Package 'phoenix'

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Title The Phoenix Pediatric Sepsis and Septic Shock Criteria

Version 1.1.3

Description Implementation of the Phoenix and Phoenix-8 Sepsis Criteria as described in ``Development and Validation of the Phoenix Criteria for Pediatric Sepsis and Septic Shock" by Sanchez-Pinto, Bennett, DeWitt, Russell et al. (2024) <doi:10.1001/jama.2024.0196> (Drs. Sanchez-Pinto and Bennett contributed equally to this manuscript; Dr. DeWitt and Mr. Russell contributed equally to the manuscript), ``International Consensus Criteria for Pediatric Sepsis and Septic Shock" by Schlapbach, Watson, Sorce, Argent, et al. (2024) <doi:10.1001/jama.2024.0179> (Drs Schlapbach, Watson, Sorce, and Argent contributed equally) and the application note ``phoenix: an R package and Python module for calculating the Phoenix pediatric sepsis score and criteria" by DeWitt, Russell, Rebull, Sanchez-Pinto, and Bennett (2024) <doi:10.1093/jamiaopen/ooae066>.

Depends R (>= 3.5.0)

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Encoding UTF-8

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BugReports https://github.com/CU-DBMI-Peds/phoenix/issues

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Contents

`map` *Mean Arterial Pressure*

Description

Estimate mean arterial pressure from systolic and diastolic blood pressures.

Usage

```
map(sbp, dbp)
```

Arguments

`sbp`	numeric vector, systolic blood pressure measured in mmHg
`dbp`	numeric vector, diastolic blood pressure measured in mmHg

Details

Mean Arterial Pressure is approximated by: (DBP + (SBP - DBP) / 3) = (2/3) DBP + (1/3) SBP

Value

a numeric vector

Examples

```
DF <- expand.grid(
        sbp = 40:130, # expected units of mmHg
        dbp = 20:100  # expected units of mmHg
      )

DF$map <- with(DF, map(sbp, dbp))
with(DF, plot(sbp, dbp, col = map))
DF$map[DF$sbp < DF$dbp] <- NA

z <- matrix(DF$map, nrow = length(unique(DF$sbp)), ncol = length(unique(DF$dbp)))

image(
  x = unique(DF$sbp),
  y = unique(DF$dbp),
  z = z,
  col = hcl.colors(100, palette = "RdBu"),
  xlab = "SBP (mmHg)",
  ylab = "DBP (mmHg)",
  main = "Estimated Mean Arterial Pressue"
)
contour(x = unique(DF$sbp), y = unique(DF$dbp), z = z, add = TRUE)
```

---

phoenix *The Phoenix Sepsis Score*

Description

The diagnostic Phoenix Sepsis Criteria based on four organ dysfunction scores, respiratory, cardiovascular, coagulation, and neurologic. A score of 2 or more indicates sepsis.

Usage

```
phoenix(
  pf_ratio,
  sf_ratio,
  imv,
  other_respiratory_support,
  vasoactives,
  lactate,
  map,
  platelets,
  inr,
```

```
  d_dimer,
  fibrinogen,
  gcs,
  fixed_pupils,
  age,
  data = parent.frame(),
  ...
)
```

Arguments

pf_ratio	numeric vector for the PaO2/FiO2 ratio; PaO2 = arterial oxygen pressure; FiO2 = fraction of inspired oxygen; PaO2 is measured in mmHg and FiO2 is from 0.21 (room air) to 1.00.
sf_ratio	numeric vector for the SpO2/FiO2 ratio; SpO2 = oxygen saturation, measured in a percent; ratio for 92% oxygen saturation on room air is 92/0.21 = 438.0952.
imv	invasive mechanical ventilation; numeric or integer vector, (0 = not intubated; 1 = intubated)
other_respiratory_support	other respiratory support; numeric or integer vector, (0 = no support; 1 = support)
vasoactives	an integer vector, the number of systemic vasoactive medications being administered to the patient. Six vasoactive medications are considered: dobutamine, dopamine, epinephrine, milrinone, norepinephrine, vasopressin.
lactate	numeric vector with the lactate value in mmol/L
map	numeric vector, mean arterial pressure in mmHg
platelets	numeric vector for platelets counts in units of 1,000/uL (thousand per microliter)
inr	numeric vector for the international normalised ratio blood test
d_dimer	numeric vector for D-Dimer, units of mg/L FEU
fibrinogen	numeric vector units of mg/dL
gcs	integer vector; total Glasgow Coma Score
fixed_pupils	integer vector; 1 = bilaterally fixed pupil, 0 = otherwise
age	numeric vector age in months
data	a list, data.frame, or environment containing the input vectors
...	pass through

Details

The details of each of the four component scores are found in their respective help files.

Value

A data.frame with seven columns:

1. phoenix_respiratory_score

2. phoenix_cardiovascular_score
3. phoenix_coagulation_score
4. phoenix_neurologic_score
5. phoenix_sepsis_score
6. phoenix_sepsis An integer vector, 0 = not septic, 1 = septic (score greater or equal to 2)
7. phoenix_septic_shock An integer vector, 0 = not septic shock, 1 = septic shock (score greater or equal 2 and cardiovascular dysfunction)

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

References

See reference details in phoenix-package or by calling citation('phoenix').

See Also

- phoenix for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - phoenix_cardiovascular,
  - phoenix_coagulation,
  - phoenix_neurologic,
  - phoenix_respiratory,
- phoenix8 for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - phoenix_endocrine,
  - phoenix_immunologic,
  - phoenix_renal,
  - phoenix_hepatic,

vignette('phoenix') for more details and examples.

Examples

```
# Using the example sepsis data set, read more details in the vignette

phoenix_scores <-
  phoenix(
    # Respiratory
      pf_ratio = pao2 / fio2,
      sf_ratio = ifelse(spo2 <= 97, spo2 / fio2, NA_real_),
      imv = vent,
      other_respiratory_support = as.integer(fio2 > 0.21),
    # Cardiovascular
    vasoactives = dobutamine + dopamine + epinephrine + milrinone + norepinephrine + vasopressin,
      lactate = lactate,
      age = age,
      map = dbp + (sbp - dbp)/3,
    # Coagulation
```

```
    platelets = platelets,
    inr = inr,
    d_dimer = d_dimer,
    fibrinogen = fibrinogen,
  # Neurologic
    gcs = gcs_total,
    fixed_pupils = as.integer(pupil == "both-fixed"),
  data = sepsis
)

str(phoenix_scores)
```

---

phoenix8 *The Phoenix 8 Sepsis Score*

Description

The extended Phoenix criteria using a total eight organ systems. This is intended mostly for research as an extension of the Phoenix Sepsis Criteria which is based on four organ systems.

Usage

```
phoenix8(
  pf_ratio,
  sf_ratio,
  imv,
  other_respiratory_support,
  vasoactives,
  lactate,
  map,
  platelets,
  inr,
  d_dimer,
  fibrinogen,
  gcs,
  fixed_pupils,
  glucose,
  anc,
  alc,
  creatinine,
  bilirubin,
  alt,
  age,
  data = parent.frame(),
  ...
)
```

Arguments

pf_ratio	numeric vector for the PaO2/FiO2 ratio; PaO2 = arterial oxygen pressure; FiO2 = fraction of inspired oxygen; PaO2 is measured in mmHg and FiO2 is from 0.21 (room air) to 1.00.
sf_ratio	numeric vector for the SpO2/FiO2 ratio; SpO2 = oxygen saturation, measured in a percent; ratio for 92% oxygen saturation on room air is 92/0.21 = 438.0952.
imv	invasive mechanical ventilation; numeric or integer vector, (0 = not intubated; 1 = intubated)
other_respiratory_support	other respiratory support; numeric or integer vector, (0 = no support; 1 = support)
vasoactives	an integer vector, the number of systemic vasoactive medications being administered to the patient. Six vasoactive medications are considered: dobutamine, dopamine, epinephrine, milrinone, norepinephrine, vasopressin.
lactate	numeric vector with the lactate value in mmol/L
map	numeric vector, mean arterial pressure in mmHg
platelets	numeric vector for platelets counts in units of 1,000/uL (thousand per microliter)
inr	numeric vector for the international normalised ratio blood test
d_dimer	numeric vector for D-Dimer, units of mg/L FEU
fibrinogen	numeric vector units of mg/dL
gcs	integer vector; total Glasgow Coma Score
fixed_pupils	integer vector; 1 = bilaterally fixed pupil, 0 = otherwise
glucose	numeric vector; blood glucose measured in mg/dL
anc	absolute neutrophil count; a numeric vector; units of 1,000 cells per cubic millimeter
alc	absolute lymphocyte count; a numeric vector; units of 1,000 cells per cubic millimeter
creatinine	numeric vector; units of mg/dL
bilirubin	numeric vector; units of mg/dL
alt	alanine aminotransferase; a numeric vector; units of IU/L
age	numeric vector age in months
data	a `list`, `data.frame`, or `environment` containing the input vectors
...	pass through

Details

The Phoenix Sepsis Criteria is based on the scores from respiratory, cardiovascular, coagulation, and neurologic systems. Phoenix 8 uses these four plus endocrine, immunologic, renal, and hepatic. Details on the scoring for each of the eight component organ systems are found in the respective manual files.

Value

a `data.frame` with 12 integer columns.

1. `phoenix_respiratory_score`
2. `phoenix_cardiovascular_score`
3. `phoenix_coagulation_score`
4. `phoenix_neurologic_score`
5. `phoenix_sepsis_score`
6. `phoenix_sepsis` 0 = not septic; 1 = septic (phoenix_sepsis_score greater or equal 2)
7. `phoenix_septic_shock` 0 = no septic shock; 1 = septic shock (sepsis with cardiovascular dysfunction)
8. `phoenix_endocrine_score`
9. `phoenix_immunologic_score`
10. `phoenix_renal_score`
11. `phoenix_hepatic_score`
12. `phoenix8_sepsis_score`

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

References

See reference details in `phoenix-package` or by calling `citation('phoenix')`.

See Also

- `phoenix` for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - `phoenix_cardiovascular`,
  - `phoenix_coagulation`,
  - `phoenix_neurologic`,
  - `phoenix_respiratory`,
- `phoenix8` for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - `phoenix_endocrine`,
  - `phoenix_immunologic`,
  - `phoenix_renal`,
  - `phoenix_hepatic`,

`vignette('phoenix')` for more details and examples.

Examples

```
# Using the example sepsis data set, read more details in the vignette

phoenix8_scores <-
  phoenix8(
    # Respiratory
      pf_ratio = pao2 / fio2,
      sf_ratio = ifelse(spo2 <= 97, spo2 / fio2, NA_real_),
      imv = vent,
      other_respiratory_support = as.integer(fio2 > 0.21),
    # Cardiovascular
    vasoactives = dobutamine + dopamine + epinephrine + milrinone + norepinephrine + vasopressin,
      lactate = lactate,
      age = age, # Also used in the renal assessment.
      map = dbp + (sbp - dbp)/3,
    # Coagulation
      platelets = platelets,
      inr = inr,
      d_dimer = d_dimer,
      fibrinogen = fibrinogen,
    # Neurologic
      gcs = gcs_total,
      fixed_pupils = as.integer(pupil == "both-fixed"),
    # Endocrine
      glucose = glucose,
    # Immunologic
      anc = anc,
      alc = alc,
    # Renal
      creatinine = creatinine,
      # no need to specify age again
    # Hepatic
      bilirubin = bilirubin,
      alt = alt,
    data = sepsis
  )

str(phoenix8_scores)
```

---

phoenix_cardiovascular

Phoenix Cardiovascular Score

Description

Generate the cardiovascular organ system dysfunction score as part of the diagnostic Phoenix Sepsis Criteria.

Usage

```
phoenix_cardiovascular(
  vasoactives = NA_integer_,
  lactate = NA_real_,
  age = NA_real_,
  map = NA_real_,
  data = parent.frame(),
  ...
)
```

Arguments

vasoactives	an integer vector, the number of systemic vasoactive medications being administered to the patient. Six vasoactive medications are considered: dobutamine, dopamine, epinephrine, milrinone, norepinephrine, vasopressin.
lactate	numeric vector with the lactate value in mmol/L
age	numeric vector age in months
map	numeric vector, mean arterial pressure in mmHg
data	a list, data.frame, or environment containing the input vectors
...	pass through

Details

There were six systemic vasoactive medications considered when the Phoenix criteria was developed: dobutamine, dopamine, epinephrine, milrinone, norepinephrine, and vasopressin.

During development, the values used for map were taken preferentially from arterial measurement, then cuff measures, and provided values before approximating the map from blood pressure values via DBP + 1/3 (SBP - DBP), where DBP is the diastolic blood pressure and SBP is the systolic blood pressure.

Value

a integer vector with values 0, 1, 2, 3, 4, 5, or 6.

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Cardiovascular Scoring

The Phoenix Cardiovascular score ranges from 0 to 6 points; 0, 1, or 2 points for each of systemic vasoactive medications, lactate, and MAP.

Systemic Vasoactive Medications

0 medications	0 points
1 medication	1 point
2 or more medications	2 points

Lactate

[0, 5)	0 points
[5, 11)	1 point
[11, Inf)	2 points

MAP

Age in [0, 1) months		
	[31, Inf) mmHg	0 points
	[17, 31) mmHg	1 point
	[0, 17) mmHg	2 points
Age in [1, 12) months		
	[39, Inf) mmHg	0 points
	[25, 39) mmHg	1 point
	[0, 25) mmHg	2 points
Age in [12, 24) months		
	[44, Inf) mmHg	0 points
	[31, 44) mmHg	1 point
	[0, 31) mmHg	2 points
Age in [24, 60) months		
	[45, Inf) mmHg	0 points
	[32, 45) mmHg	1 point
	[0, 32) mmHg	2 points
Age in [60, 144) months		
	[49, Inf) mmHg	0 points
	[36, 49) mmHg	1 point
	[0, 36) mmHg	2 points
Age in [144, 216] months		
	[52, Inf) mmHg	0 points
	[38, 52) mmHg	1 point
	[0, 38) mmHg	2 points

References

See reference details in `phoenix-package` or by calling `citation('phoenix')`.

See Also

- `phoenix` for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - `phoenix_cardiovascular`,
  - `phoenix_coagulation`,
  - `phoenix_neurologic`,
  - `phoenix_respiratory`,
- `phoenix8` for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and

- phoenix_endocrine,
- phoenix_immunologic,
- phoenix_renal,
- phoenix_hepatic,

vignette('phoenix') for more details and examples.

Examples

```
# using the example sepsis data set
phoenix_cardiovascular(
  vasoactives = dobutamine + dopamine + epinephrine + milrinone + norepinephrine + vasopressin,
   lactate = lactate,
   age = age,
   map = dbp + (sbp - dbp)/3,
   data = sepsis
)

# example data set to get all the possible scores
DF <-
  expand.grid(vasos = c(NA, 0:6),
              lactate = c(NA, 3.2, 5, 7.8, 11, 14), # units of mmol/L
              age = c(NA, 0.4, 1, 3, 12, 18, 24, 45, 60, 61, 144, 145), # months
              map = c(NA, 16:52)) # mmHg
DF$card <- phoenix_cardiovascular(vasos, lactate, age, map, DF)
head(DF)

# what if lactate is unknown for all records? - set the value either in the
# data object or the arguement value to NA
DF2 <-
  expand.grid(vasos = c(NA, 0:6),
              age = c(NA, 0.4, 1, 3, 12, 18, 24, 45, 60, 61, 144, 145), # months
              map = c(NA, 16:52)) # mmHg
DF2$card <- phoenix_cardiovascular(vasos, lactate = NA, age, map, DF2)

DF3 <-
  expand.grid(vasos = c(NA, 0:6),
              lactate = NA, # mmol/L
              age = c(NA, 0.4, 1, 3, 12, 18, 24, 45, 60, 61, 144, 145), # months
              map = c(NA, 16:52)) # mmHg
DF3$card <- phoenix_cardiovascular(vasos, lactate, age, map, DF3)

identical(DF2$card, DF3$card)
```

---

phoenix_coagulation *Phoenix Coagulation Score*

Description

Applies the Phoenix coagulation organ dysfunction scoring to a set of inputs.

Usage

```
phoenix_coagulation(
  platelets = NA_real_,
  inr = NA_real_,
  d_dimer = NA_real_,
  fibrinogen = NA_real_,
  data = parent.frame(),
  ...
)
```

Arguments

`platelets`	numeric vector for platelets counts in units of 1,000/uL (thousand per microliter)
`inr`	numeric vector for the international normalised ratio blood test
`d_dimer`	numeric vector for D-Dimer, units of mg/L FEU
`fibrinogen`	numeric vector units of mg/dL
`data`	a `list`, `data.frame`, or `environment` containing the input vectors
`...`	pass through

Value

a integer vector with values 0, 1, or 2

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Coagulation Scoring

1 point each for platelets < 100 K/micro liter, INR > 1.3, D-dimer > 2 mg/L FEU, and fibrinogen < 100 mg/dL, with a max total score of 2.

References

See reference details in `phoenix-package` or by calling `citation('phoenix')`.

See Also

- `phoenix` for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - `phoenix_cardiovascular`,
  - `phoenix_coagulation`,
  - `phoenix_neurologic`,
  - `phoenix_respiratory`,
- `phoenix8` for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - `phoenix_endocrine`,
  - `phoenix_immunologic`,

- phoenix_renal,
- phoenix_hepatic,

vignette('phoenix') for more details and examples.

Examples

```
# using the example data set
phoenix_coagulation(
  platelets = platelets,    # 1000/uL (thousand per microliter)
  inr = inr,                # unitless
  d_dimer = d_dimer,        # mg/L FEU
  fibrinogen = fibrinogen,  # mg/dL
  data = sepsis
)

# build a data.frame with values for all possible combationations of values
# leading to all possible coagulation scores.
DF <-
  expand.grid(plts = c(NA, 20, 100, 150),
              inr  = c(NA, 0.2, 1.3, 1.8),
              ddmr = c(NA, 1.7, 2.0, 2.8),
              fib  = c(NA, 88, 100, 120))

DF$coag <- phoenix_coagulation(plts, inr, ddmr, fib, DF)
DF
```

---

phoenix_endocrine *Phoenix Endocrine Score*

Description

Assess the Phoenix endocrine organ dysfunction score. This score is not part of the Phoenix score, only part of the Phoenix-8 score.

Usage

```
phoenix_endocrine(glucose = NA_real_, data = parent.frame(), ...)
```

Arguments

glucose	numeric vector; blood glucose measured in mg/dL
data	a list, data.frame, or environment containing the input vectors
...	pass through

Value

a integer vector with values 0 or 1

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Endocrine Scoring

The endocrine dysfunction score is based on blood glucose with one point for levels < 50 mg/dL or > 150 mg/dL.

References

See reference details in phoenix-package or by calling `citation('phoenix')`.

See Also

- phoenix for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - phoenix_cardiovascular,
  - phoenix_coagulation,
  - phoenix_neurologic,
  - phoenix_respiratory,
- phoenix8 for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - phoenix_endocrine,
  - phoenix_immunologic,
  - phoenix_renal,
  - phoenix_hepatic,

`vignette('phoenix')` for more details and examples.

Examples

```
# using the example sepsis data set
# recall glucose is expected to have units of mg/dL

endo_example       <- sepsis[c("pid", "glucose")]
endo_example$score <- phoenix_endocrine(glucose, data = sepsis)
endo_example

# example data set to get all the possible endocrine scores
# recall glucose is expected to have units of mg/dL

DF <- data.frame(glc = c(NA, 12, 50, 55, 100, 150, 178))
phoenix_endocrine(glucose = glc, data = DF)
```

`phoenix_hepatic` *Phoenix Hepatic Score*

Description

Apply the Phoenix Hepatic scoring based on total bilirubin and ALT.

Usage

```
phoenix_hepatic(
  bilirubin = NA_real_,
  alt = NA_real_,
  data = parent.frame(),
  ...
)
```

Arguments

`bilirubin`	numeric vector; units of mg/dL
`alt`	alanine aminotransferase; a numeric vector; units of IU/L
`data`	a `list`, `data.frame`, or `environment` containing the input vectors
`...`	pass through

Value

a integer vector with values 0 or 1

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Hepatic Scoring

1 point for total bilirubin greater or equal to 4 mg/dL and/or ALT strictly greater than 102 IU/L.

References

See reference details in `phoenix-package` or by calling `citation('phoenix')`.

See Also

- `phoenix` for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - `phoenix_cardiovascular`,
  - `phoenix_coagulation`,
  - `phoenix_neurologic`,
  - `phoenix_respiratory`,
- `phoenix8` for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and

- phoenix_endocrine,
- phoenix_immunologic,
- phoenix_renal,
- phoenix_hepatic,

vignette('phoenix') for more details and examples.

Examples

```
# using the example sepsis data set
# recall expected units:
#   (total) bilirubin: mg/dL
#   alt: IU/L

hep_example       <- sepsis[c("pid", "bilirubin", "alt")]
hep_example$score <- phoenix_hepatic(bilirubin, alt, sepsis)
hep_example

# example data set with all possilbe hepatic scores
DF <- expand.grid(bil = c(NA, 3.2, 4.0, 4.3), alt = c(NA, 99, 102, 106))
phoenix_hepatic(bilirubin = bil, alt = alt, data = DF)
```

---

phoenix_immunologic *Phoenix Immunologic Score*

Description

Apply the Phoenix immunologic scoring based on ANC and ALC. This is only part of Phoenix-8 and not Phoenix.

Usage

```
phoenix_immunologic(anc = NA_real_, alc = NA_real_, data = parent.frame(), ...)
```

Arguments

anc	absolute neutrophil count; a numeric vector; units of 1,000 cells per cubic millimeter
alc	absolute lymphocyte count; a numeric vector; units of 1,000 cells per cubic millimeter
data	a list, data.frame, or environment containing the input vectors
...	pass through

Value

a integer vector with values 0 or 1

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Immunologic Scoring

1 point if ANC < 0.500 or ALC < 1.000 (units are 1000 cells per cubic millimeter).

References

See reference details in phoenix-package or by calling `citation('phoenix')`.

See Also

- phoenix for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - phoenix_cardiovascular,
  - phoenix_coagulation,
  - phoenix_neurologic,
  - phoenix_respiratory,
- phoenix8 for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - phoenix_endocrine,
  - phoenix_immunologic,
  - phoenix_renal,
  - phoenix_hepatic,

`vignette('phoenix')` for more details and examples.

Examples

```
# using the example sepsis data set
# Expected units for ALC and ANC are 1000 cells per cubic millimeter

immu_example <- sepsis[c("pid", "anc", "alc")]
immu_example$score <- phoenix_immunologic(anc, alc, sepsis)
immu_example

# example data set with all possilbe immunologic scores
# Expected units for anc and alc are 1000 cells per cubic millimeter

DF <- expand.grid(anc = c(NA, 0.200, 0.500, 0.600),
                  alc = c(NA, 0.500, 1.000, 2.000))
phoenix_immunologic(anc = anc, alc = alc, data = DF)
```

---

phoenix_neurologic *Phoenix Sepsis Neurological Score*

Description

Assessment of neurologic dysfunction based on Glasgow Coma Scale (GCS) and pupil reactivity. This score is part of the diagnostic Phoenix Sepsis criteria and Phoenix 8 Sepsis criteria.

Usage

```
phoenix_neurologic(
  gcs = NA_integer_,
  fixed_pupils = NA_real_,
  data = parent.frame(),
  ...
)
```

Arguments

gcs	integer vector; total Glasgow Coma Score
fixed_pupils	integer vector; 1 = bilaterally fixed pupil, 0 = otherwise
data	a list, data.frame, or environment containing the input vectors
...	pass through

Details

Missing values will map to a value of 0 as was done when developing the Phoenix criteria. Note that this is done on a input by input basis. That is, if pupil reactivity is missing but GCS (total) is 9, then the neurologic dysfunction score is 1.

GCS total is the sum of a score based on eyes, motor control, and verbal responsiveness.

Eye response:

1. no eye opening,
2. eye opening to pain,
3. eye opening to sound,
4. eyes open spontaneously.

Verbal response:

1. no verbal response,
2. incomprehensible sounds,
3. inappropriate words,
4. confused,
5. orientated

Motor response:

1. no motor response,
2. abnormal extension to pain,
3. abnormal flexion to pain,
4. withdrawal from pain,
5. localized pain,
6. obeys commands

Value

an integer vector with values 0, 1, or 2. As with all Phoenix organ dysfunction scores, missing input values map to scores of zero.

Phoenix Neurological Scoring

Bilaterally fixed pupil	2 points
Glasgow Coma Score (total) less or equal 10	1 point
Reactive pupils and GCS > 10	0 point

References

See reference details in phoenix-package or by calling `citation('phoenix')`.

See Also

- phoenix for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - phoenix_cardiovascular,
  - phoenix_coagulation,
  - phoenix_neurologic,
  - phoenix_respiratory,
- phoenix8 for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - phoenix_endocrine,
  - phoenix_immunologic,
  - phoenix_renal,
  - phoenix_hepatic,

`vignette('phoenix')` for more details and examples.

Examples

```
# using the example sepsis data set
# Expected units:
#   GCS integer values from 3, 4, 5, ..., 15
#   fixed_pupils: 1 if bilaterially fixed pupils, 0 otherwise

phoenix_neurologic(
  gcs = gcs_total,
  fixed_pupils = as.integer(pupil == "both-fixed"),
  data = sepsis
)

# build an example data set with all possible neurologic scores
DF <- expand.grid(gcs = c(3:15, NA), pupils = c(0, 1, NA))
DF$target <- 0L
```

```
DF$target[DF$gcs <= 10] <- 1L
DF$target[DF$pupils == 1] <- 2L
DF$current <- phoenix_neurologic(gcs, pupils, DF)
stopifnot(identical(DF$target, DF$current))
DF
```

`phoenix_renal` *Phoenix Renal Score*

Description

Apply the Phoenix renal organ dysfunction score based on age adjusted creatinine levels.

Usage

```
phoenix_renal(
  creatinine = NA_real_,
  age = NA_real_,
  data = parent.frame(),
  ...
)
```

Arguments

`creatinine`	numeric vector; units of mg/dL
`age`	numeric vector age in months
`data`	a `list`, `data.frame`, or `environment` containing the input vectors
`...`	pass through

Value

an integer vector with values 0 or 1

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Renal Scoring

Age in [0, 1) months		
	creatinine [0, 0.8) mg/dL	0 points
	creatinine [0.8, Inf) mg/dL	1 point
Age in [1, 12) months		
	creatinine in [0, 0.3) mg/dL	0 points
	creatinine in [0.3, Inf) mg/dL	1 point
Age in [12, 24) months		
	creatinine in [0, 0.4) mg/dL	0 points

	creatinine in [0.4, Inf) mg/dL	1 point
Age in [24, 60) months		
	creatinine in [0, 0.6) mg/dL	0 points
	creatinine in [0.6, Inf) mg/dL	1 point
Age in [60, 144) months		
	creatinine in [0, 0.7) mg/dL	0 points
	creatinine in [0.7, Inf) mg/dL	1 point
Age in [144, 216] months		
	creatinine in [0, 1.0) mg/dL	0 points
	creatinine in [1.0, Inf) mg/dL	1 point

References

See reference details in phoenix-package or by calling `citation('phoenix')`.

See Also

- phoenix for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - phoenix_cardiovascular,
  - phoenix_coagulation,
  - phoenix_neurologic,
  - phoenix_respiratory,
- phoenix8 for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - phoenix_endocrine,
  - phoenix_immunologic,
  - phoenix_renal,
  - phoenix_hepatic,

`vignette('phoenix')` for more details and examples.

Examples

```
# using the example sepsis data set
# Expected units:
#   age: months
#   creatinine: mg/dL

renal_example <- sepsis[c("creatinine", "age")]
renal_example$score <- phoenix_renal(creatinine, age, sepsis)
renal_example

# build an example data set with representative renal scores
DF <- expand.grid(age = c(NA, 0.4, 1, 3, 12, 18, 24, 45, 60, 61, 144, 145),
                  creatinine = c(NA, seq(0.0, 1.1, by = 0.1)))
```

```
DF$card <- phoenix_renal(age = age, creatinine = creatinine, data = DF)

head(DF)
```

`phoenix_respiratory` *Phoenix Respiratory Score*

Description

Apply the Phoenix Respiratory Scoring rubric to a data set. The respiratory score is part of the diagnostic Phoenix Sepsis criteria and the diagnostic Phoenix 8 Sepsis criteria.

Usage

```
phoenix_respiratory(
  pf_ratio = NA_real_,
  sf_ratio = NA_real_,
  imv = NA_integer_,
  other_respiratory_support = NA_integer_,
  data = parent.frame(),
  ...
)
```

Arguments

`pf_ratio`	numeric vector for the PaO2/FiO2 ratio; PaO2 = arterial oxygen pressure; FiO2 = fraction of inspired oxygen; PaO2 is measured in mmHg and FiO2 is from 0.21 (room air) to 1.00.
`sf_ratio`	numeric vector for the SpO2/FiO2 ratio; SpO2 = oxygen saturation, measured in a percent; ratio for 92% oxygen saturation on room air is 92/0.21 = 438.0952.
`imv`	invasive mechanical ventilation; numeric or integer vector, (0 = not intubated; 1 = intubated)
`other_respiratory_support`	other respiratory support; numeric or integer vector, (0 = no support; 1 = support)
`data`	a `list`, `data.frame`, or `environment` containing the input vectors
`...`	pass through

Details

`pf_ratio` is the ratio of partial pressure of oxygen in arterial blood (PaO2) to the fraction of inspiratory oxygen concentration (FiO2).

`sf_ratio` is a non-invasive surrogate for `pf_ratio` using pulse oximetry (SpO2) instead of invasive PaO2.

Important Note: when the Phoenix Sepsis criteria was developed there is a requirement that SpO2 <= 97 in order for the `sf_ratio` to be valid. That assumption is not checked in this code and it is left to the end user to account for this when building the `sf_ratio` vector.

`imv` Invasive mechanical ventilation - integer vector where 0 = not intubated and 1 = intubated.

`other_respiratory_support` other respiratory support such as receiving oxygen, high-flow, non-invasive positive pressure, or imv.

Value

a integer vector with values 0, 1, 2, or 3.

As with all other Phoenix organ system scores, missing values in the data set will map to a score of zero - this is consistent with the development of the criteria.

Phoenix Respiratory Scoring

0 points	1 point	2 points
pf_ratio >= 400 and sf_ratio >= 292	(pf_ratio < 400 or sf_ratio < 292) and any respiratory support	(pf_ratio < 200 or sf_ra

References

See reference details in `phoenix-package` or by calling `citation('phoenix')`.

See Also

- `phoenix` for generating the diagnostic Phoenix Sepsis score based on the four organ systems:
  - `phoenix_cardiovascular`,
  - `phoenix_coagulation`,
  - `phoenix_neurologic`,
  - `phoenix_respiratory`,
- `phoenix8` for generating the diagnostic Phoenix 8 Sepsis criteria based on the four organ systems noted above and
  - `phoenix_endocrine`,
  - `phoenix_immunologic`,
  - `phoenix_renal`,
  - `phoenix_hepatic`,

`vignette('phoenix')` for more details and examples.

Examples

```
# Using the provided example data set:
# Expected units:
#   pf_ratio: PaO2 / FiO2
#     PaO2: mmHg
#     FiO2: decimal between 0.21 (room air) to 1.00 (pure oxygen)
#   sf_ratio: SpO2 / FiO2
#     SpO2: percentage, 0 to 100
#     FiO2: decimal between 0.21 (room air) to 1.00 (pure oxygen)
#   imv: (invasive mechanical ventilation) 1 for yes, 0 for no
#   other_respiratory_support: 1 for yes, 0 for no

phoenix_respiratory(
  pf_ratio = pao2 / fio2,
  sf_ratio = spo2 / fio2,
  imv      = vent,
  other_respiratory_support = as.integer(fio2 > 0.21),
  data = sepsis
)

# A set of values that will get all possible respiratory scores:
DF <- expand.grid(
  pfr = c(NA, 500, 400, 350, 200, 187, 100, 56),
  sfr = c(NA, 300, 292, 254, 220, 177, 148, 76),
  vent = c(NA, 0, 1),
  o2  = c(NA, 0, 1)
)

phoenix_respiratory(
  pf_ratio = pfr,
  sf_ratio = sfr,
  imv = vent,
  other_respiratory_support = o2,
  data = DF
)
```

`sepsis` *sepsis*

Description

A fully synthetic data set with variables needed for examples and documentation of the Phoenix Sepsis Criteria.

Usage

```
sepsis
```

Format

a data.frame with 20 rows and 27 columns

[, 1]	pid	patient identification number
[, 2]	age	age in months
[, 3]	fio2	fraction of inspired oxygen
[, 4]	pao2	partial pressure of oxygen in arterial blood (mmHg)
[, 5]	spo2	pulse oximetry
[, 6]	vent	indicator for invasive mechanical ventilation
[, 7]	gcs_total	total Glasgow Coma Scale
[, 8]	pupil	character vector reporting if pupils are reactive or fixed.
[, 9]	platelets	platelets measured in 1,000 / microliter
[, 10]	inr	international normalized ratio
[, 11]	d_dimer	D-dimer; units of mg/L FEU
[, 12]	fibrinogen	units of mg/dL
[, 13]	dbp	diastolic blood pressure (mmHg)
[, 14]	sbp	systolic blood pressure (mmHg)
[, 15]	lactate	units of mmol/L
[, 16]	dobutamine	indicator for receiving systemic dobutamine
[, 17]	dopamine	indicator for receiving systemic dopamine
[, 18]	epinephrine	indicator for receiving systemic epinephrine
[, 19]	milrinone	indicator for receiving systemic milrinone
[, 20]	norepinephrine	indicator for receiving systemic norepinephrine
[, 21]	vasopressin	indicator for receiving systemic vasopressin
[, 22]	glucose	units of mg/dL
[, 23]	anc	units of 1,000 cells per cubic millimeter
[, 24]	alc	units of 1,000 cells per cubic millimeter
[, 25]	creatinine	units of mg/dL
[, 26]	bilirubin	units of mg/dL
[, 27]	alt	units of IU/L

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