

# Package ‘isni’

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**Title** Index of Local Sensitivity to Nonignorability

**Version** 0.4

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**Description** The current version provides functions to compute, print and summarize the Index of Sensitivity to Nonignorability (ISNI) in the generalized linear model for independent data, and in the marginal multivariate Gaussian model and the linear mixed model for longitudinal/clustered data. It allows for arbitrary patterns of missingness in the regression outcomes caused by dropout and/or intermittent missingness. One can compute the sensitivity index without estimating any nonignorable models or positing specific magnitude of nonignorability. Thus ISNI provides a simple quantitative assessment of how robust the standard estimates assuming missing at random is with respect to the assumption of ignorability. For a tutorial, download at <[http://huixie.people.uic.edu/Research/ISNI\\_R\\_tutorial.pdf](http://huixie.people.uic.edu/Research/ISNI_R_tutorial.pdf)>. For more details, see Troxel Ma and Heitjan (2004) and Xie and Heitjan (2004) <doi:10.1191/1740774504cn005oa> and Ma Troxel and Heitjan (2005) <doi:10.1002/sim.2107> and Xie (2008) <doi:10.1002/sim.3117> and Xie (2012) <doi:10.1016/j.csda.2010.11.1>.

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## R topics documented:

coc	2
definemissingstatus	3
isniglm	4
isnilmm	5
isningm	7
print.isniglm	8
print.isnilmm	9
print.isningm	9
qolef	10
sos	11
summary.isniglm	11
summary.isnilmm	12
summary.isningm	12
tmdm	13

<b>Index</b>	<b>14</b>
--------------	-----------

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coc	<i>A data set for Psychiatric Drug Treatment</i>
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### Description

The variables are as follows:

- y. number of days
- time. in weeks
- sub. patients id
- group. treatment group with placebo (PBO) and desipramine (DMI)
- basey. baseline days
- g1. dummy variables for treatment group
- g2. dummy variables for treatment group
- time1. dummy variables for time
- time2. dummy variables for time
- grptime. group by time

### Usage

```
data(coc)
```

### Format

A data frame with 869 rows and 10 variables

---

definmissingstatus     *Utility function to generate missing status variables in longitudinal data with dropout and/or intermittent missingness.*

---

### Description

Utility function to generate missing status variables in longitudinal data with dropout and/or intermittent missingness.

### Usage

```
definmissingstatus(data, id, time, y)
```

### Arguments

data	the name of the panel dataset in the long format with each row denoting a subject-visit observation for ALL the planned visits, regardless of being missed or not. When a subject is lost to follow up, the data set must include the observation at the first time of being lost to follow up.
id	the name of the level-2 clustering variable.
time	the name of the variable denoting the time of the visit. Can set time=NULL if data is already sorted by id and time within id.
y	the name of the outcome variable of the interest that is subject to missingness.

### Value

a dataset with the following three new variables added:

- g\_ : missingness indicator, "O"-observed, "I"-intermittent missing, "D"-dropout
- gp\_ : missingness indicator in the previous visit, "O"-observed, "I"-intermittent missing, "D"-dropout, "U"-undefined.
- yp\_ : the immediately observed prior outcome.

### Examples

```
qolefnew <- definmissingstatus(qolef, id=id, time=time, y=y)
```

---

 isniglm

---

*Function for ISNI computation when the outcome follows GLMs.*


---

### Description

Calculate the ISNI when the regression outcome is subject to missingness and follows generalized linear models (GLMs)

### Usage

```
isniglm(formula, family = gaussian, data, weights, subset, start = NULL,
         offset)
```

### Arguments

formula	an object of class "Formula": a symbolic description of the models to be fitted for the outcome and missingness status variable. The details of model specification are given under "Details".
family	a description of the error distribution to be used in the GLM for the outcome.
data	the name of data frame containing the variables in the model and all the observations including those intended to be collected but became missing.
weights	an optional vector of "prior weights" to be used in the fitting process for the outcome model and the missingness mechanism model. Should be NULL or a numeric vector.
subset	an optional vector specifying a subset of observations to be used in the fitting process for the outcome model and the missingness mechanism model.
start	starting values for the parameters in the linear predictor of the outcome model.
offset	an optional vector to specify an a priori known component to be included in the linear predictor during fitting the GLM for the outcome. This should be NULL or a numeric vector of length equal to the number of observations.

### Details

The ISNI analysis is based on a joint selection model and requires specifying two model equations: the complete-data model and the missing data mechanism model. To specify the variables in the models and required for computing the ISNI measures, we make use of the R package "Formula" designed for handling model equations with multiple responses and multiple sets of predictors. At a minimum, the user should supply a single-equation in the typical form:  $\text{response} \sim X\text{terms}$  where response is the (numeric or factor) vector for the outcome of interest and Xterms is a series of terms, separated by + operators, which specify a linear predictor for response. With the single-equation specification, the isniglm function will by default use  $(\text{is.na}(\text{response}))$  as the missingness status variable and Xterms as the observed predictors for missingness. The isniglm then computes the MAR estimates and conducts ISNI computation to evaluate the rate of change of model estimates in the neighborhood of the MAR model where the missingness probability is allowed to depend on the unobserved value of response, even after conditioning on the other missingness predictors.

The above single-equation formula specification uses the same set of predictors for the outcome model and the missingness mechanism model for computing ISNI. To use different sets of predictors, one can explicitly specify a two-equation formula as: `response | is.na(response) ~ Xterms | Sterms`, which specifies the formula for the complete-data model as `response ~ Xterms` and that for the missing data mechanism model as `is.na(response) ~ Sterms`, and `Xterms` and the observed predictors for missingness `Sterms` can be different.

## Examples

```
## load data set
data(sos)

## Perform the MAR analysis
ymodel= sexact ~ gender*faculty
summary(glm(ymodel,family=binomial, data=sos))

## Perform ISNI analysis
sos.isni<-isniglmm(ymodel, family=binomial, data=sos)
sos.isni
summary(sos.isni)

## specifying the missing data model explicitly
ygmodel= sexact | is.na(sexact) ~ gender*faculty | gender *faculty
summary(isniglmm(ygmodel, family=binomial, data=sos))

## ISNI for grouped binomial regression.
gender <- c(0,0,1,1,0,0,1,1)
faculty   <- c(0,0,0,0,1,1,1,1)
gender = factor(gender, levels = c(0, 1), labels =c("male", "female"))
faculty = factor(faculty, levels = c(0, 1), labels =c("other", "mdv"))

SAcount <- c(NA, 1277, NA, 1247, NA, 126, NA, 152)
total    <- c(1189,1710,978,1657,68,215,73,246)
sosgrp <- data.frame(gender=gender, faculty=faculty, SAcount=SAcount, total=total)
ymodel <- SAcount/total ~gender*faculty
sosgrp.isni<-isniglmm(ymodel, family=binomial, data=sosgrp, weight=total)
```

---

isnilmm

*Function for ISNI computation when the outcome follows LMM.*

---

## Description

Calculate the ISNI when the regression outcome is subject to missingness and follows linear mixed-effects models (LMMs)

## Usage

```
isnilmm(formula, data, random, id, weights, subset, predprobabs,
        misni = FALSE)
```

## Arguments

formula	an object of class "Formula": a symbolic description of the models to be fitted for the outcome and missingness status variable. The details of model specification are given under "Details".
data	the name of data frame containing all the variables in the model and all the observations including those intended to be collected but became missing.
random	an object of class "formula": an one-sided linear formula description of the random-effects part of the model to be fitted for the outcome
id	the name of the level-2 clustering variable.
weights	frequency weights to be assigned to each id. when supplied, indicates differential weights are used; otherwise each id is weighted equally.
subset	an optional vector specifying a subset of observations to be used in the fitting process for the outcome model and the missingness mechanism model.
predprobobs	Null if using built-in multinomial transitional logistic model to obtain predicted probabilities of being observed; otherwise user supply the name of the variable in data that gives these probabilities for all the observations in the data.
misni	FALSE if using the default approach to computing ISNI with a scalar nonignorability parameter; TRUE when computing ISNI with multiple nonignorability parameters.

## Details

The ISNI analysis is based on a joint selection model and requires specifying two model equations: the complete-data model and the missing data mechanism model. To specify the variables in the models that are required for computing the ISNI measures, we make use of the R package "Formula" designed for handling model equations with multiple responses and multiple sets of predictors. At a minimum, the user should supply a single-equation in the typical form:  $\text{response} \sim X\text{terms}$  where response is the (numeric or factor) vector for the outcome of interest and Xterms is a series of terms, separated by + operators, which specify a linear predictor for response. With the single-equation specification, the `isniglm` function will by default use the utility function `definmissingstatus` provided in the package to generate the missingness status variables at the current and prior visits and then use Xterms as the observed missingness predictors for fitting a first-order transitional missing data model. It is important to sort within-id observations by time so that the missingness status variables can be defined correctly in this default setting. The `isniglm` then computes the MAR estimates and conducts ISNI computation to evaluate the rate of change of model estimates in the neighborhood of the MAR model where the missingness probability is allowed to depend on the unobserved value of response, even after conditioning on the other missingness predictors.

The above single-equation formula specification uses the same set of predictors for the outcome model and the missingness mechanism model for computing ISNI. To use different sets of predictors, one can explicitly specify a two-equation formula as:  $\text{response} \mid \text{miss} + \text{missprior} \sim X\text{terms} \mid S\text{terms}$ , which specifies the formula for the complete-data model as  $\text{response} \sim X\text{terms}$  and that for the missing data mechanism model as  $\text{miss} + \text{missprior} \sim S\text{terms}$ , where Xterms and the observed predictors for missingness Sterms can be different, miss and missprior are the variable names in data denoting the missingness status at the current and prior visits, respectively.

For `isnilmm`, `response ~ Xterms` specified the fixed-effect part of the linear mixed-effects model for the outcome. The random-effect part of the model is specified as a one-sided formula via the argument `random`.

### Examples

```
data(qolef)
ymodel= y | g+ gp~ as.factor(time)*group+perf+sever

##Random intercept model
result=isnilmm(ymodel, random=~1, id=id, data=qolef)
summary(result)
```

---

isningm	<i>Function for ISNI computation when the outcome follows marginal multivariate Gaussian Models.</i>
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---

### Description

Calculate the ISNI when the regression outcome is subject to missingness and follows marginal multivariate Gaussian models.

### Usage

```
isningm(formula, data, cortype = "CS", id, subset, weights, predprobabs,
  misni = FALSE)
```

### Arguments

formula	an object of class "Formula": a symbolic description of the models to be fitted for the outcome and missingness status variable. The details of model specification are given under "Details".
data	the name of data frame containing all the variables in the model and all the observations including those intended to be collected but became missing.
cortype	the type of within-subject correlation structure.
id	the name of variable for the level-2 clustering variable.
subset	an optional vector specifying a subset of observations to be used in the fitting process for the outcome model and the missingness mechanism model.
weights	frequency weights to be assigned to each id. when supplied, indicates differential weights are used; otherwise each id is weighted equally.
predprobabs	Null if using built-in multinomial transitional logistic model to obtain predicted probabilities of being observed; otherwise user supply the name of the variable in data that gives these probabilities for all the observations in the data.
misni	FALSE if using the default approach to computing ISNI with a scalar nonignorability parameter; TRUE when computing ISNI with multiple nonignorability parameters.

## Details

The ISNI analysis is based on a joint selection model and requires specifying two model equations: the complete-data model and the missing data mechanism model. To specify the variables in the models that are required for computing the isni measures, we make use of the R package "Formula" designed for handling model equations with multiple responses and multiple sets of predictors. At a minimum, the user should supply a single-equation in the typical form: `response ~ Xterms` where `response` is the (numeric or factor) vector for the outcome of interest and `Xterms` is a series of terms, separated by `+` operators, which specify a linear predictor for response. With the single-equation specification, the `isniglm` function will by default use the utility function `definmissingstatus` provided in the package to generate the missingness status variables at the current and prior visits and then use `Xterms` as the observed missingness predictors for fitting a first-order transitional missing data model. It is important to sort within-id observations by time so that the missingness status variables can be defined correctly in this default setting. The `isniglm` then computes the MAR estimates and conducts ISNI computation to evaluate the rate of change of model estimates in the neighborhood of the MAR model where the missingness probability is allowed to depend on the unobserved value of response, even after conditioning on the other missingness predictors.

The above single-equation formula specification uses the same set of predictors for the outcome model and the missing data mechanism model for computing ISNI. To use different sets of predictors, one can explicitly specify a two-equation formula as: `response | miss + missprior ~ Xterms | Sterms`, which specifies the formula for the outcome model as `response ~ Xterms` and that for the missing data mechanism model as `miss + missprior ~ Sterms`, where `Xterms` and the observed missingness predictors `Sterms` can be different, `miss` and `missprior` are the variable names in data denoting the missingness status at the current and prior visits, respectively.

## Examples

```
models= y | g+gp ~ perf + sever+ as.factor(time) + group +as.factor(time):group |
        as.factor(time) * group + yp+ perf + sever
qolef.isni=isniglm(models, data=qolef, id=id)
summary(qolef.isni)
```

---

print.isniglm

*Function to print the isniglm object.*

---

## Description

print method for class isniglm

## Usage

```
## S3 method for class 'isniglm'
print(x, digits = max(3, getOption("digits") - 2), ...)
```



**Arguments**

x	the isniglm object obtained from the isniglm function
digits	the number of significant digits to use when printing
...	further arguments passed to or from other methods.

**Value**

The function prints the model call, isni and c statistics from the isniglm object.

---

print.isnilmm	<i>Function to print the isnilmm object.</i>
---------------	--

---

**Description**

print method for class isnilmm

**Usage**

```
## S3 method for class 'isnilmm'  
print(x, digits = max(3, getOption("digits") - 2), ...)
```

**Arguments**

x	the isnilmm object obtained from the isnilmm function
digits	the number of significant digits to use when printing
...	further arguments passed to or from other methods.

**Value**

The function print.isnilmm prints the model call, isni and c statistics from the isnilmm object.

---

print.isnimgm	<i>Function to print the isnimgm object.</i>
---------------	--

---

**Description**

print method for class isnimgm

**Usage**

```
## S3 method for class 'isnimgm'  
print(x, digits = max(3, getOption("digits") - 2), ...)
```

**Arguments**

x	the isningm object obtained from the isningm function
digits	the number of significant digits to use when printing
...	further arguments passed to or from other methods.

**Value**

The function `print.isningm` prints the model call, `isni` and `c` statistics from the `isningm` object.

---

qolef

*A data set for Quality of Life Emotional Functioning outcome.*

---

**Description**

The variables are as follows:

- `id`: patients id
- `y`: EF score
- `time`: time in months since randomization.
- `group`: placebo (0) or flutamide (1)
- `perf`: baseline performance score
- `sever`: baseline disease severity
- `basey`: EF at baseline
- `g`: missingness status ("O"=observed, "D"=dropout, "I"=intermittent missingness)
- `gp`: missingness status in the prior visit ("O"=observed, "D"=dropout, "I"=intermittent missingness, "U"=undefined)

**Usage**

```
data(qolef)
```

**Format**

A data frame with 2860 rows and 10 variables

---

 sos

*Dataset for a survey of sexual behavior*


---

**Description**

A dataset from a survey of sexual behavior

**Usage**

```
data(sos)
```

**Format**

A data frame with 6136 rows and 3 variables

**Details**

This data frame contains the following three factor variables:

- `sexact`: response to the survey question "Have you ever had sexual intercourse" with two levels of no (ref level) and yes.
- `gender`: two levels of male (ref level) and female.
- `faculty`: the student's faculty with two levels of `mdv=medical/dental/veterinary` (ref level) and `other` =all the other faculty categories.

---

 summary.isniglm

*Function to print out a summary of isniglm object in a matrix form.*


---

**Description**

Function to print out a summary of isniglm object in a matrix form.

**Usage**

```
## S3 method for class 'isniglm'
summary(object, digits = max(3, getOption("digits") - 2),
  ...)
```

**Arguments**

<code>object</code>	the isniglm object obtained from the isniglm function
<code>digits</code>	the number of significant digits to use when printing
<code>...</code>	further arguments passed to or from other methods.

**Value**

The function summarizes the MAR coefficient estimates, standard errors, isni and c statistics from the isniglm object as a matrix form.

---

summary.isnilmm	<i>Function to print out a summary of isnilmm object in a matrix form.</i>
-----------------	--

---

**Description**

Function to print out a summary of isnilmm object in a matrix form.

**Usage**

```
## S3 method for class 'isnilmm'
summary(object, digits = max(3, getOption("digits") - 2),
  ...)
```

**Arguments**

object	the isnilmm object obtained from the isnilmm function
digits	the number of significant digits to use when printing
...	additional arguments

---

summary.isnimgm	<i>Function to print out a summary of isnimgm object in a matrix form.</i>
-----------------	--

---

**Description**

Function to print out a summary of isnimgm object in a matrix form.

**Usage**

```
## S3 method for class 'isnimgm'
summary(object, digits = max(3, getOption("digits") - 2),
  ...)
```

**Arguments**

object	the isnimgm object obtained from the isnimgm function
digits	the number of significant digits to use when printing
...	additional arguments

---

tmdm	<i>Function to fit the transitional missing data model and obtain the predicted probabilities of being observed for all observations.</i>
------	---

---

**Description**

Fit missing data model and obtain predicted probabilities of being observed for all observations.

**Usage**

```
tmdm(formula, data, weights, subset)
```

**Arguments**

formula	a formula to specify a multinomial transitional missing data model in the form of <code>g+gp ~Sterms</code> .
data	the name of the dataset for fitting missing data mechanism model
weights	an optional vector of "prior weights" to be used in the fitting process for the missingness mechanism model. Should be NULL or a numeric vector.
subset	an optional vector specifying a subset of observations to be used in the fitting process for the outcome model and the missingness mechanism model.

**Examples**

```
qolefitg <- tmdm(g+gp~as.factor(time)+group+perf+sever,data=qolef)
```

# Index

## \*Topic **datasets**

coc, [2](#)

qolef, [10](#)

sos, [11](#)

coc, [2](#)

definemissingstatus, [3](#)

isniglm, [4](#)

isnilmm, [5](#)

isningm, [7](#)

print.isniglm, [8](#)

print.isnilmm, [9](#)

print.isningm, [9](#)

qolef, [10](#)

sos, [11](#)

summary.isniglm, [11](#)

summary.isnilmm, [12](#)

summary.isningm, [12](#)

tndm, [13](#)