coronavírus, que vem causando uma pandemia, foi incorporada na rede de vigilância da Influenza e outros vírus respiratórios.

Esta página tem como finalidade disponibilizar o legado dos banco de dados (BD) epidemiológicos de SRAG, da rede de vigilância da Influenza e outros vírus respiratórios, desde o início da sua implantação (2009) até os dias atuais (2020), com a incorporação da vigilância da COVID-19.

Para mais informações, acessar:

Gripe/Influenza - <https://saude.gov.br/saude-de-a-z/gripe>

COVID-19 - <https://coronavirus.saude.gov.br/>

```
suppressPackageStartupMessages(expr = library(tidyverse))
suppressPackageStartupMessages(expr = library(bnlearn))
suppressPackageStartupMessages(expr = library(bnstruct))
suppressPackageStartupMessages(expr = library(readr))
suppressPackageStartupMessages(expr = library(Rgraphviz))
suppressPackageStartupMessages(expr = library(Rmpfr))
```

```
dados <- read_csv("x_to_be_factors.csv",
  col_types = cols(
    FEBRE = col_factor(levels = c("1", "2", "9")),
    TOSSE = col_factor(levels = c("1", "2", "9")),
    GARGANTA = col_factor(levels = c("1", "2", "9")),
    DISPNEIA = col_factor(levels = c("1", "2", "9")),
    DESC_RESP = col_factor(levels = c("1", "2", "9")),
    SATURACAO = col_factor(levels = c("1", "2", "9")),
    DIARREIA = col_factor(levels = c("1", "2", "9")),
    VOMITO = col_factor(levels = c("1", "2", "9")),
    OUTRO_SIN = col_factor(levels = c("1", "2", "9")),
    HOSPITAL = col_factor(levels = c("1", "2", "9")),
    EVOLUCAO = col_factor(levels = c("1", "2", "3", "9")),
```

```

    RENAL = col_factor(levels = c("1", "2", "9")),
    DIABETES = col_factor(levels = c("1", "2", "9")),
    OBESIDADE = col_factor(levels = c("1", "2", "9")),
    CLASSI_OUT = col_character(),
    PERD_OLFT = col_factor(levels = c("1", "2", "9")),
    PERD_PALA = col_factor(levels = c("1", "2", "9")),
    VACINA = col_factor(levels = c("1", "2", "9")),
    CLASSI_FIN = col_factor(levels = c("1", "2", "3", "4", "5"))))

## Warning: Missing column names filled in: 'X1' [1]

#View(dados)

```

## Inferência da estrutura da Rede Causal usando o algoritmo mmpc

```

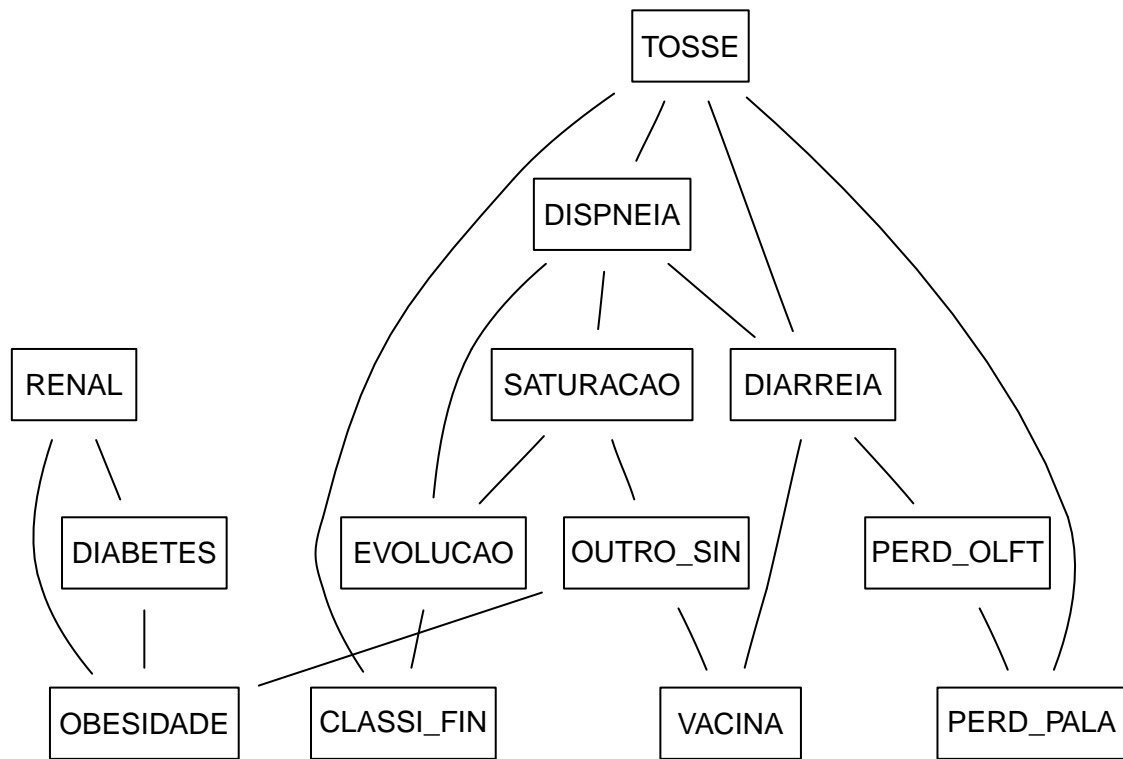
#reselecionar retira a variavel automatica X1
xx <- select(dados,
  #FEBRE,
  TOSSE,
  #GARGANTA,
  DISPNEIA,
  #DESC_RESP,
  SATURACAO,
  DIARREIA,
  #VOMITO,
  OUTRO_SIN,
  #HOSPITAL,
  EVOLUCAO,
  RENAL,
  DIABETES,
  OBESIDADE,
  #CLASSI_OUT,
  PERD_OLFT,
  PERD_PALA,
  VACINA,
  CLASSI_FIN)
# dado não pode ser `tibble` nas funções de *bnlearn*
x = as.data.frame(xx)

# mmpc e mmhc não admitem NA
x_no_na <- na.omit(x)

graphviz.plot(bn_mmpc, shape = 'rectangle', main = "Algo = mmpc. DATA = full")

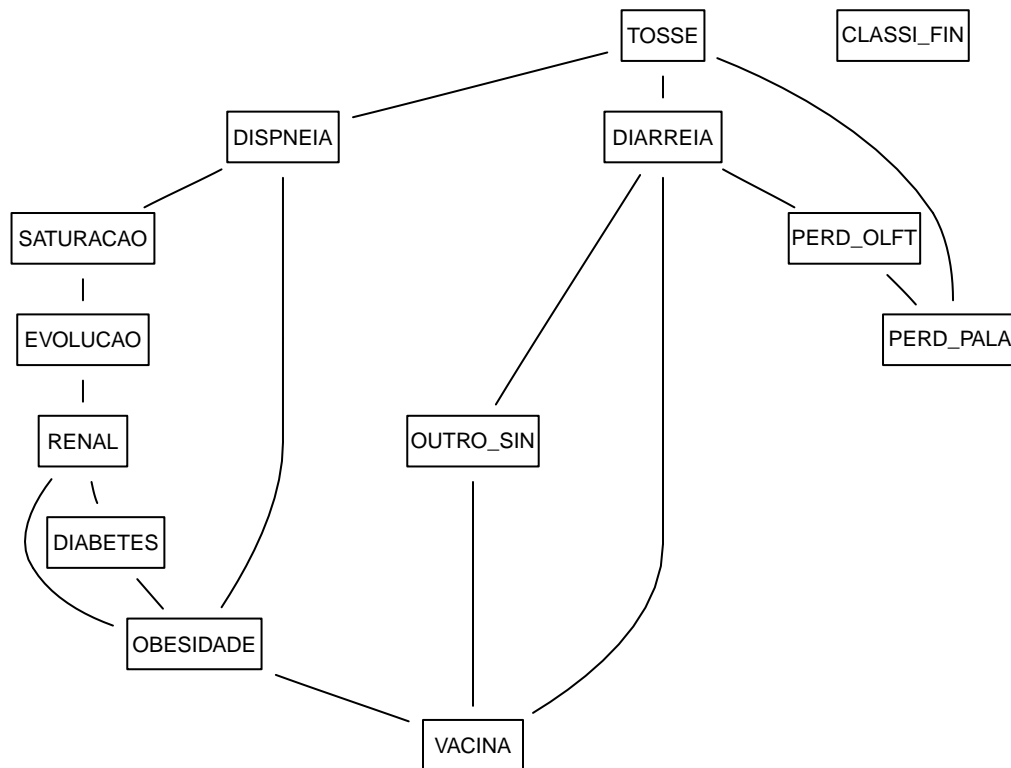
```

Algo = mmpc. DATA = full

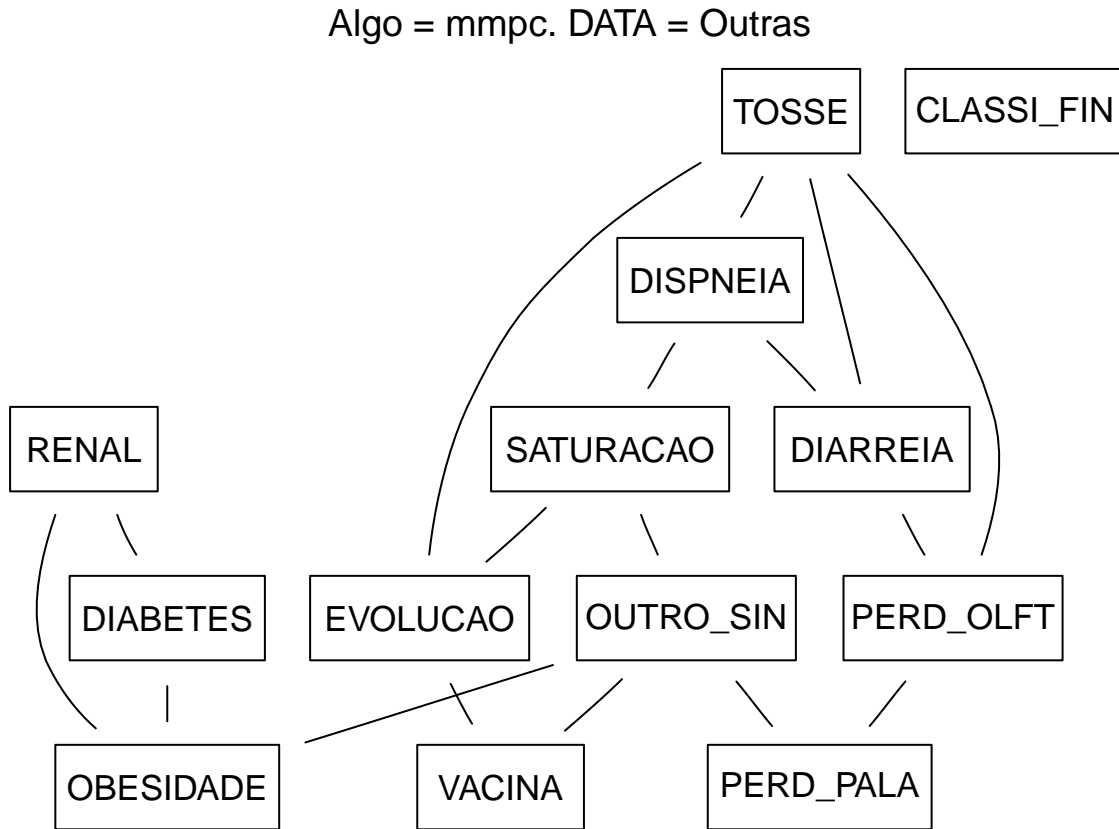


`graphviz.plot(bn_mmpc_covid, shape = 'rectangle', main = "Algo = mmpc. DATA = COVID")`

Algo = mmpc. DATA = COVID



```
graphviz.plot(bn_mmpc_outras, shape='rectangle', main = "Algo = mmpc. DATA = Outras")
```



## Inferência da estrutura da Rede Causal usando o algoritmo mmhc

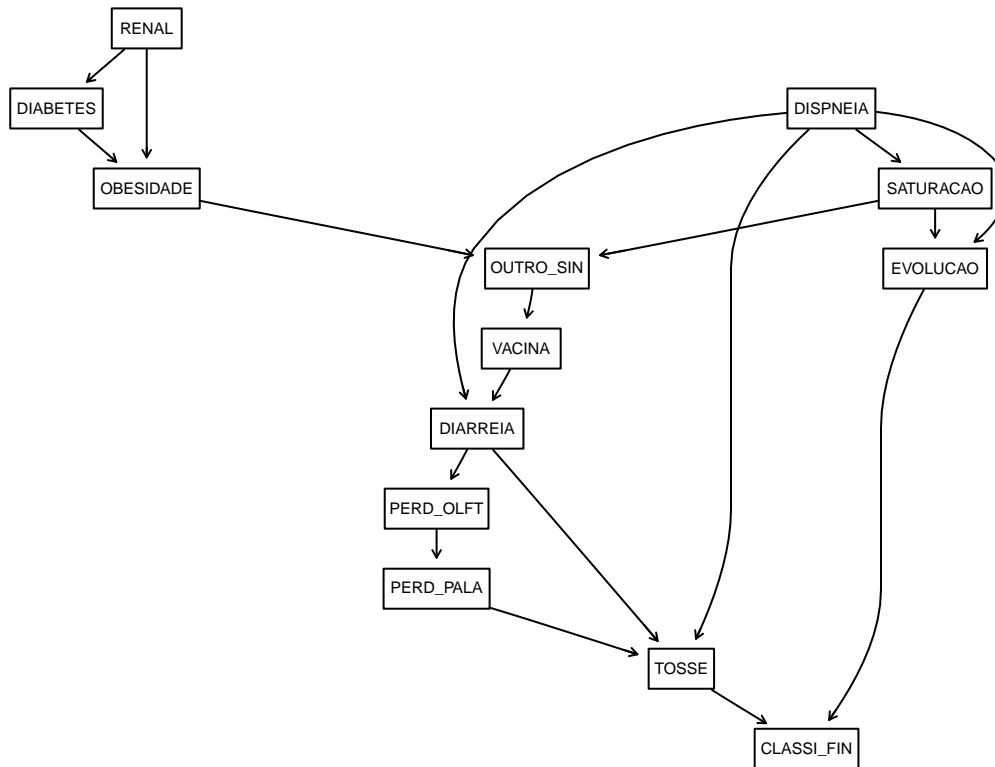
```

suppressWarnings(bn_mmhc <- mmhc(x_no_na))
suppressWarnings(bn_mmhc_outras <- mmhc(srag_outras))
suppressWarnings(bn_mmhc_covid <- mmhc(srag_covid))

graphviz.plot(bn_mmhc, shape = 'rectangle', main = "Data = full, ALGO = mmhc")

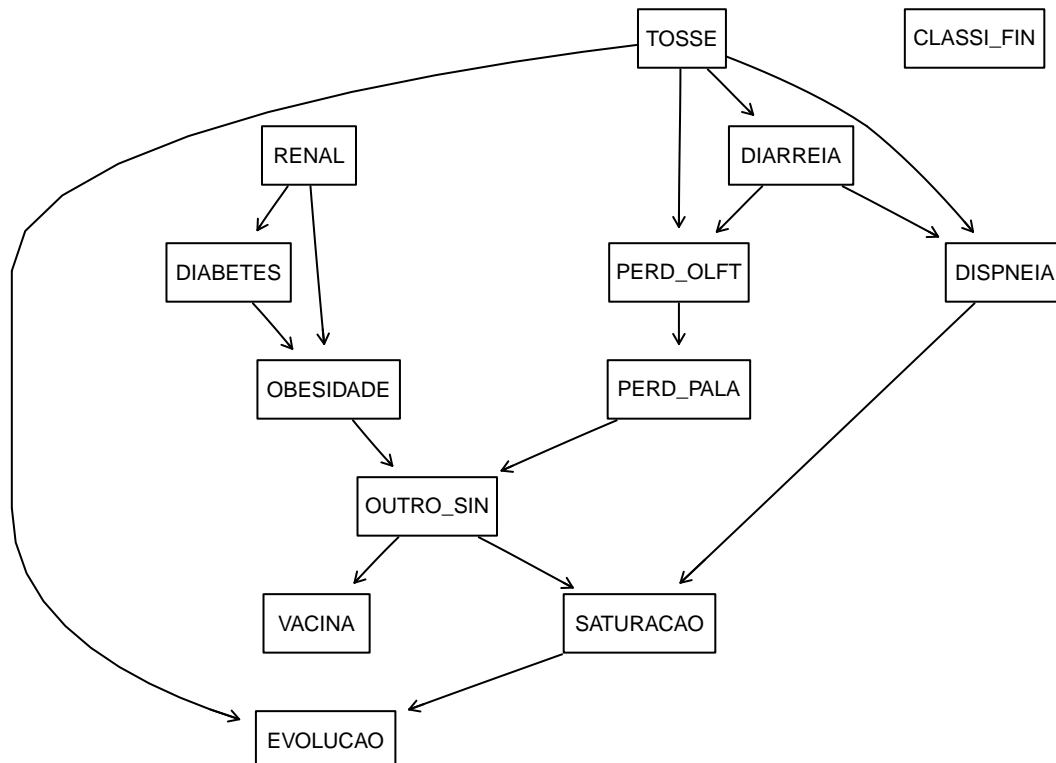
```

Data = full, ALGO = mmhc



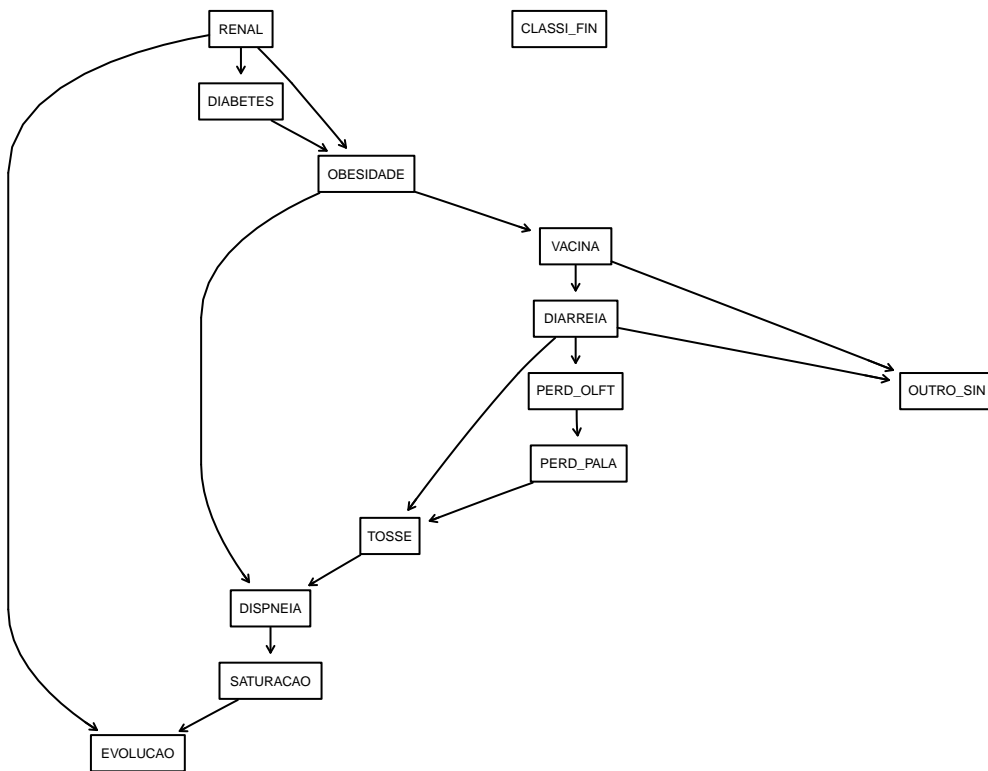
```
graphviz.plot(bn_mmhc_outras, shape = 'rectangle', main = "Data = outras, ALGO = mmhc")
```

Data = outras, ALGO = mmhc



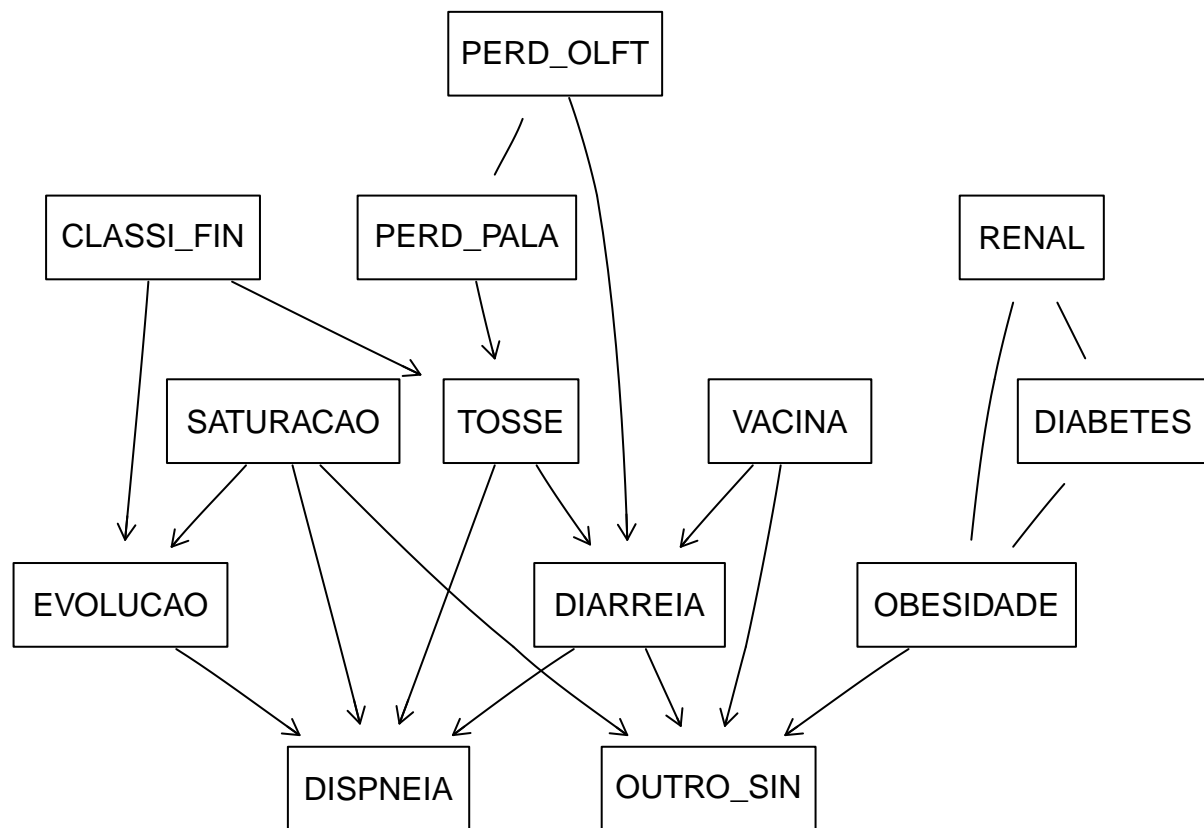
```
graphviz.plot(bn_mmhc_covid, shape = 'rectangle', main = "Data = COVID, ALGO = mmhc")
```

Data = COVID, ALGO = mmhc



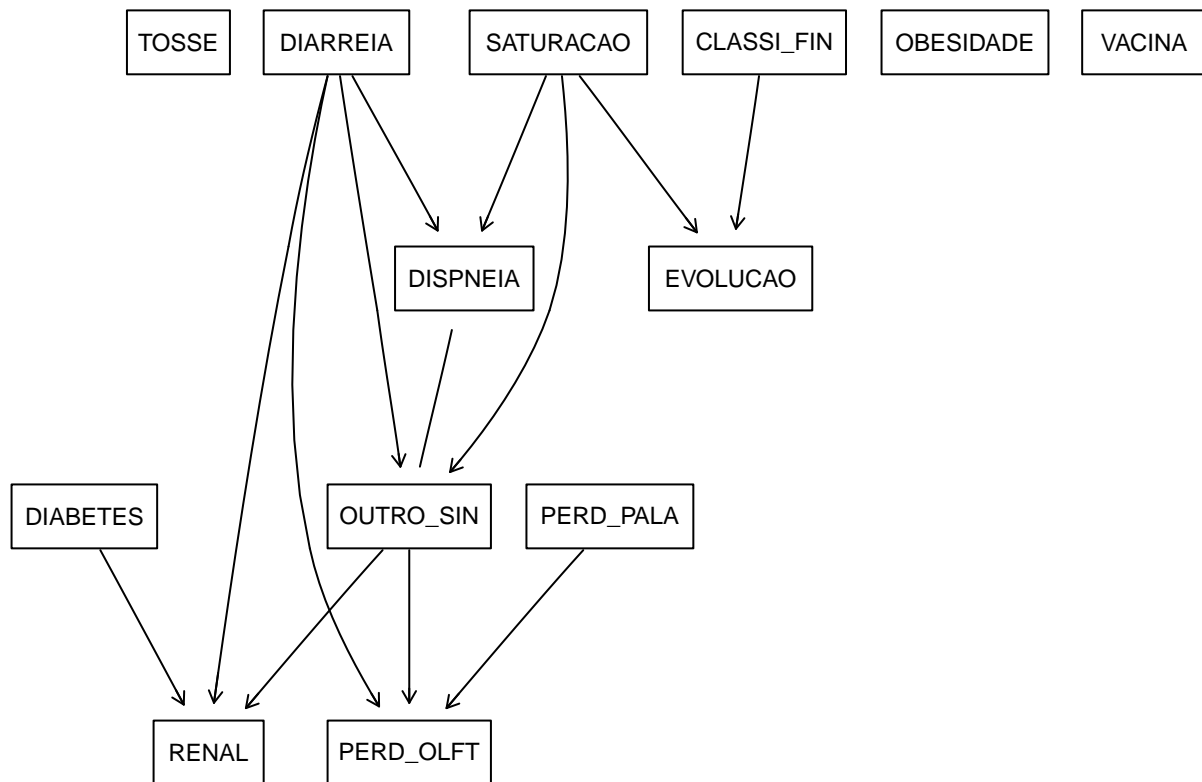
Inferência da estrutura da Rede Causal usando o algoritmo iamb

```
suppressWarnings(bn_iamb <- iamb(x_no_na))
graphviz.plot(bn_iamb, shape = 'rectangle')
```



Inferência da estrutura da Rede Causal usando o algoritmo gs

```
suppressWarnings(bn_gs <- gs(x_no_na))  
graphviz.plot(bn_gs, shape = 'rectangle')
```



## Inferência da estrutura da Rede Causal usando o algoritmo hc

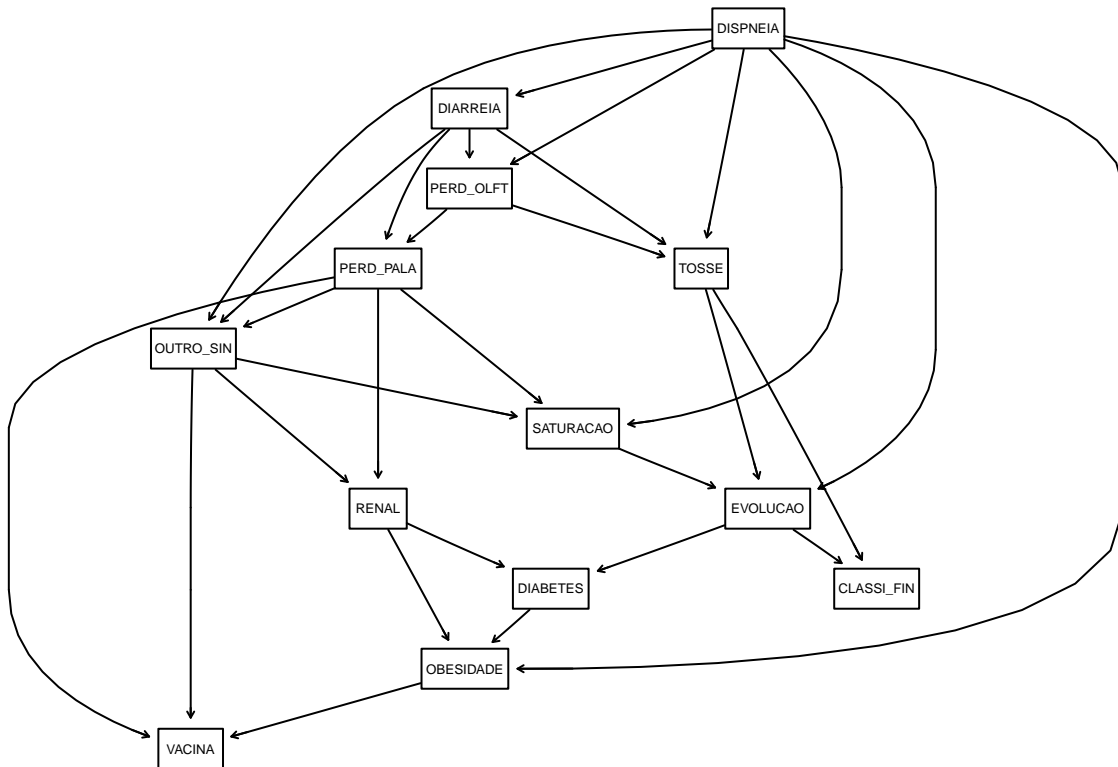
```

suppressWarnings(bn_hc <- hc(x_no_na))
suppressWarnings(bn_hc_outras <- hc(srag_outras))
suppressWarnings(bn_hc_covid <- hc(srag_covid))
graphviz.plot(bn_hc, shape = 'rectangle', main = "Algo = hc DATA = full")

```

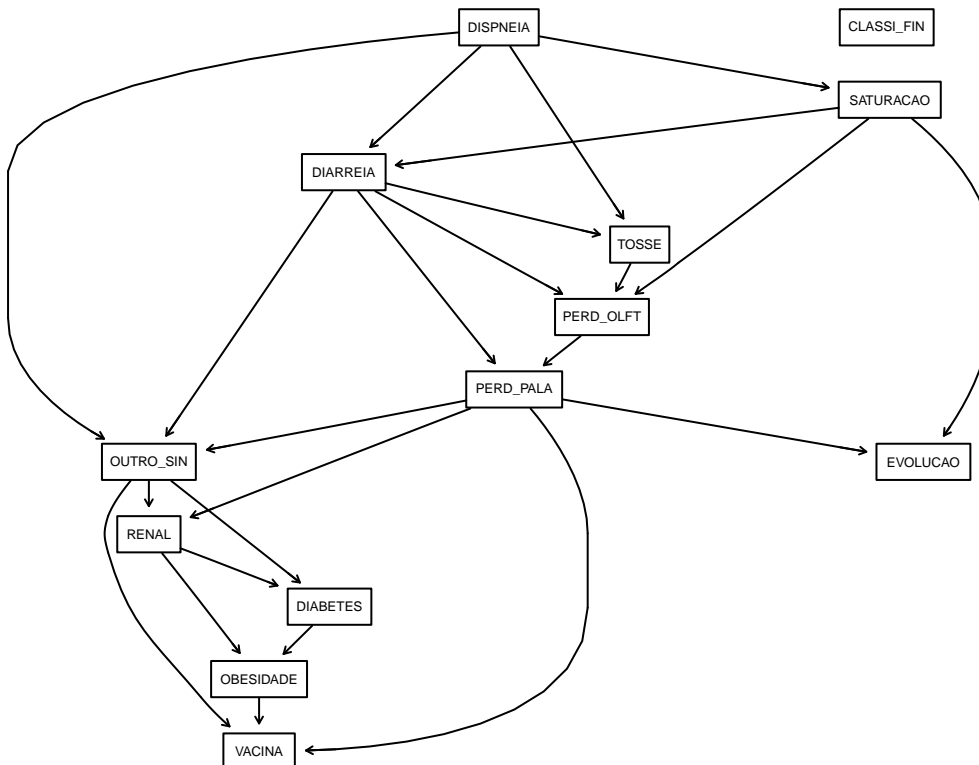


Algo = hc DATA = full

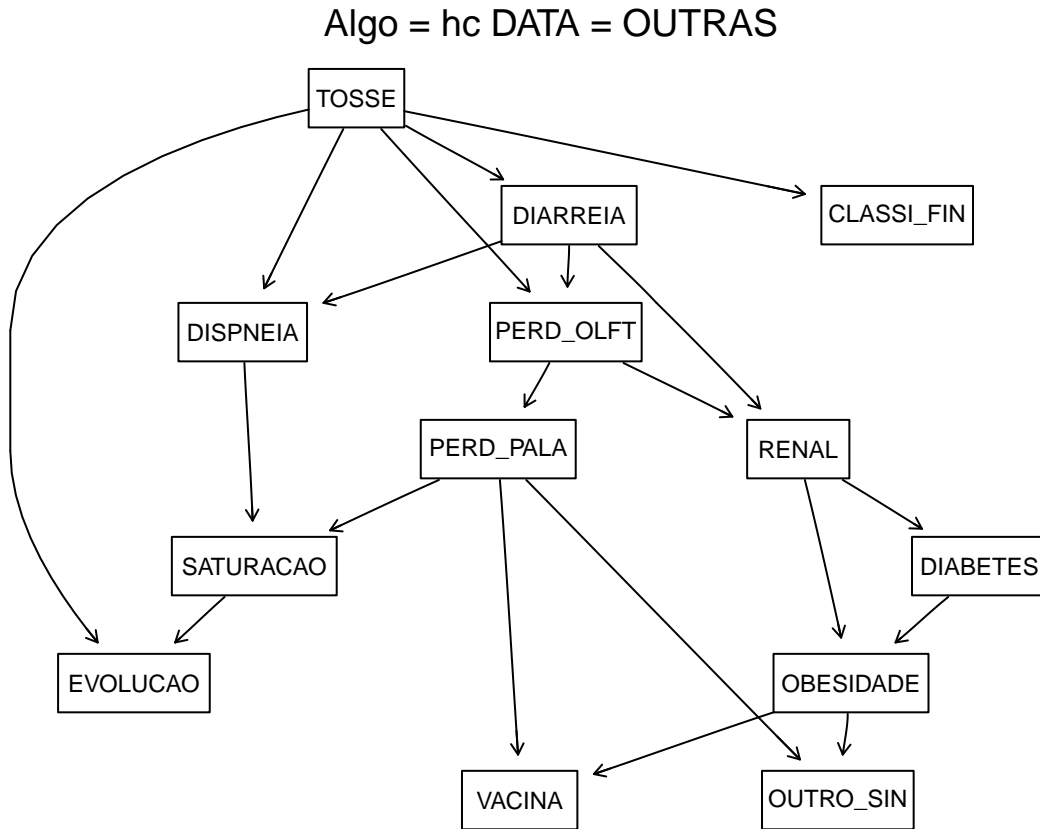


```
graphviz.plot(bn_hc_covid, shape = 'rectangle', main = "Algo = hc DATA = COVID")
```

Algo = hc DATA = COVID



```
graphviz.plot(bn_hc_outras, shape = 'rectangle', main = "Algo = hc DATA = OUTRAS")
```



## Ajustamento da estrutura do algoritmo *hc* com os dados

```
fitted_hc = bn.fit(bn_hc, x_no_na)
fitted_hc_outras = bn.fit(bn_hc_outras, srag_outras)
```

```
## Warning in check.data(data, allow.missing = TRUE): variable CLASSI_FIN has
## levels that are not observed in the data.
```

```
fitted_hc_covid = bn.fit(bn_hc_covid, srag_covid)
```

```
## Warning in check.data(data, allow.missing = TRUE): variable CLASSI_FIN has
## levels that are not observed in the data.
```

## Descrição estatística da rede para a variável EVOLUCAO DATA = full

```
##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , DISPNEIA = 1, SATURACAO = 1
```

```

##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.518256633 0.429568653 0.309045226
##      2 0.442675065 0.508462298 0.633165829
##      3 0.011765055 0.031807705 0.032663317
##      9 0.027303247 0.030161343 0.025125628
##
## , , DISPNEIA = 2, SATURACAO = 1
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.612189371 0.538291402 0.300000000
##      2 0.338472701 0.396461156 0.500000000
##      3 0.010520588 0.029029583 0.100000000
##      9 0.038817341 0.036217860 0.100000000
##
## , , DISPNEIA = 9, SATURACAO = 1
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.579439252 0.384615385 0.404494382
##      2 0.392523364 0.615384615 0.539325843
##      3 0.009345794 0.000000000 0.011235955
##      9 0.018691589 0.000000000 0.044943820
##
## , , DISPNEIA = 1, SATURACAO = 2
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.637237314 0.590873328 0.555555556
##      2 0.323423885 0.345921846 0.444444444
##      3 0.010891850 0.030159979 0.000000000
##      9 0.028446950 0.033044847 0.000000000
##
## , , DISPNEIA = 2, SATURACAO = 2
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.710062071 0.682413088 0.500000000
##      2 0.251388435 0.243967280 0.250000000
##      3 0.009637373 0.031492843 0.000000000
##      9 0.028912120 0.042126789 0.250000000
##
## , , DISPNEIA = 9, SATURACAO = 2
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.500000000 0.400000000 0.500000000
##      2 0.500000000 0.600000000 0.000000000
##      3 0.000000000 0.000000000 0.500000000
##      9 0.000000000 0.000000000 0.000000000
##
## , , DISPNEIA = 1, SATURACAO = 9

```

```

##
##          TOSSE
## EVOLUCAO      1          2          9
##      1 0.512000000 0.404255319 0.337837838
##      2 0.440000000 0.489361702 0.621621622
##      3 0.016000000 0.085106383 0.013513514
##      9 0.032000000 0.021276596 0.027027027
##
## , , DISPNEIA = 2, SATURACAO = 9
##
##          TOSSE
## EVOLUCAO      1          2          9
##      1 0.571428571 0.370370370 0.666666667
##      2 0.314285714 0.518518519 0.333333333
##      3 0.028571429 0.074074074 0.000000000
##      9 0.085714286 0.037037037 0.000000000
##
## , , DISPNEIA = 9, SATURACAO = 9
##
##          TOSSE
## EVOLUCAO      1          2          9
##      1 0.603174603 0.285714286 0.472118959
##      2 0.373015873 0.571428571 0.494423792
##      3 0.000000000 0.000000000 0.003717472
##      9 0.023809524 0.142857143 0.029739777

```

## Descrição estatística da rede para a variável EVOLUCAO DATA = COVID

```

##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , PERD_PALA = 1
##
##          SATURACAO
## EVOLUCAO      1          2          9
##      1 0.5912354999 0.7510040161 0.5208333333
##      2 0.3859326091 0.2231784280 0.4583333333
##      3 0.0009206408 0.0000000000 0.0000000000
##      9 0.0219112502 0.0258175559 0.0208333333
##
## , , PERD_PALA = 2
##
##          SATURACAO
## EVOLUCAO      1          2          9
##      1 0.4622428438 0.6092170866 0.4000000000
##      2 0.5049835518 0.3581053766 0.5636363636
##      3 0.0026513478 0.0027624309 0.0000000000
##      9 0.0301222566 0.0299151058 0.0363636364
##

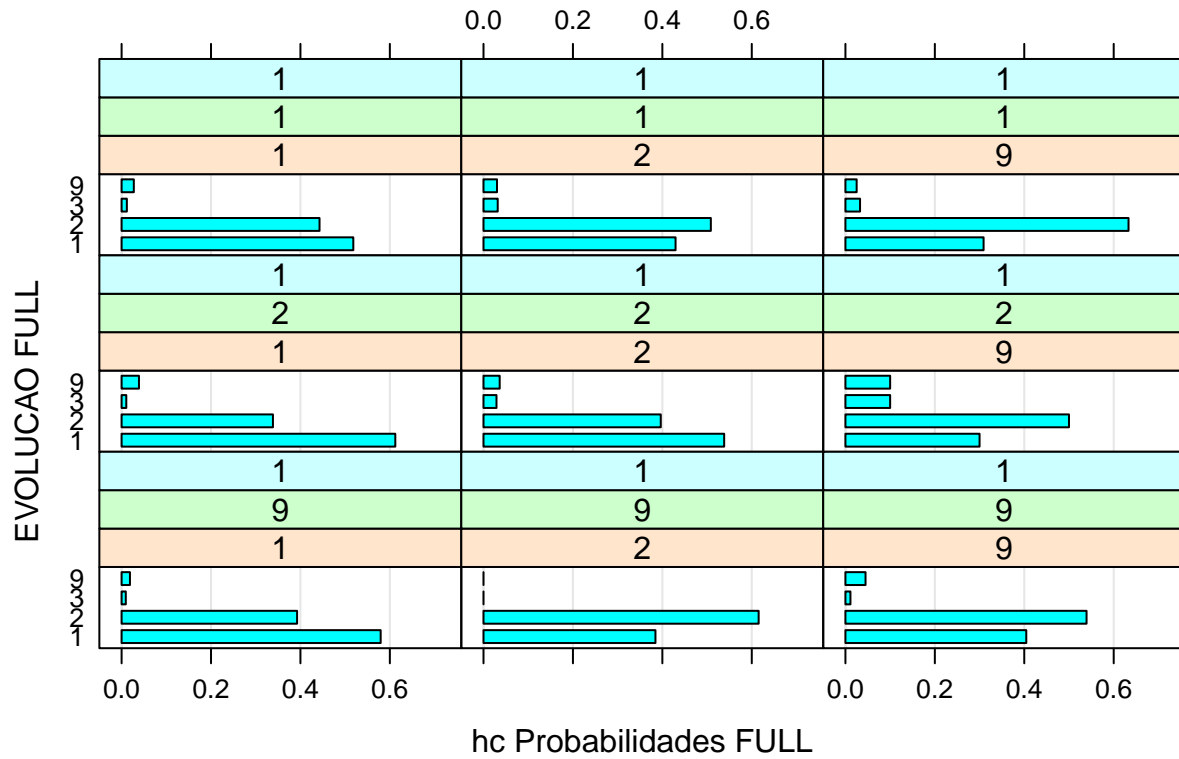
```

```
## , , PERD_PALA = 9
##
##          SATURACAO
## EVOLUCAO      1      2      9
##      1 0.3565285379 0.6153846154 0.4211618257
##      2 0.6082877248 0.3736263736 0.5477178423
##      3 0.0023455825 0.0109890110 0.0000000000
##      9 0.0328381548 0.0000000000 0.0311203320
```

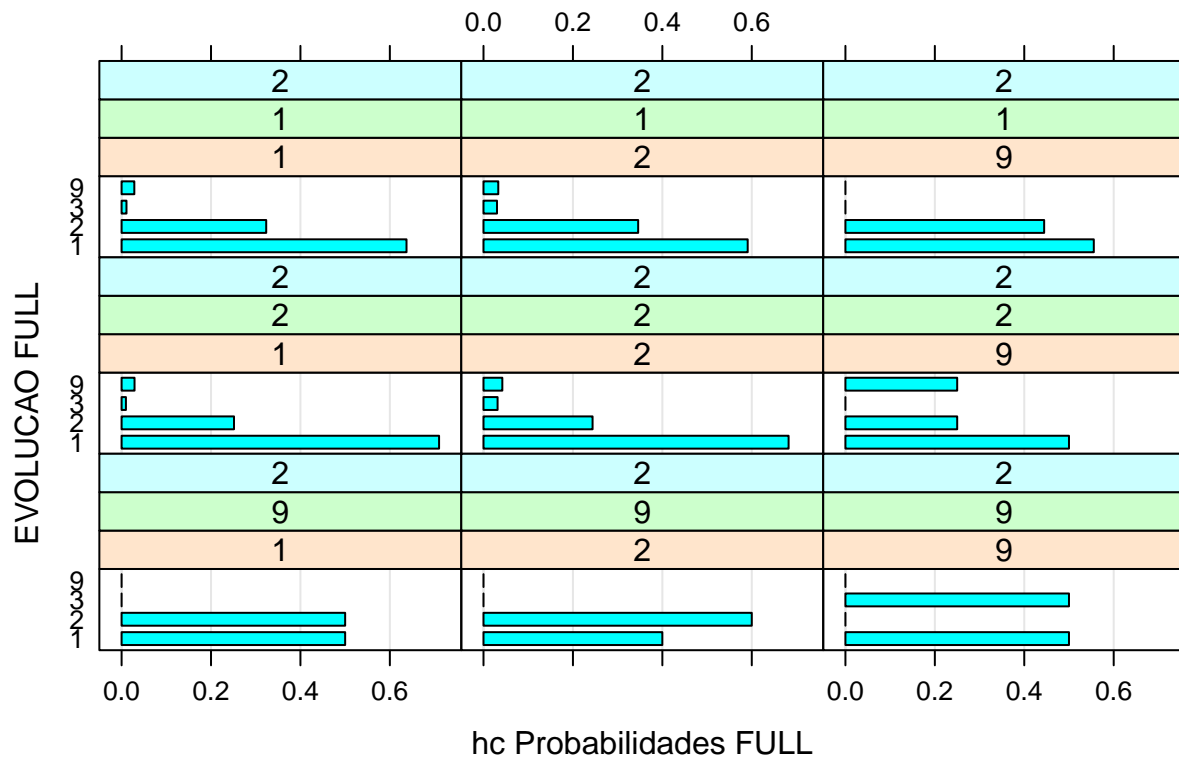
## Descrição estatística da rede para a variável EVOLUCAO DATA = OUTRAS

```
##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , SATURACAO = 1
##
##          TOSSE
## EVOLUCAO      1      2      9
##      1 0.69547260 0.54784992 0.41666667
##      2 0.21064337 0.30817875 0.40740741
##      3 0.06306593 0.11193086 0.12962963
##      9 0.03081811 0.03204047 0.04629630
##
## , , SATURACAO = 2
##
##          TOSSE
## EVOLUCAO      1      2      9
##      1 0.78928337 0.72046306 0.25000000
##      2 0.12590401 0.15866530 0.25000000
##      3 0.04273504 0.08205652 0.25000000
##      9 0.04207758 0.03881512 0.25000000
##
## , , SATURACAO = 9
##
##          TOSSE
## EVOLUCAO      1      2      9
##      1 0.75268817 0.53846154 0.67088608
##      2 0.16129032 0.23076923 0.25316456
##      3 0.05376344 0.23076923 0.02531646
##      9 0.03225806 0.00000000 0.05063291
```

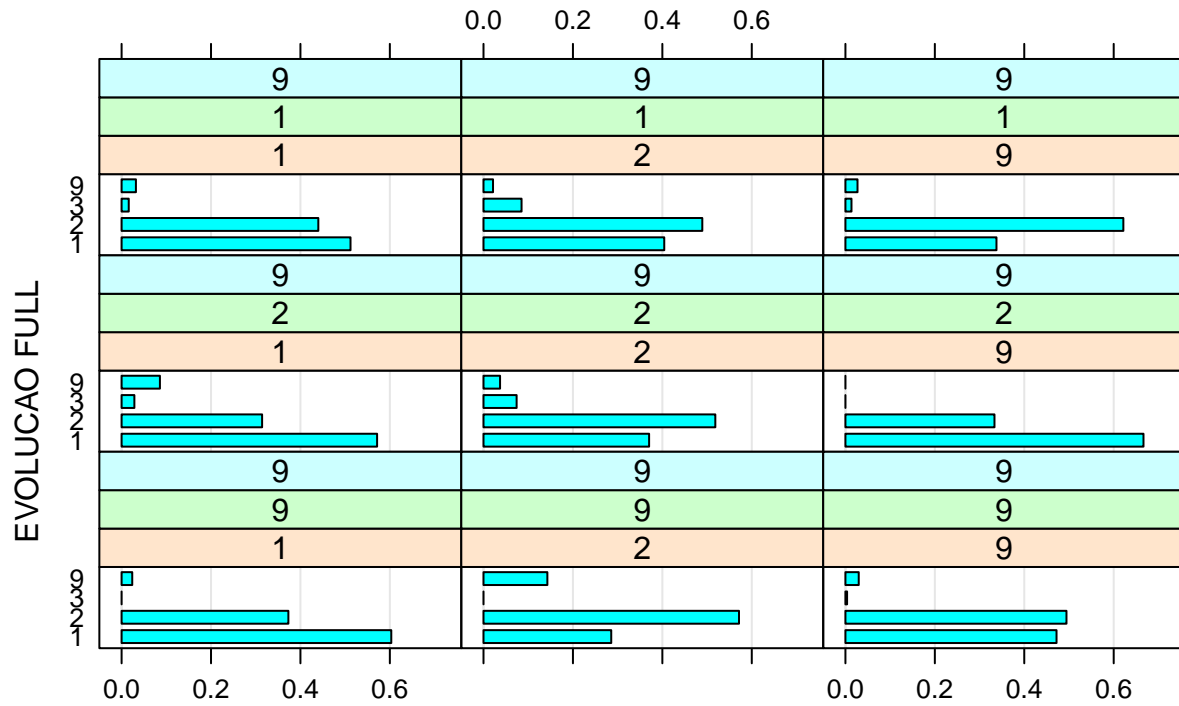
## Conditional Probabilities for Node EVOLUCAO



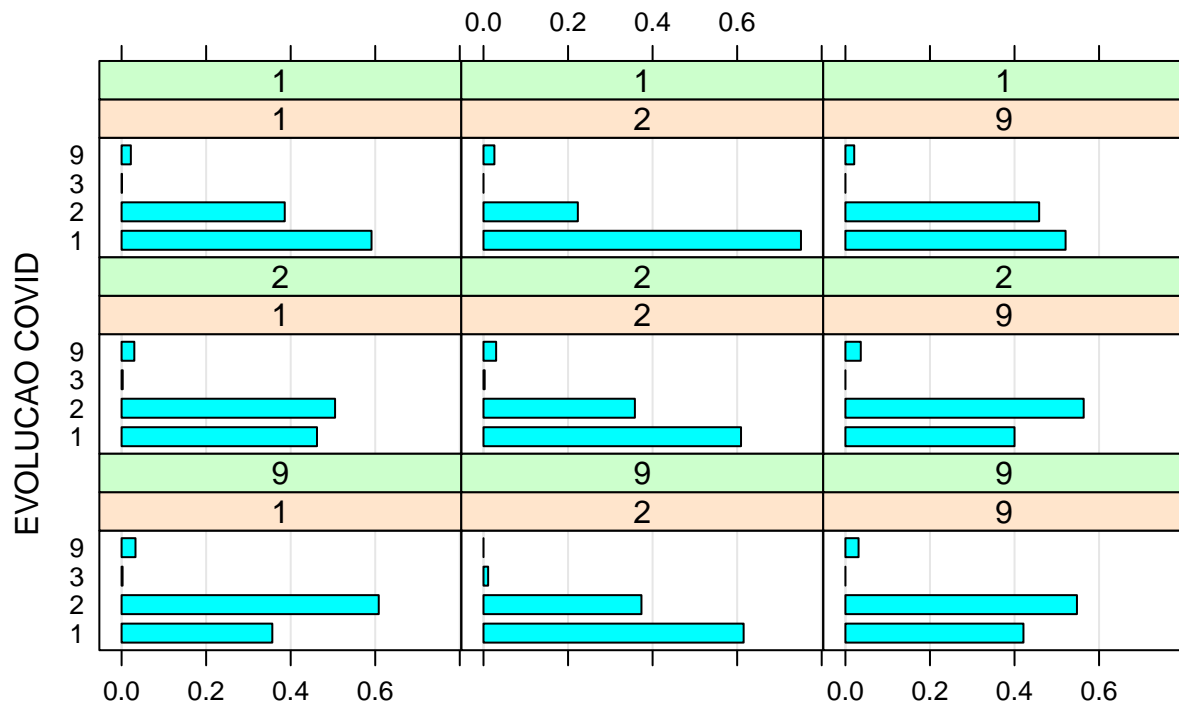
## Conditional Probabilities for Node EVOLUCAO



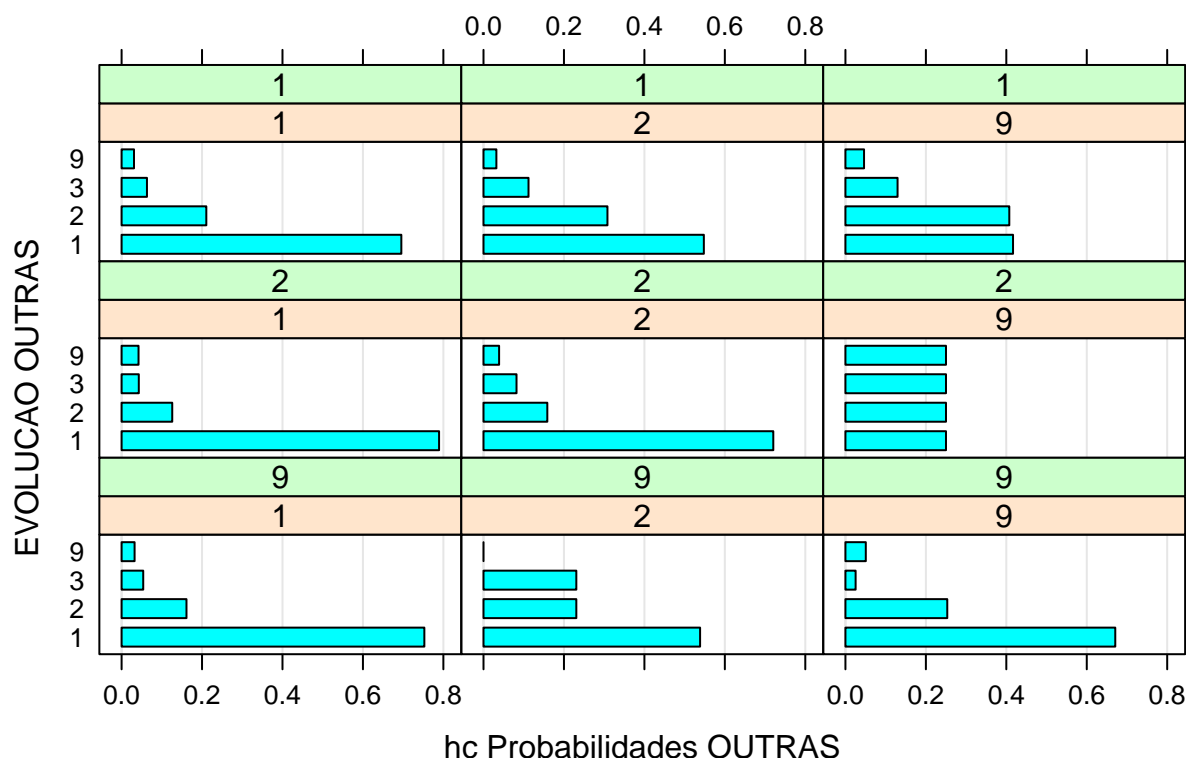
## Conditional Probabilities for Node EVOLUCAO



## Conditional Probabilities for Node EVOLUCAO



## Conditional Probabilities for Node EVOLUCAO



## Descrição estatística da rede para a variável EVOLUCAO ALGO = mmhc

```
## Warning in check.data(data, allow.missing = TRUE): variable CLASSI_FIN has
## levels that are not observed in the data.
```

```
## Warning in check.data(data, allow.missing = TRUE): variable CLASSI_FIN has
## levels that are not observed in the data.
```

```
##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , SATURACAO = 1
##
## DISPNEIA
## EVOLUCAO 1 2 9
## 1 0.489216522 0.582603939 0.492822967
## 2 0.464501848 0.361597374 0.468899522
## 3 0.018114618 0.017943107 0.009569378
## 9 0.028167012 0.037855580 0.028708134
##
## , , SATURACAO = 2
```



```

##
##          DISPNEIA
## EVOLUCAO      1          2          9
##      1 0.621968003 0.697712418 0.470588235
##      2 0.330896267 0.248093682 0.470588235
##      3 0.017202821 0.019335512 0.058823529
##      9 0.029932909 0.034858388 0.000000000
##
## , , SATURACAO = 9
##
##          DISPNEIA
## EVOLUCAO      1          2          9
##      1 0.463611860 0.492307692 0.509950249
##      2 0.482479784 0.400000000 0.457711443
##      3 0.024258760 0.046153846 0.002487562
##      9 0.029649596 0.061538462 0.029850746
##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , RENAL = 1
##
##          SATURACAO
## EVOLUCAO      1          2          9
##      1 0.303498779 0.486966825 0.318181818
##      2 0.668429618 0.483412322 0.613636364
##      3 0.006509357 0.001184834 0.000000000
##      9 0.021562246 0.028436019 0.068181818
##
## , , RENAL = 2
##
##          SATURACAO
## EVOLUCAO      1          2          9
##      1 0.482873605 0.630394476 0.378830084
##      2 0.485368841 0.337957931 0.596100279
##      3 0.002245713 0.002621316 0.000000000
##      9 0.029511841 0.029026277 0.025069638
##
## , , RENAL = 9
##
##          SATURACAO
## EVOLUCAO      1          2          9
##      1 0.513303769 0.712041885 0.514767932
##      2 0.447893570 0.230366492 0.451476793
##      3 0.001108647 0.000000000 0.000000000
##      9 0.037694013 0.057591623 0.033755274
##
## Parameters of node EVOLUCAO (multinomial distribution)
##
## Conditional probability table:
##
## , , SATURACAO = 1

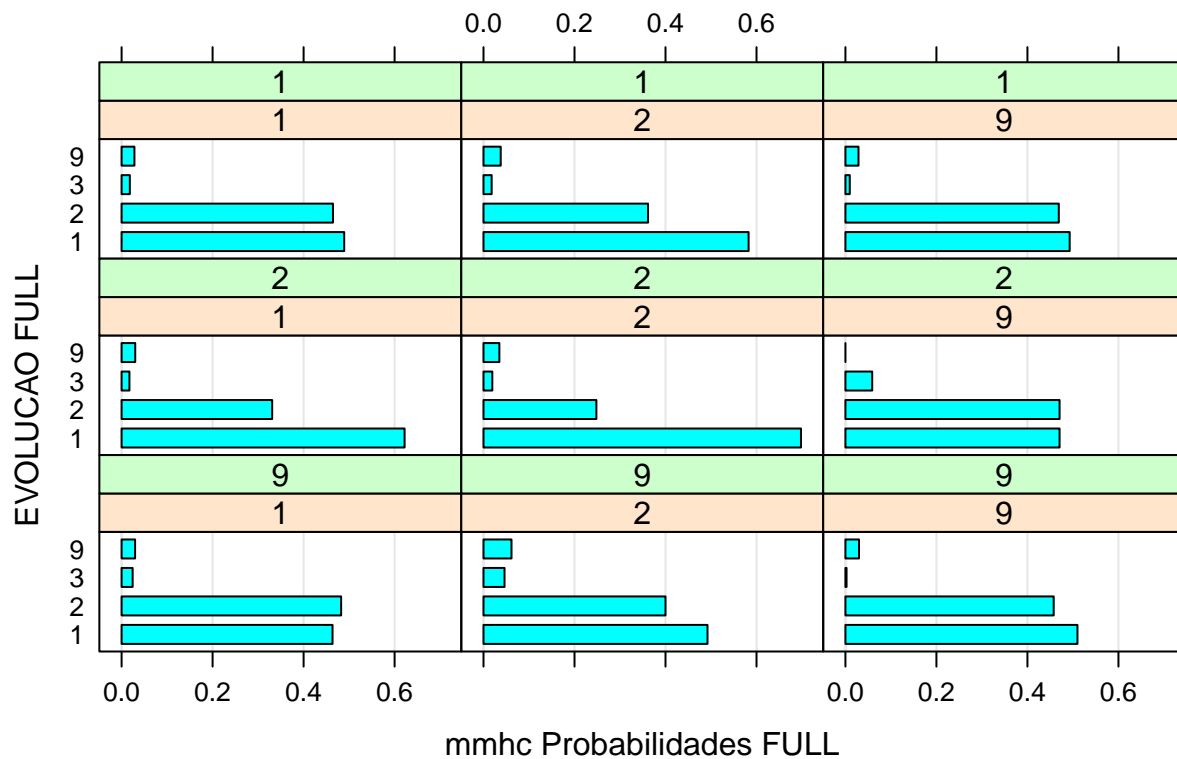
```

```

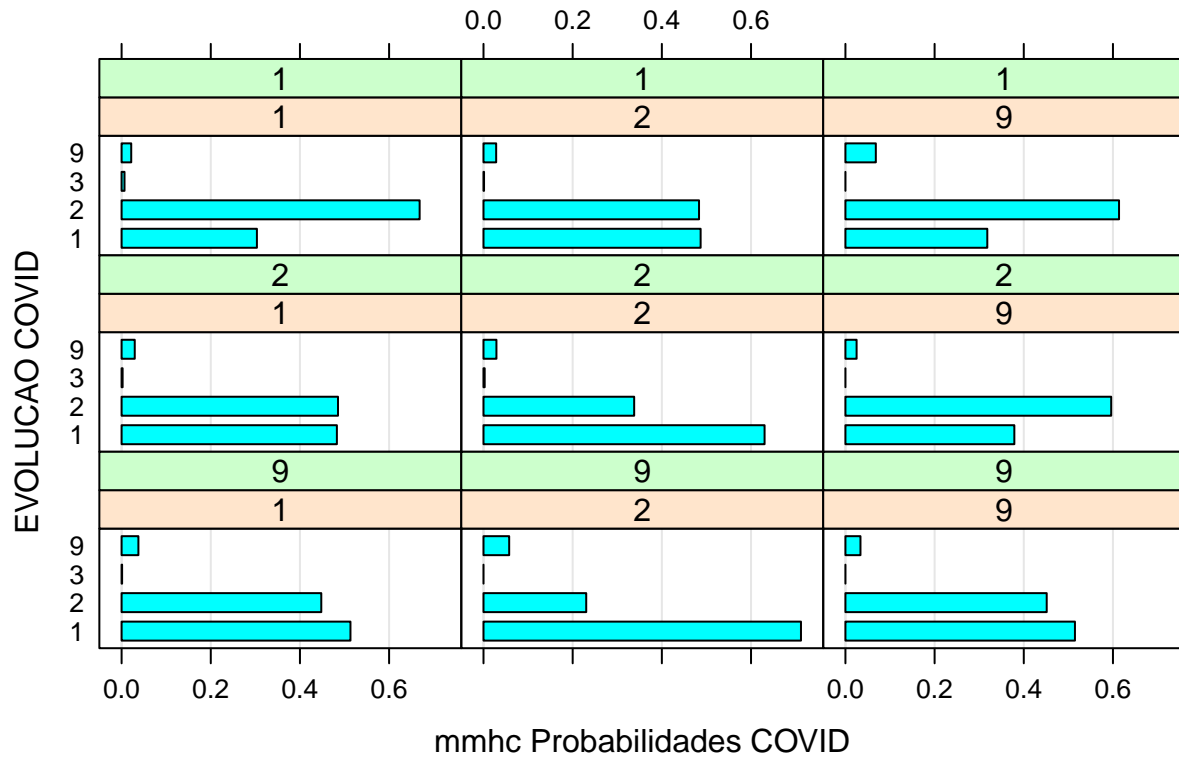
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.69547260 0.54784992 0.41666667
##      2 0.21064337 0.30817875 0.40740741
##      3 0.06306593 0.11193086 0.12962963
##      9 0.03081811 0.03204047 0.04629630
##
## , , SATURACAO = 2
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.78928337 0.72046306 0.25000000
##      2 0.12590401 0.15866530 0.25000000
##      3 0.04273504 0.08205652 0.25000000
##      9 0.04207758 0.03881512 0.25000000
##
## , , SATURACAO = 9
##
##      TOSSE
## EVOLUCAO      1      2      9
##      1 0.75268817 0.53846154 0.67088608
##      2 0.16129032 0.23076923 0.25316456
##      3 0.05376344 0.23076923 0.02531646
##      9 0.03225806 0.00000000 0.05063291

```

## Conditional Probabilities for Node EVOLUCAO



## Conditional Probabilities for Node EVOLUCAO



## Conditional Probabilities for Node EVOLUCAO

