STRATOS INITIATIVE

MICHIGAN STATE UNIVERSITY

Building blocks of efficient initial data analysis and data quality assessments Best practice examples

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Topic Group 3 of STRATOS: Initial Data Analysis

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STRATOS INITIATIVE

https://stratosida.github.io/

Scan for IDA resources: TG3

What is Initial Data Analysis (IDA)?

IDA = systematic process to provide reliable knowledge about the data to determine the suitability of the data for the main data analysis

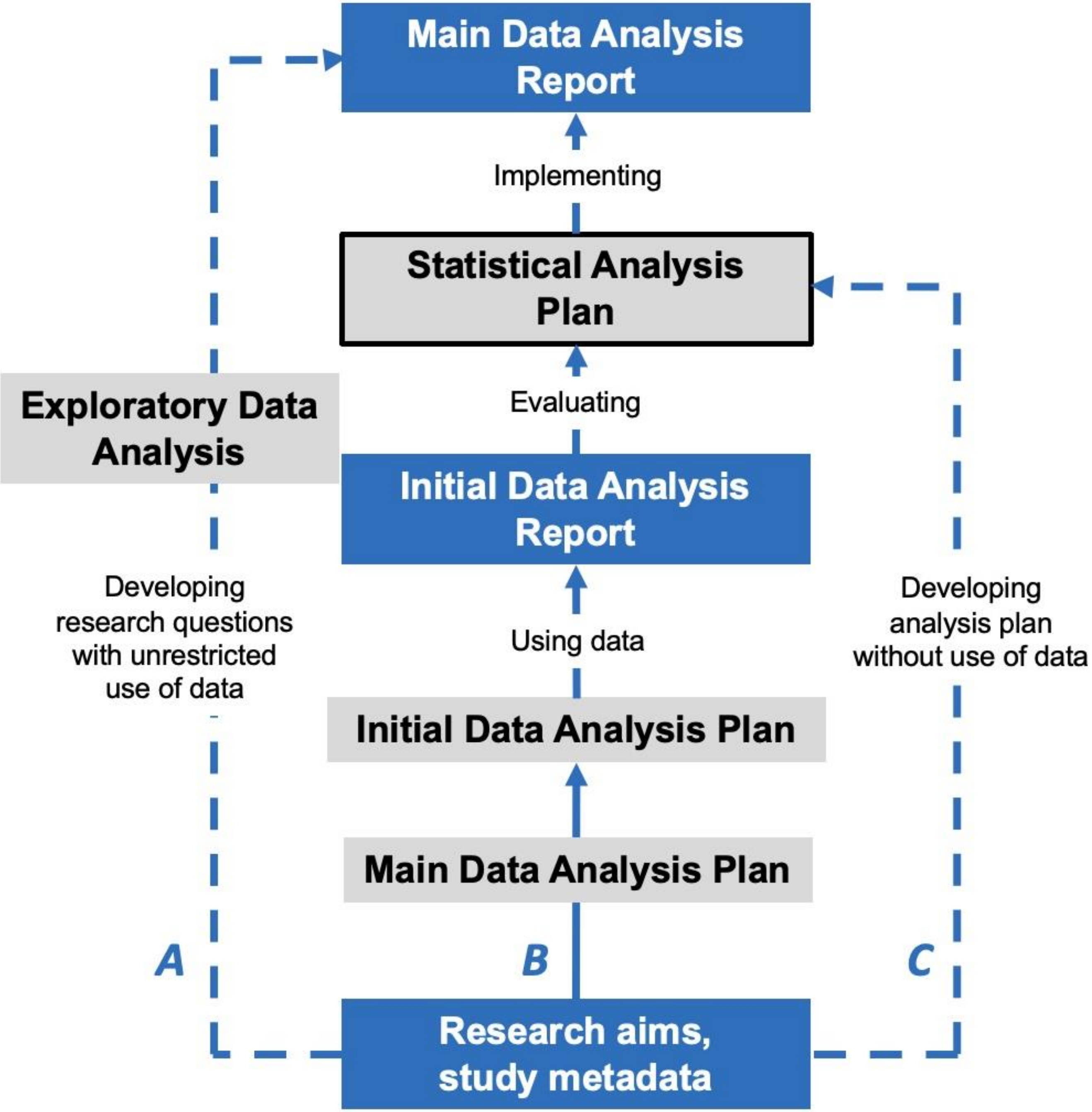
- Aligned with the research aims and the main data analysis
- Does NOT include hypothesis generating activities
- Does NOT include assessing associations between predictors and outcomes

Scan for IDA resources: TG3

Publications by our team

- Contemporary framework for initial data analysis
- Hidden analyses (systematic review)
- Ten Simple Rules for initial data analysis
- Regression without regrets
- IDA checklist for longitudinal studies
- *International consensus project:* Statistical Analysis Plan for Observational Studies including IDA plan
- *In progress:* Teaching example including dataset, R code,

  workflow: analysis plan→ IDA → regression model


Main Data Analysis Report
Implementing
Statistical Analysis Plan
Evaluating
Exploratory Data Analysis
Initial Data Analysis Report
Developing research questions with unrestricted use of data
Using data
Developing analysis plan without use of data
Initial Data Analysis Plan
Main Data Analysis Plan
A
B
C
Research aims, study metadata

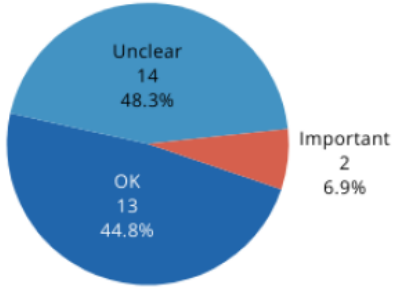
Why should you be concerned about underlying data properties?

Scan for R package dataquier

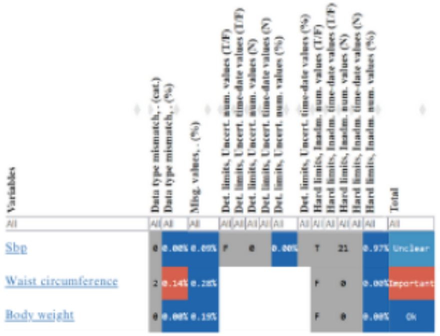
Data quality dashboard

Data quality assessment

1. Data quality overview



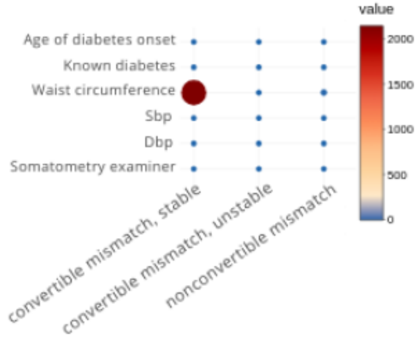
Percentage of variables per quality categories



Variables	Data type mismatch, . (cat.)	Data type mismatch, . (%)	Missg. values, . (%)	Det. limits, Uncert. num. values (T/F)	Det. limits, Uncert. time-date values (T/F)	Det. limits, Uncert. num. values (N)	Det. limits, Uncert. time-date values (N)	Det. limits, Uncert. num. values (%)	Det. limits, Uncert. time-date values (%)	Hard limits, Inadm. num. values (T/F)	Hard limits, Inadm. time-date values (T/F)	Hard limits, Inadm. num. values (N)	Hard limits, Inadm. time-date values (N)	Hard limits, Inadm. num. values (%)	Total
All	All	All	All	All	All	All	All	All	All	All	All	All	All	All	All
Sbp	0	0.00%	0.09%	F		0		0.00%		T		21		0.97%	Unclear
Waist circumference	2	0.14%	0.28%							F		0		0.00%	Important
Body weight	0	0.00%	0.19%							F		0		0.00%	Ok

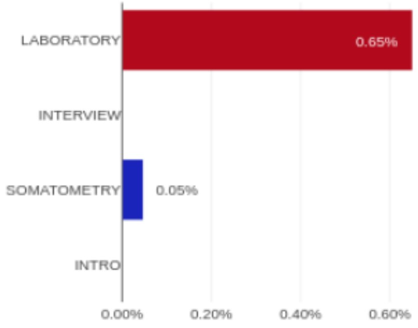
Targeted quality indicators, potential issues, and applicability problems

2. Integrity



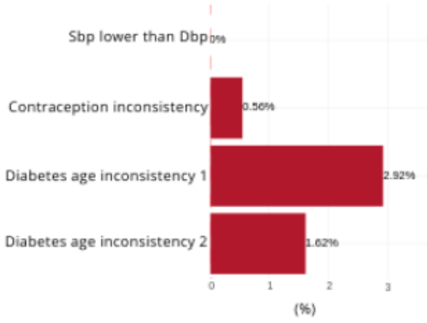
Data type mismatch

3. Completeness



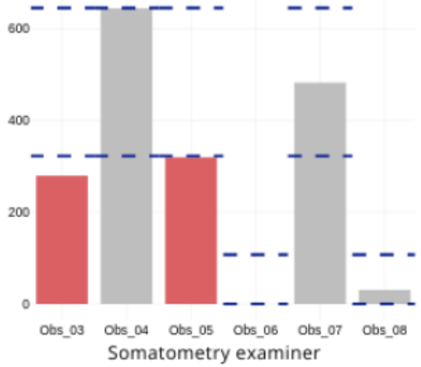
Missing values per segment

4. Consistency



Contradictions

5. Accuracy



Unexpected proportions

Underlying knowledge about data: Metadata

Variable names

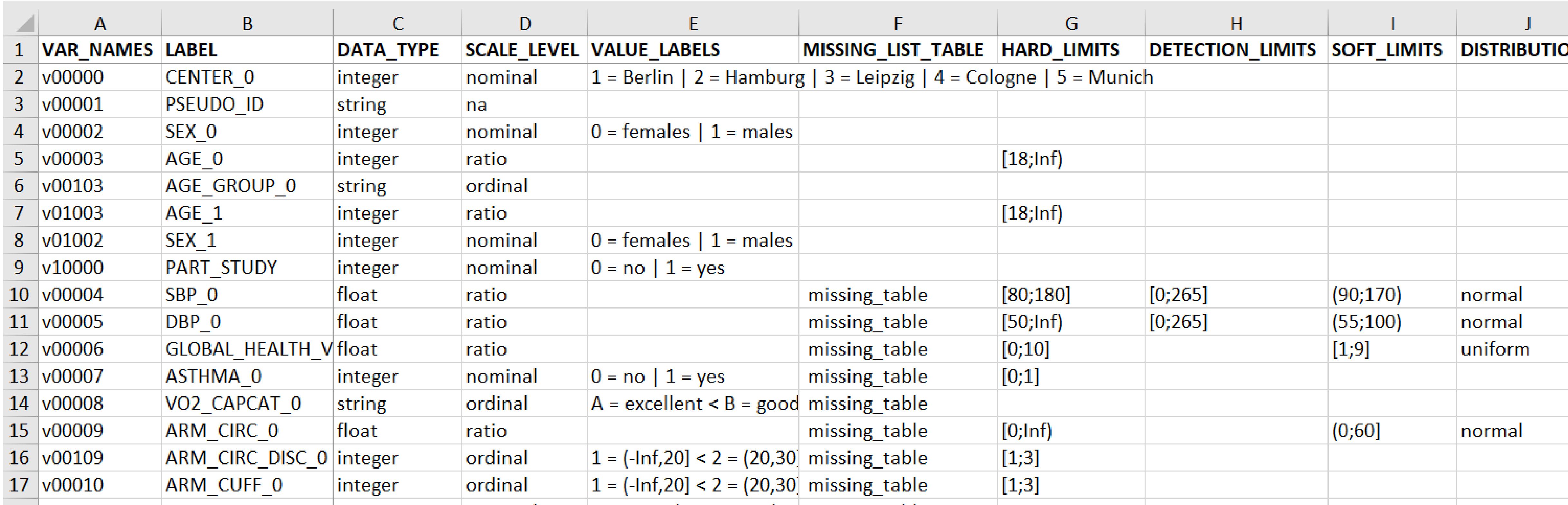
Label

Type (integer, string, date,..)

Values (categories)

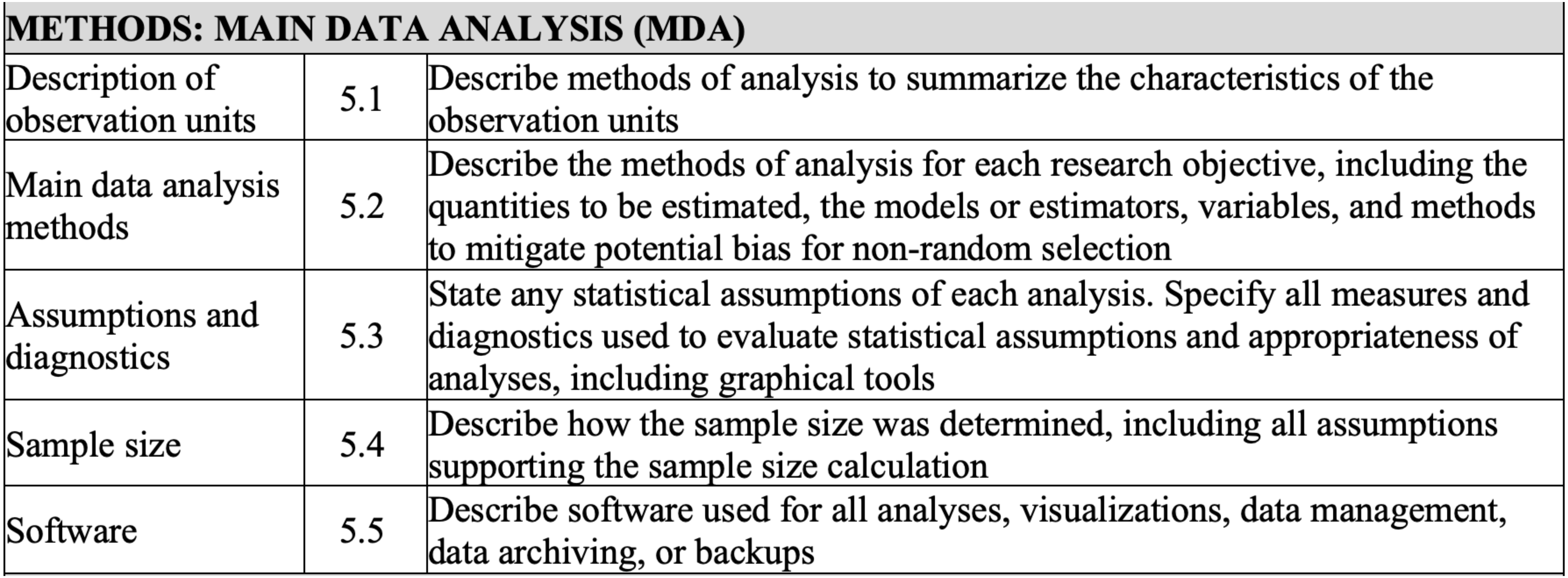
Range (continuous)

Expectations (distribution, missingness,…)



	A	B	C	D	E	F	G	H	I	J
1	VAR_NAMES	LABEL	DATA_TYPE	SCALE_LEVEL	VALUE_LABELS	MISSING_LIST_TABLE	HARD_LIMITS	DETECTION_LIMITS	SOFT_LIMITS	DISTRIBUTIO
2	v00000	CENTER_0	integer	nominal	1 = Berlin | 2 = Hamburg | 3 = Leipzig | 4 = Cologne | 5 = Munich					
3	v00001	PSEUDO_ID	string	na						
4	v00002	SEX_0	integer	nominal	0 = females | 1 = males					
5	v00003	AGE_0	integer	ratio			[18;Inf)			
6	v00103	AGE_GROUP_0	string	ordinal						
7	v01003	AGE_1	integer	ratio			[18;Inf)			
8	v01002	SEX_1	integer	nominal	0 = females | 1 = males					
9	v10000	PART_STUDY	integer	nominal	0 = no | 1 = yes					
10	v00004	SBP_0	float	ratio		missing_table	[80;180]	[0;265]	(90;170)	normal
11	v00005	DBP_0	float	ratio		missing_table	[50;Inf)	[0;265]	(55;100)	normal
12	v00006	GLOBAL_HEALTH_V	float	ratio		missing_table	[0;10]		[1;9]	uniform
13	v00007	ASTHMA_0	integer	nominal	0 = no | 1 = yes	missing_table	[0;1]			
14	v00008	VO2_CAPCAT_0	string	ordinal	A = excellent < B = good	missing_table				
15	v00009	ARM_CIRC_0	float	ratio		missing_table	[0;Inf)		(0;60]	normal
16	v00109	ARM_CIRC_DISC_0	integer	ordinal	1 = (-Inf,20] < 2 = (20,30]	missing_table	[1;3]			
17	v00010	ARM_CUFF_0	integer	ordinal	1 = (-Inf,20] < 2 = (20,30]	missing_table	[1;3]			

Statistical Analysis Plan for Observational Studies

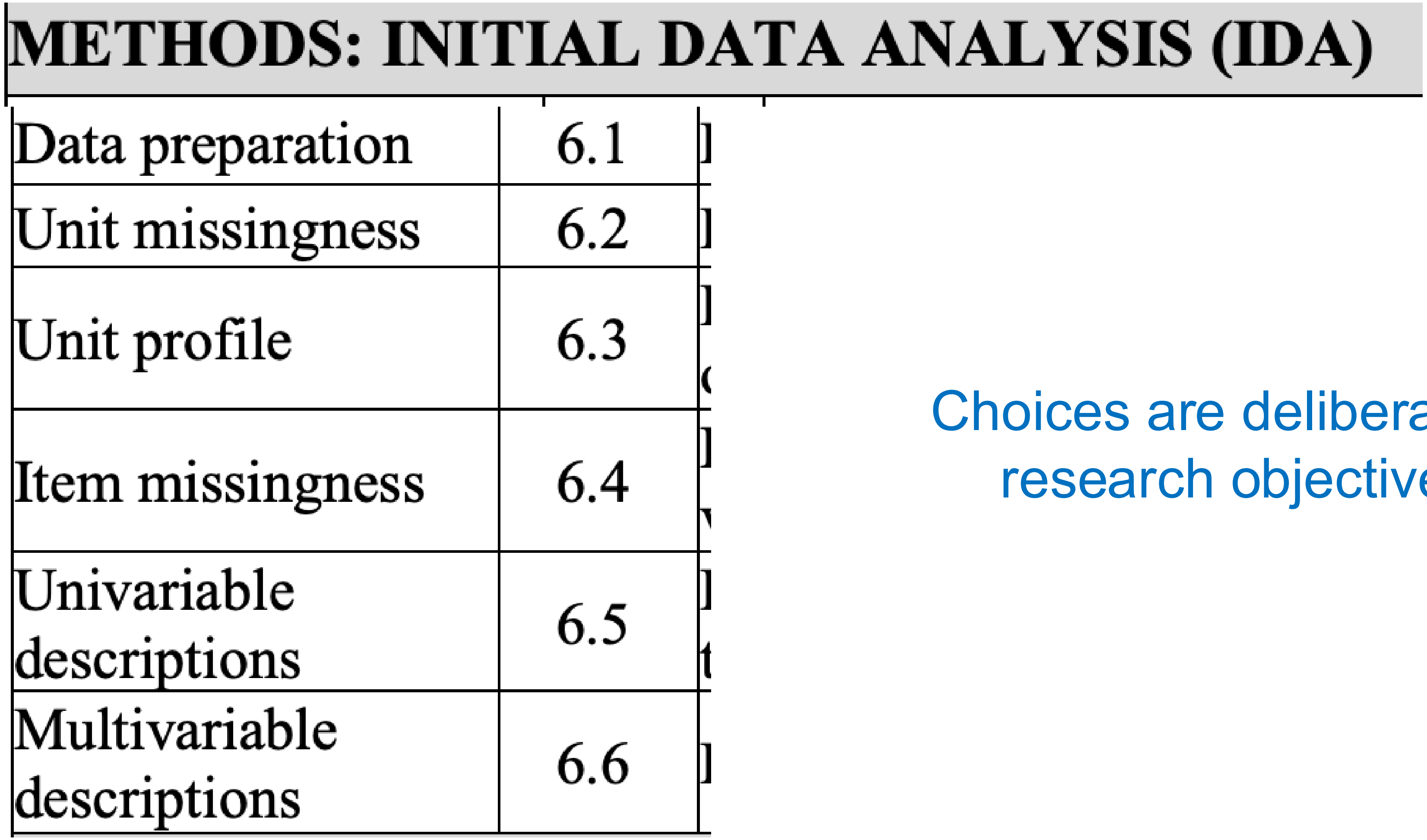


METHODS: MAIN DATA ANALYSIS (MDA)		
Description of observation units	5.1	Describe methods of analysis to summarize the characteristics of the observation units
Main data analysis methods	5.2	Describe the methods of analysis for each research objective, including the quantities to be estimated, the models or estimators, variables, and methods to mitigate potential bias for non-random selection
Assumptions and diagnostics	5.3	State any statistical assumptions of each analysis. Specify all measures and diagnostics used to evaluate statistical assumptions and appropriateness of analyses, including graphical tools
Sample size	5.4	Describe how the sample size was determined, including all assumptions supporting the sample size calculation
Software	5.5	Describe software used for all analyses, visualizations, data management, data archiving, or backups

Assumes “appropriate” dataset →

- Changes mid-analysis
- Ad-hoc decisions – non-transparent
- Time consuming – repeating analyses

SAPI: Statistical Analysis Plan with **IDA**



METHODS: INITIAL DATA ANALYSIS (IDA)

Data preparation	6.1
Unit missingness	6.2
Unit profile	6.3
Item missingness	6.4
Univariable descriptions	6.5
Multivariable descriptions	6.6

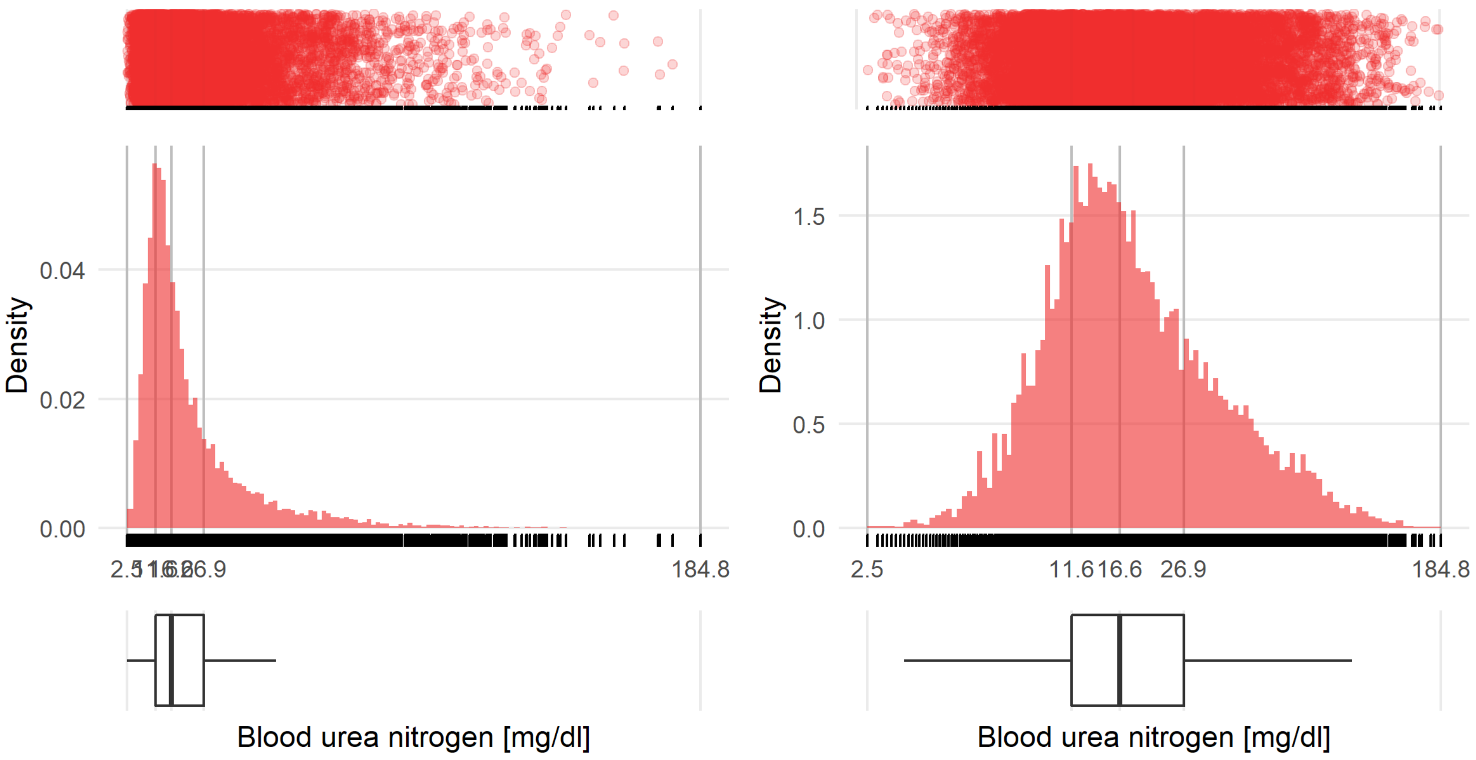
Choices are deliberate: aligned with research objectives and MDA.

Scan for worked example

Example: Univariable distributions

Univariate summary of Blood urea nitrogen [mg/dl]

original [left] vs. pseudo-log transformed scale [right]



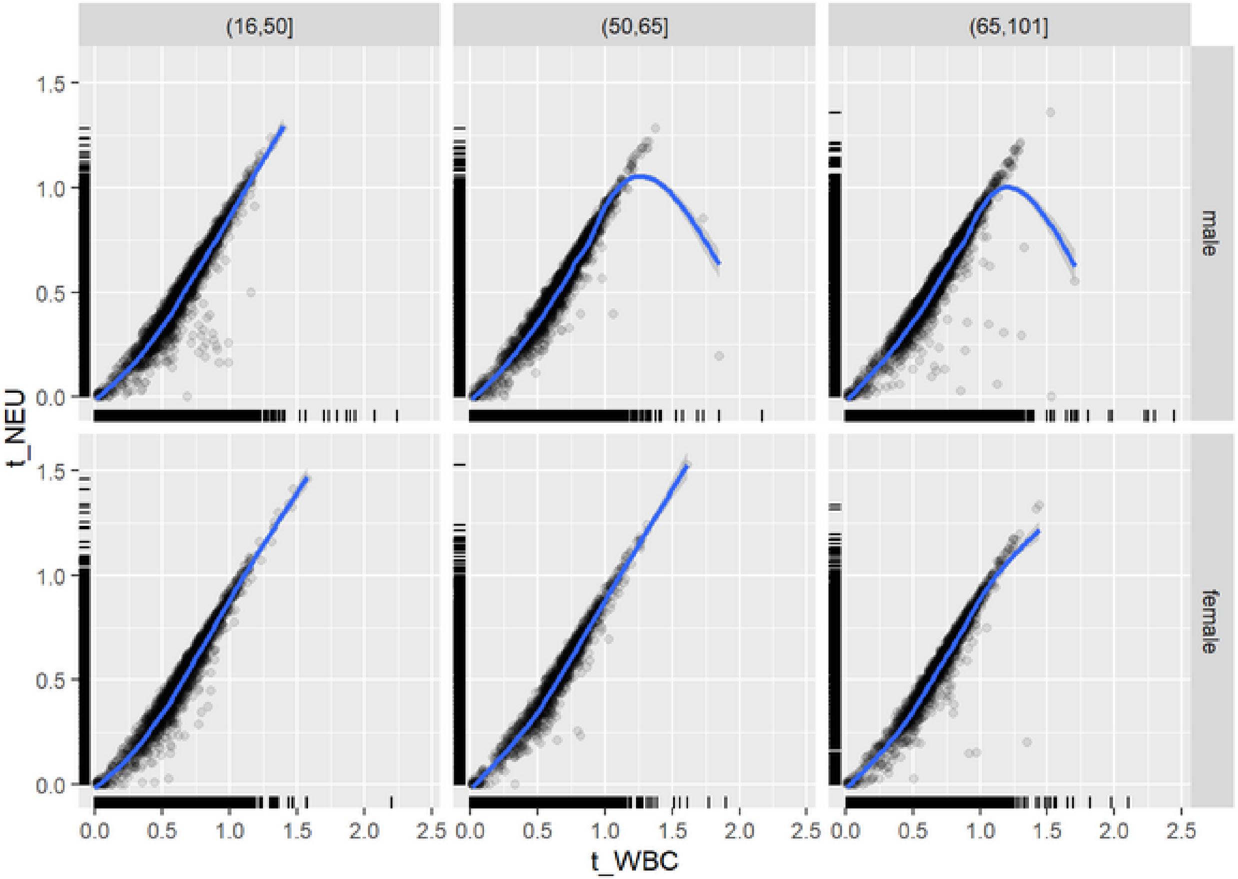
All observed values, the distribution and the, min, max and interquartile range are reported
n = 14519 subjects displayed. 172 subjects with missing values are not presented. Pseudo-log transformation is suggested.

A log transformation stabilizes the distribution of this predictor

IF used in a regression model, it will change the interpretation of the coefficients.

Scan for worked example

Example: Multivariable distributions

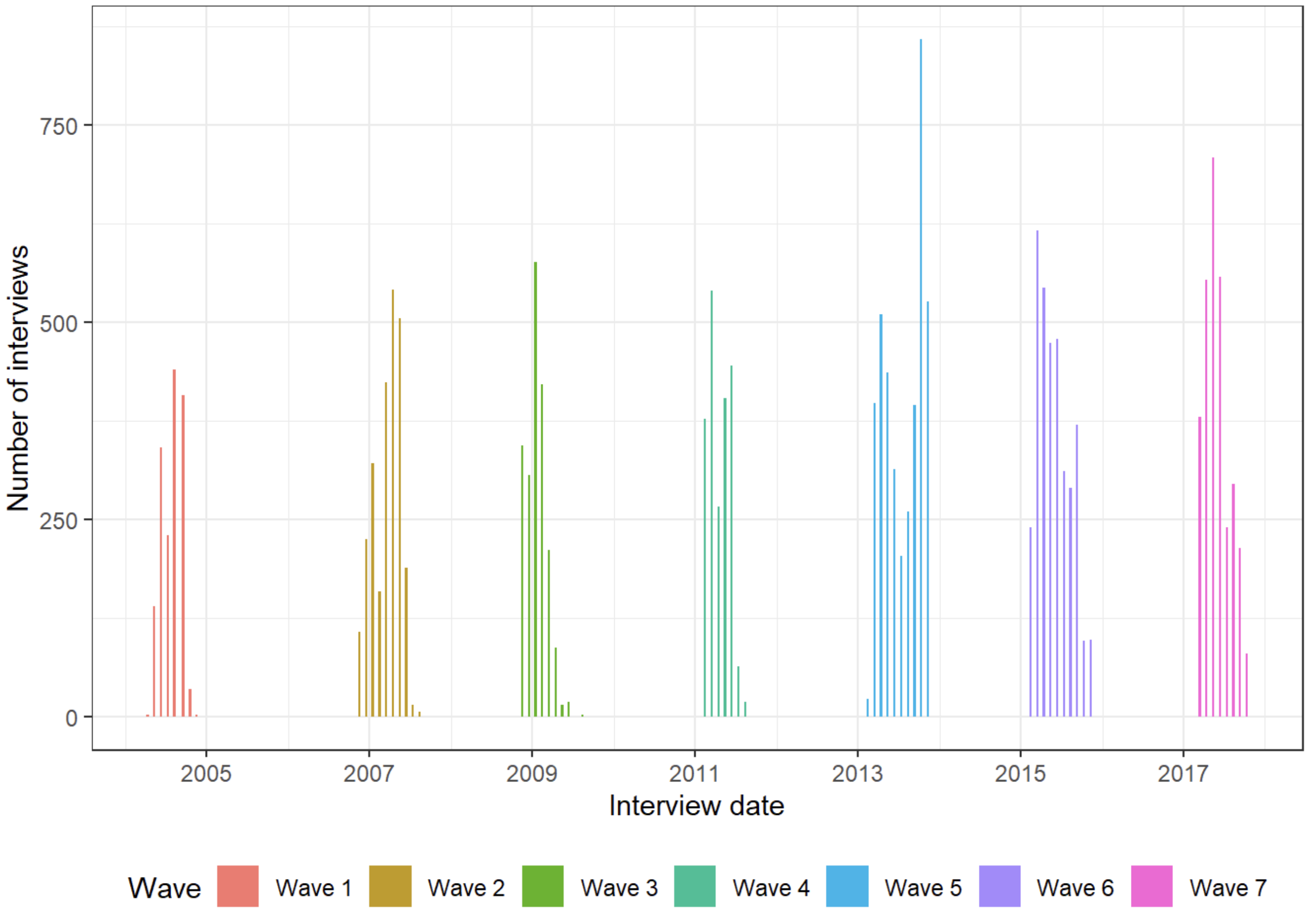


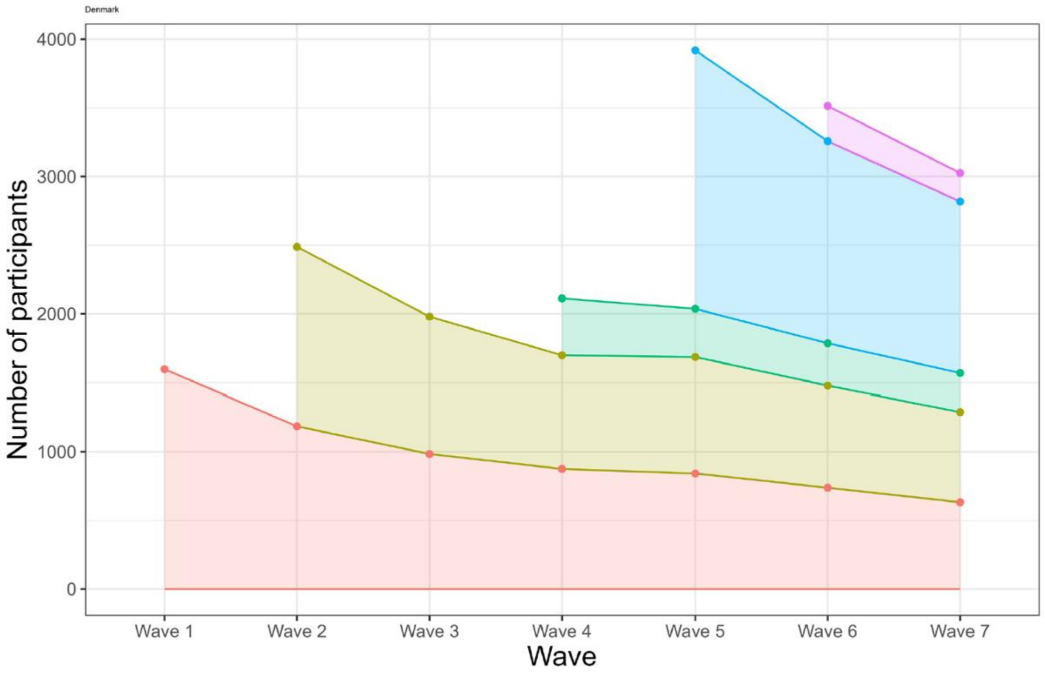
NEU and WBC are highly correlated…

NEU is a component of WBC

Scan for worked example

Example: IDA in longitudinal studies



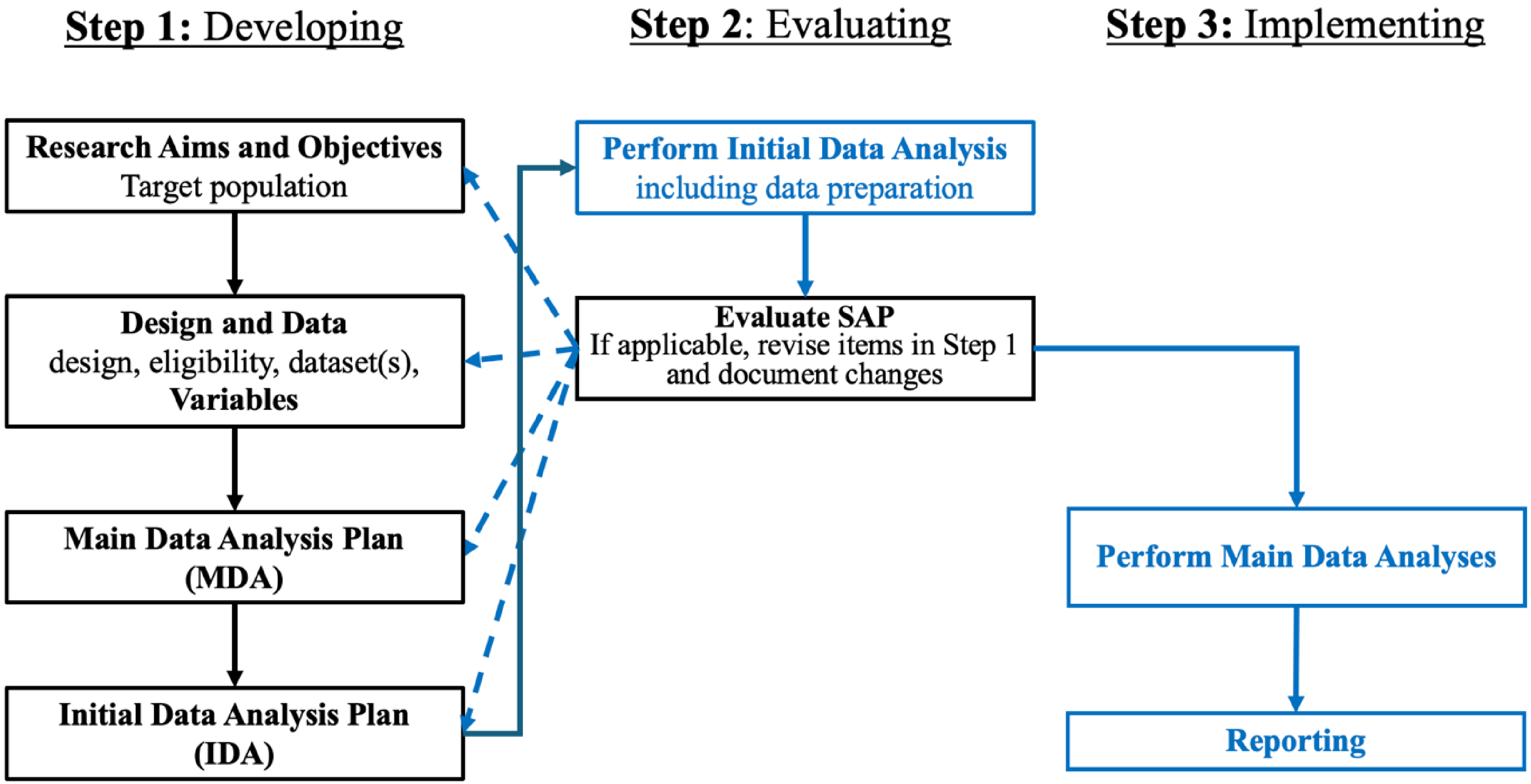


Time metric of data collection process
Time metric of analysis strategy

What the PI knew (or not) and didn’t tell the statistician

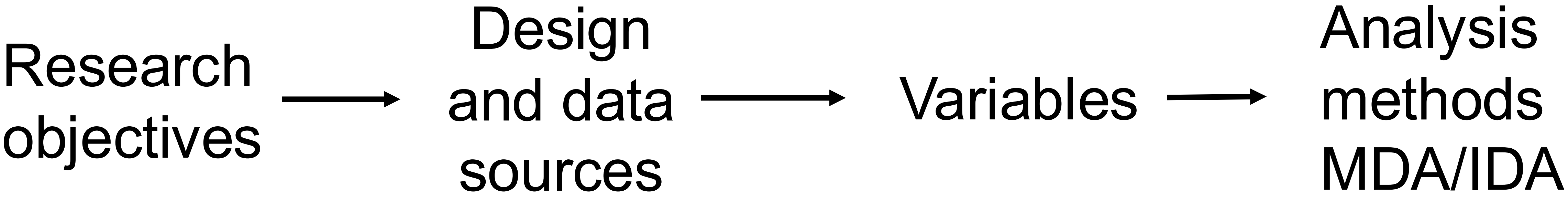
1. Physical activity data were collected with GPS (missing data when exercising inside buildings)
2. New medical procedure was introduced and for awhile performed together with standard procedure (outcome=duration)
3. Data were collected in two periods with a gap of several months
4. IDA findings were more interesting to the investigators than the statistical model: unexpected distributions

Iterative process of developing an analysis plan



Step 1: Developing
Step 2: Evaluating
Step 3: Implementing
Research Aims and Objectives
Target population
Design and Data
design, eligibility, dataset(s),
Variables
Main Data Analysis Plan
(MDA)
Initial Data Analysis Plan
(IDA)
Perform Initial Data Analysis
including data preparation
Evaluate SAP
If applicable, revise items in Step 1
and document changes
Perform Main Data Analyses
Reporting

Roadmap for Statistical Analysis Plan for Observational Studies (SAPI)



Research objectives → Design and data sources → Variables → Analysis methods MDA/IDA

SAP guideline developed via a (international) consensus process
with researchers, analysts, editors/reviewers, instructors/mentors.

Lessons learned: Initial Data Analysis

IDA plan is part of a statistical analysis plan

IDA (and data quality assessments):

- Is the foundation for correct modeling
- Needs to be reported in papers
- Takes time *(but ignoring it takes more time later!)*

PIs and statisticians learn from each other when discussing IDA report:

- Understanding data content better; learning about expected or unexpected data properties
- “Reality hits” for research aims; confirm suspicions from the protocol phase

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