UNIVERSITÀ
DEGLI STUDI
DI MILANO

Scientific Visualization
A.A. - 2025/2026

DATA IMPUTATION

based on PTB-XL dataset (PhysioNet)

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OUR **GOAL**

Study how the Body Mass Index (**BMI**) of patients in the PTBXL dataset is related to the appearance of particular **cardiovascular pathologies**.

identify **patterns** on the patient's physical condition

probability of developing certain diagnoses

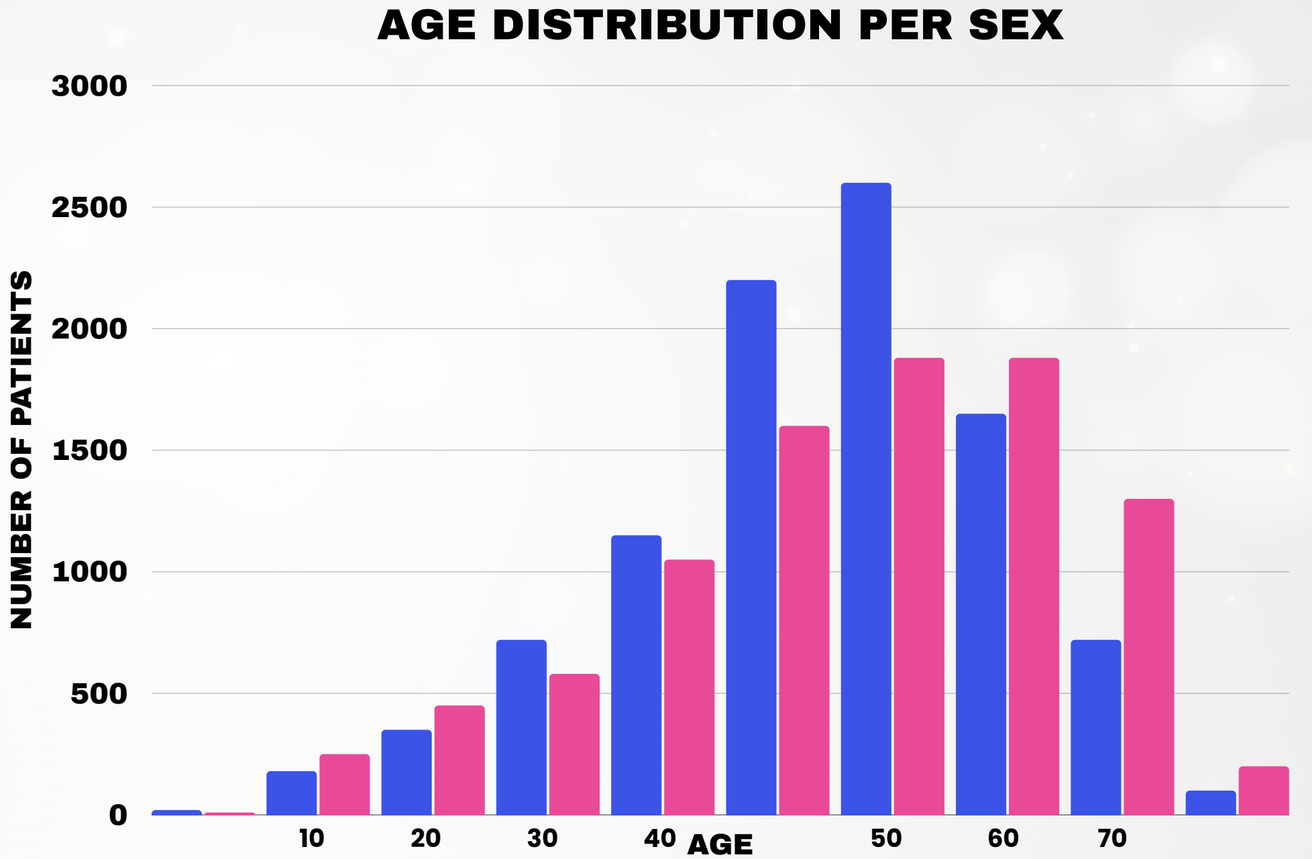
OUR WORKFLOW

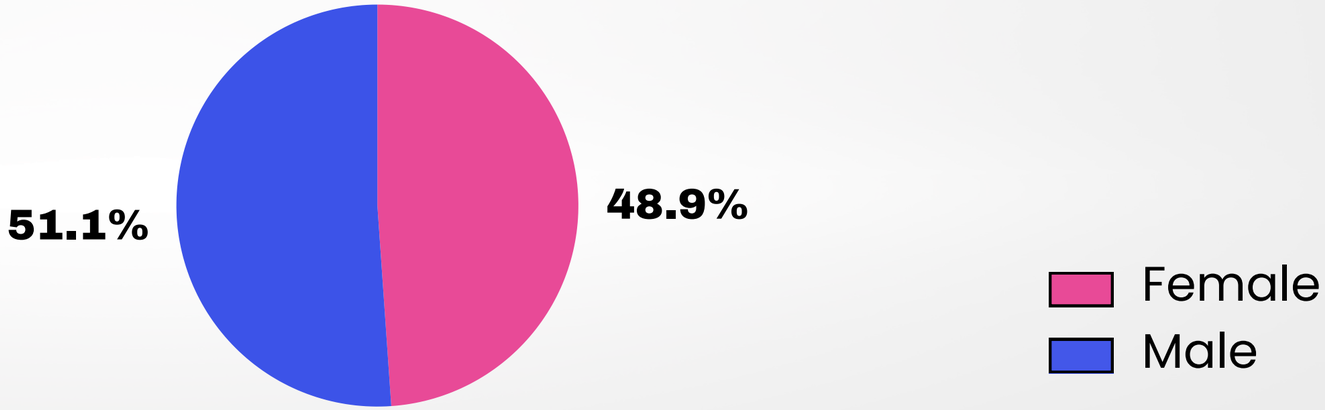
1. Initial data exploration and cleaning
2. Data Imputation
3. BMI calculation
4. Analysis of BMI linked to pathologies

1 DATASET

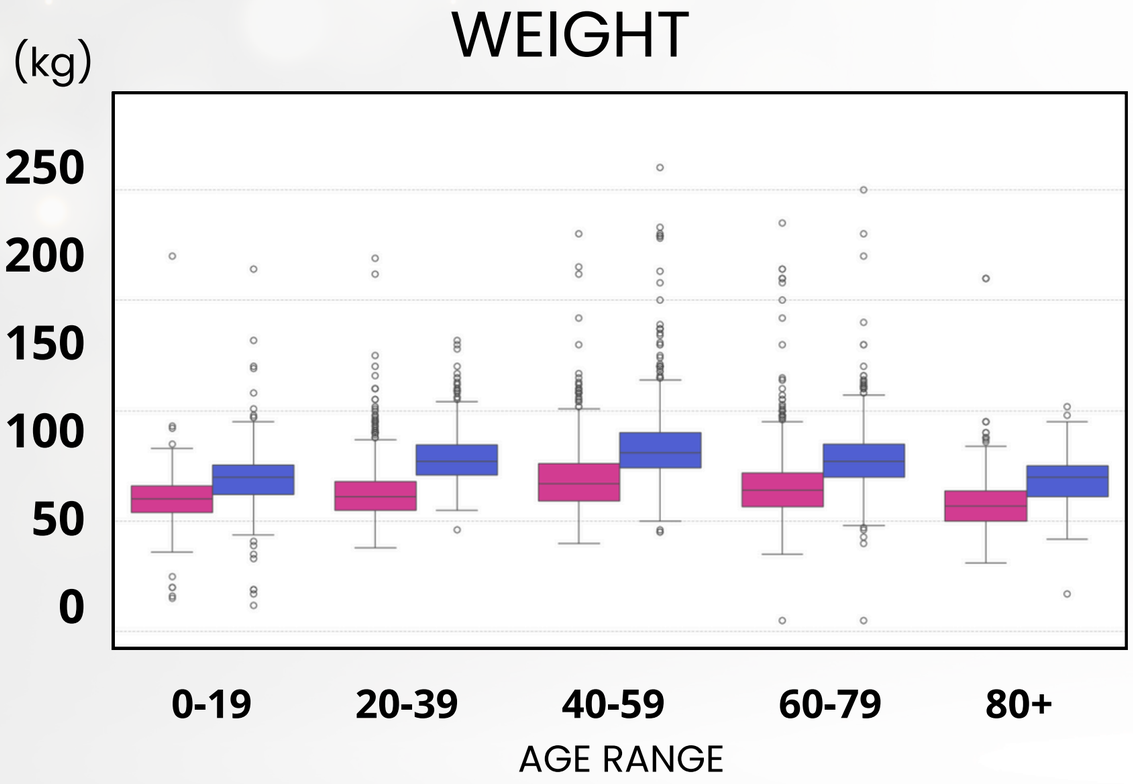
18.870 patients

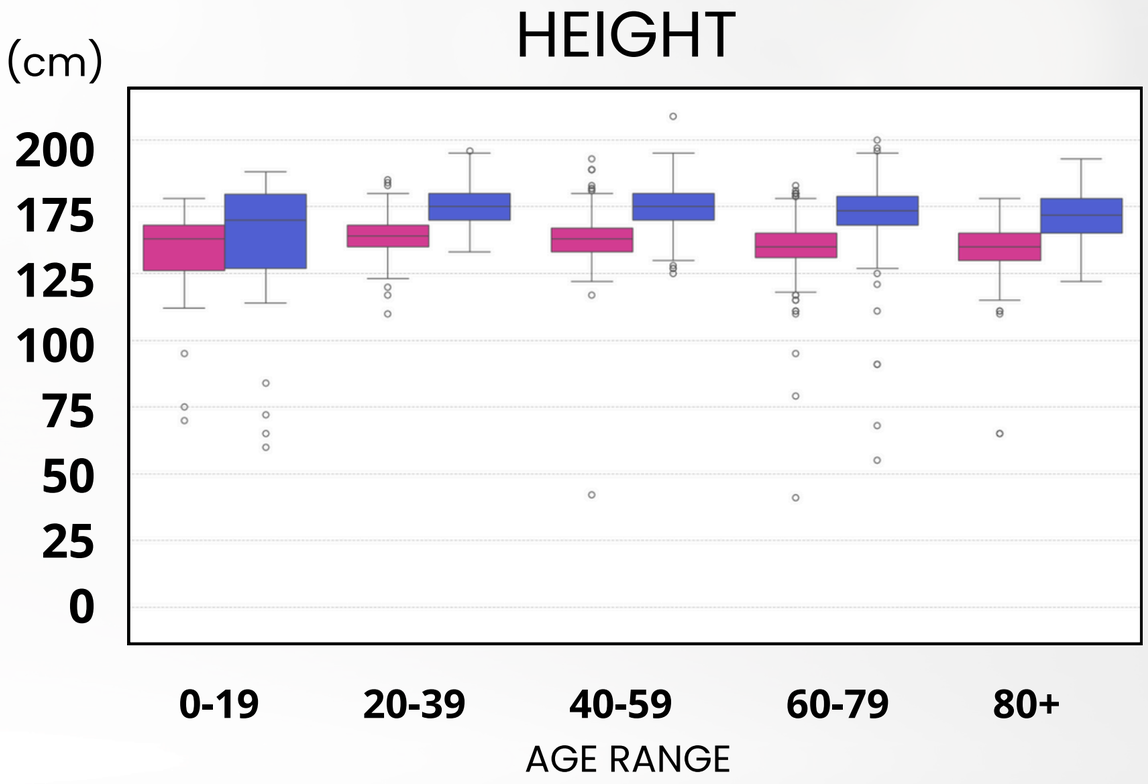
- AGE
- SEX
- HEIGHT
- WEIGHT
- SCP_CODES





BOXPLOT

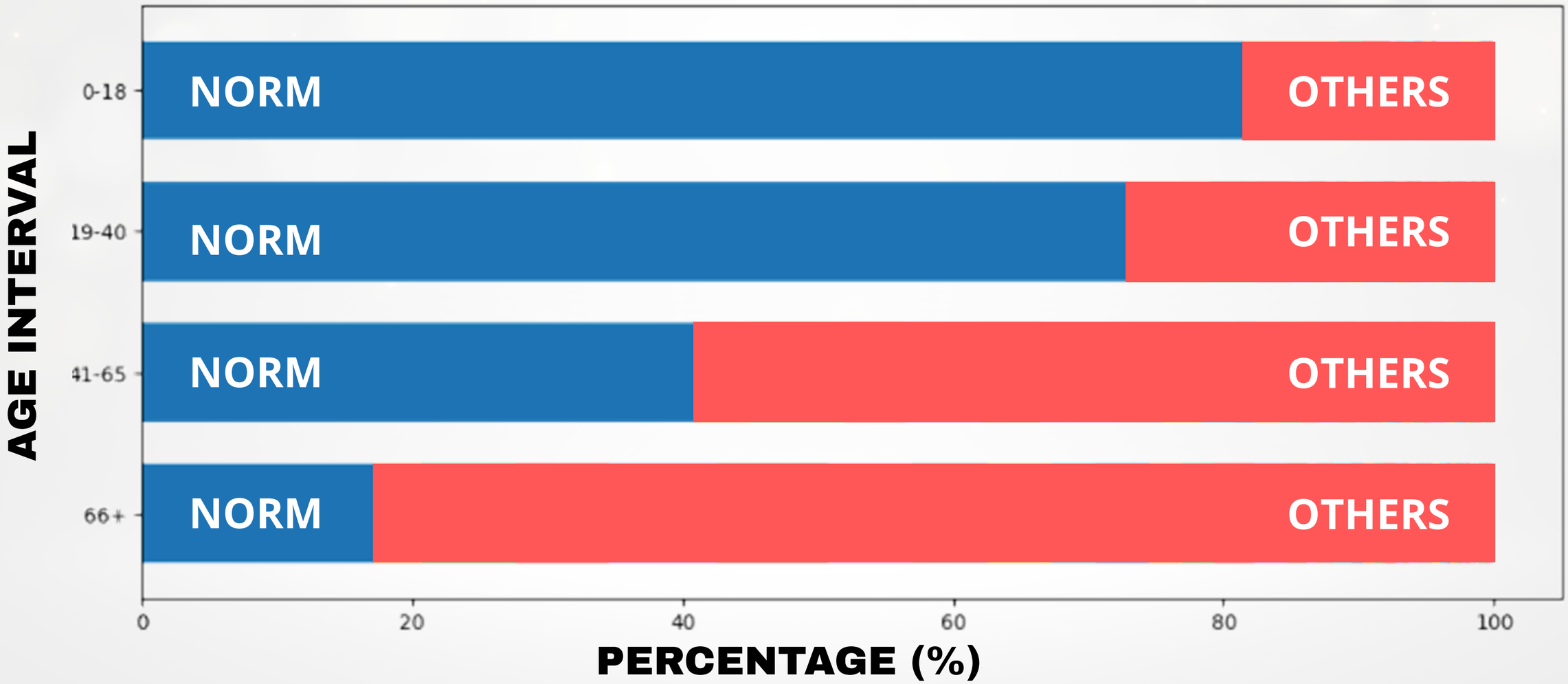




Female
Male

TYPES OF

PATHOLOGIES (scp_codes)



TYPES OF

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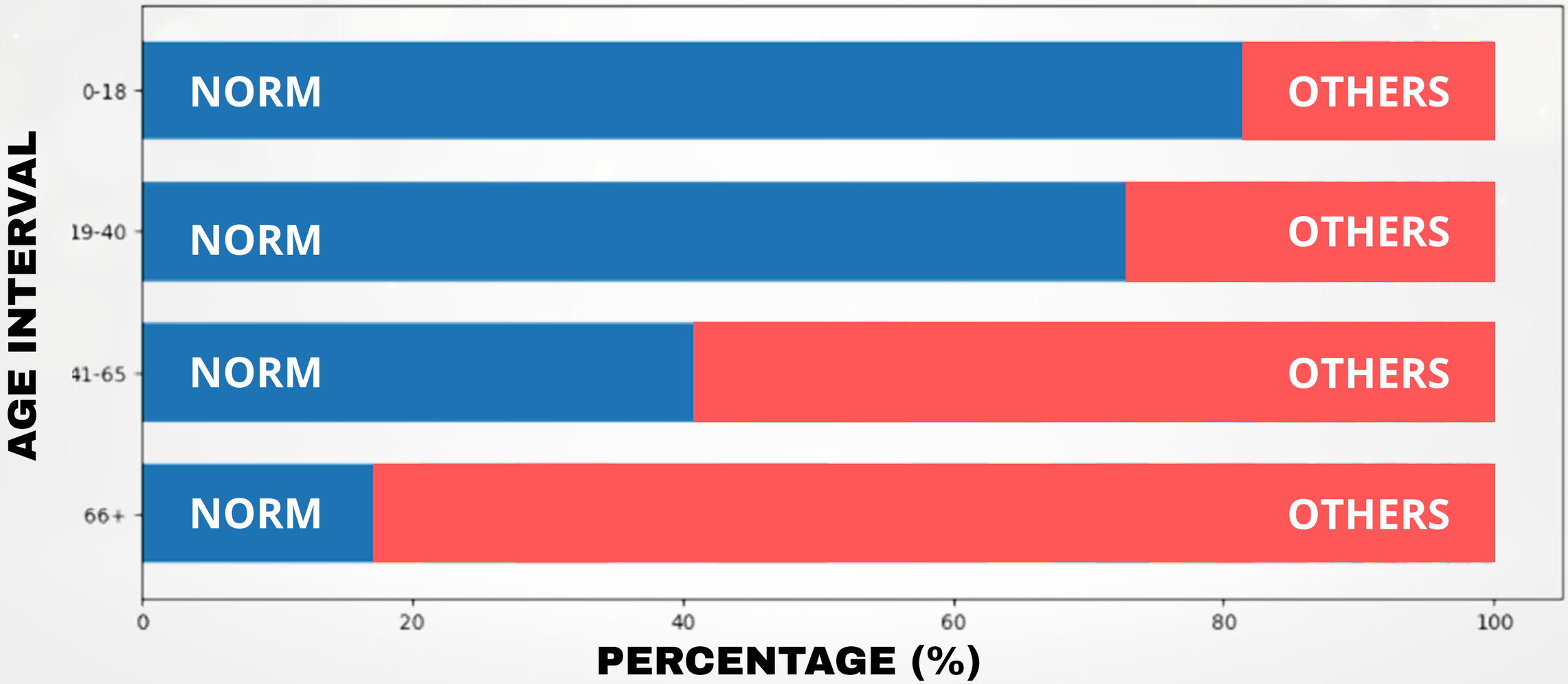


STUDY OF **CHI²**

The Chi-Squared Test is a statistical hypothesis test used to examine the differences between **observed data** (**O**) and **expected data** (**E**) under a specific hypothesis.

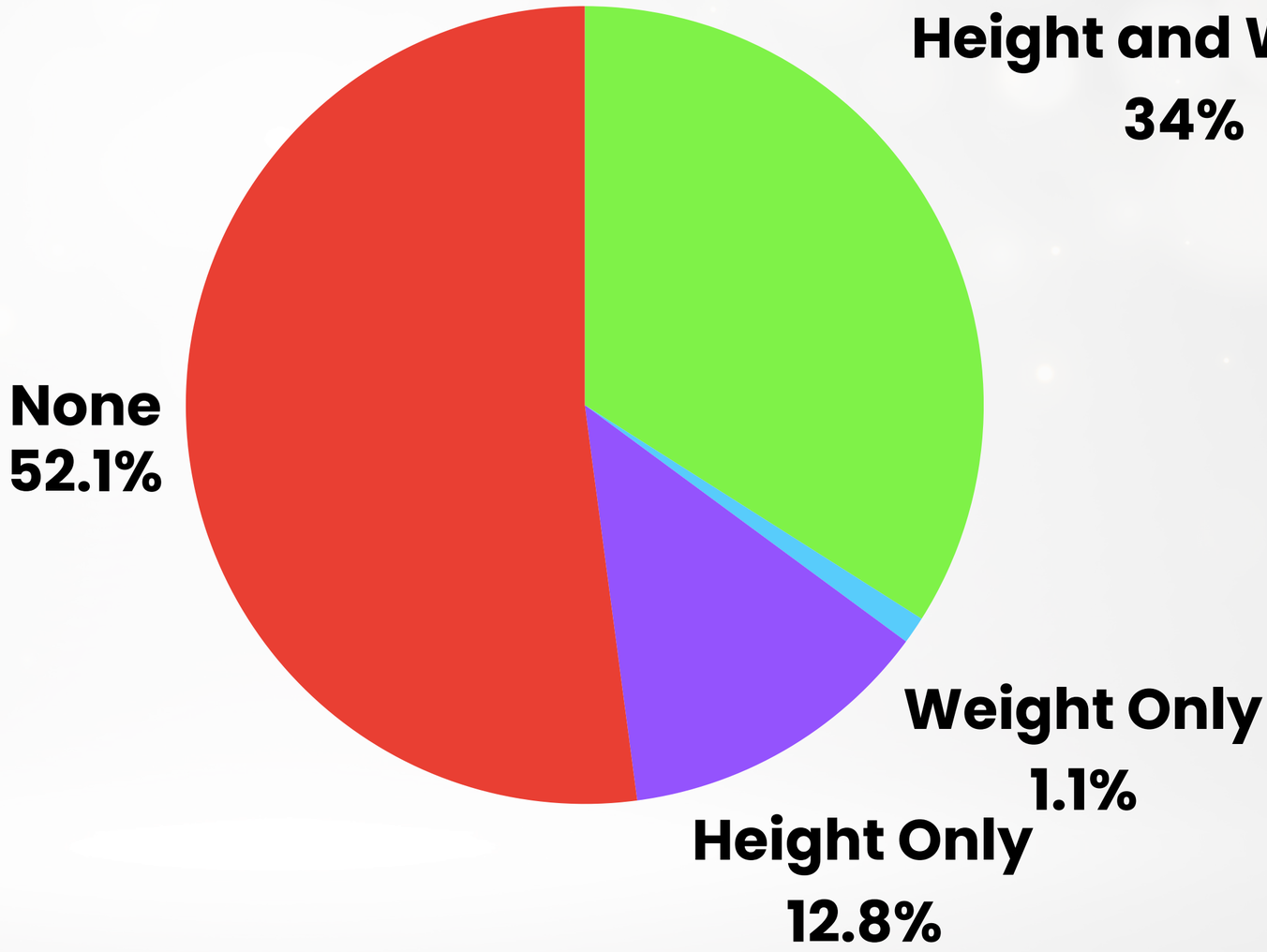
$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

→ 2619,3798

2 DATA IMPUTATION

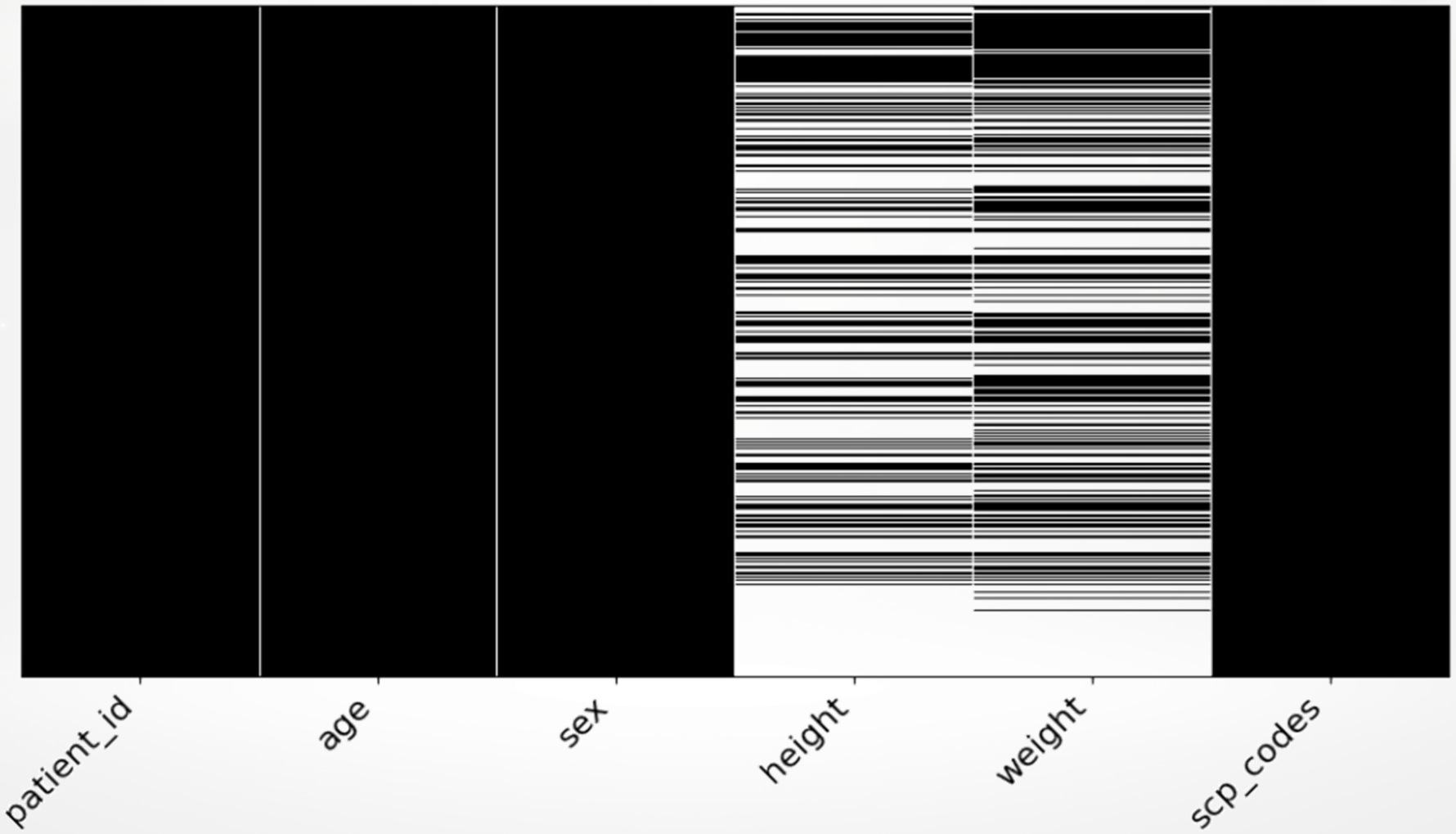
Missing data in
WEIGHT and **HEIGHT**

Data imputation is the process of **replacing missing data** in a data set with estimated or predicted values.



MISSING DATA PATTERN

VISUALIZATION



TYPES OF **MISSING DATA**

MCAR

Missing Completely At Random

The probability that a value is missing is unrelated to any observed or unobserved data.

MAR

Missing At Random

The probability of missingness depends only on observed data, not on the missing values themselves.

MNAR

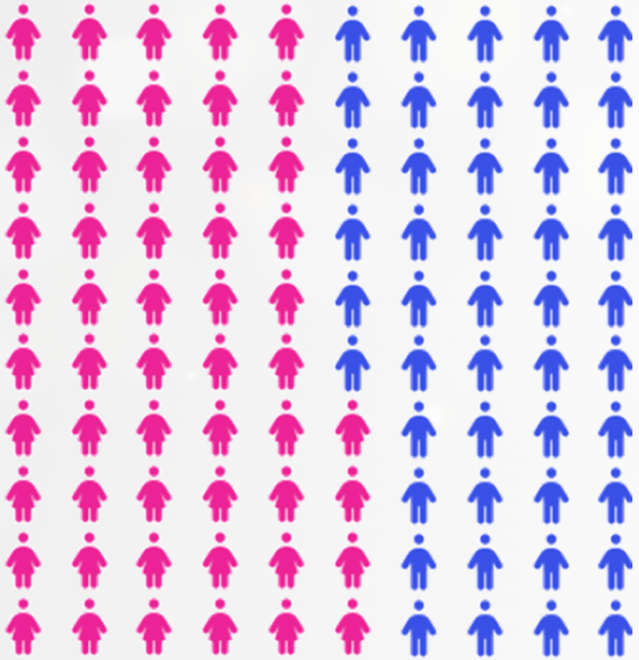
Missing Not At Random

The probability that data are missing depends on the missing values themselves, even after controlling for other observed data.

OUR

DATA

Missing HEIGHT



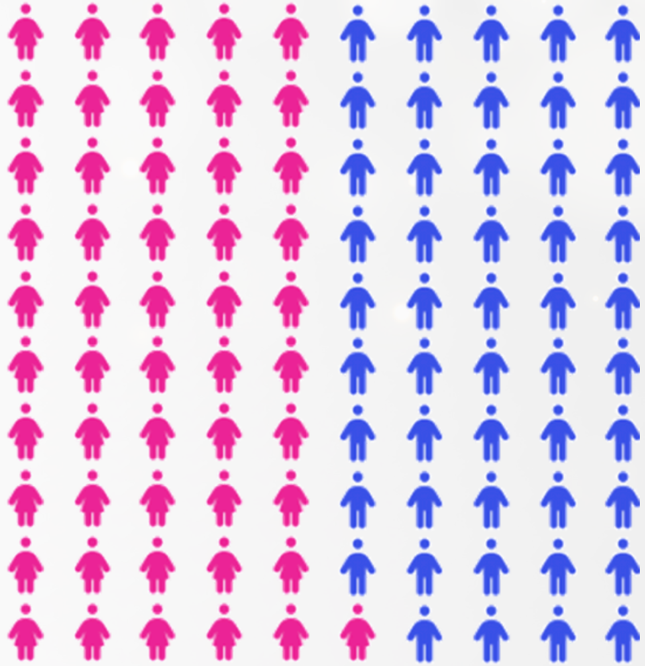
Female - 54%

Male - 46%

MCAR

Missing Completely At Random

Missing WEIGHT



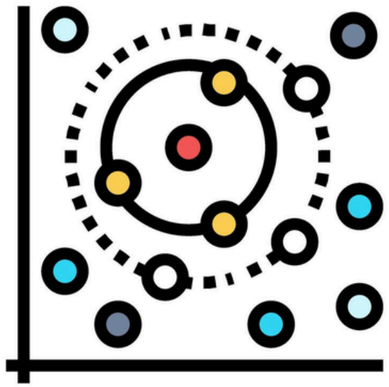
Female - 51%

Male - 49%

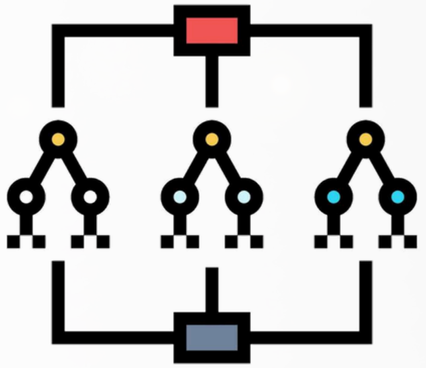
TYPES OF

DATA IMPUTATION

Linear Regression



K-Nearest Neighbors (KNN)

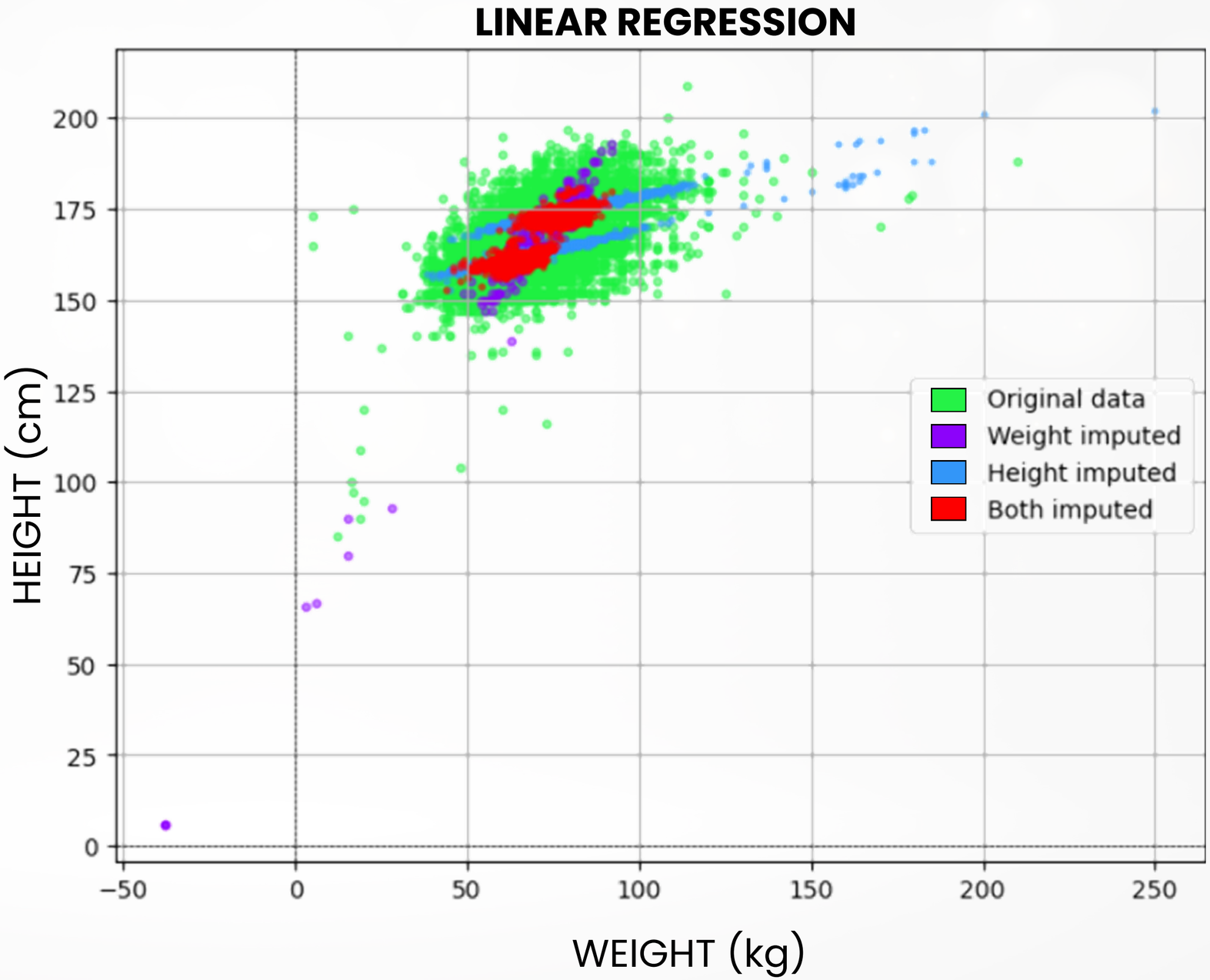


Miss Forest

LINEAR REGRESSION

Linear regression estimates and replaces missing values by modeling the relationships between variables. Specifically, it involves fitting a **linear equation** to **observed data**.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon$$



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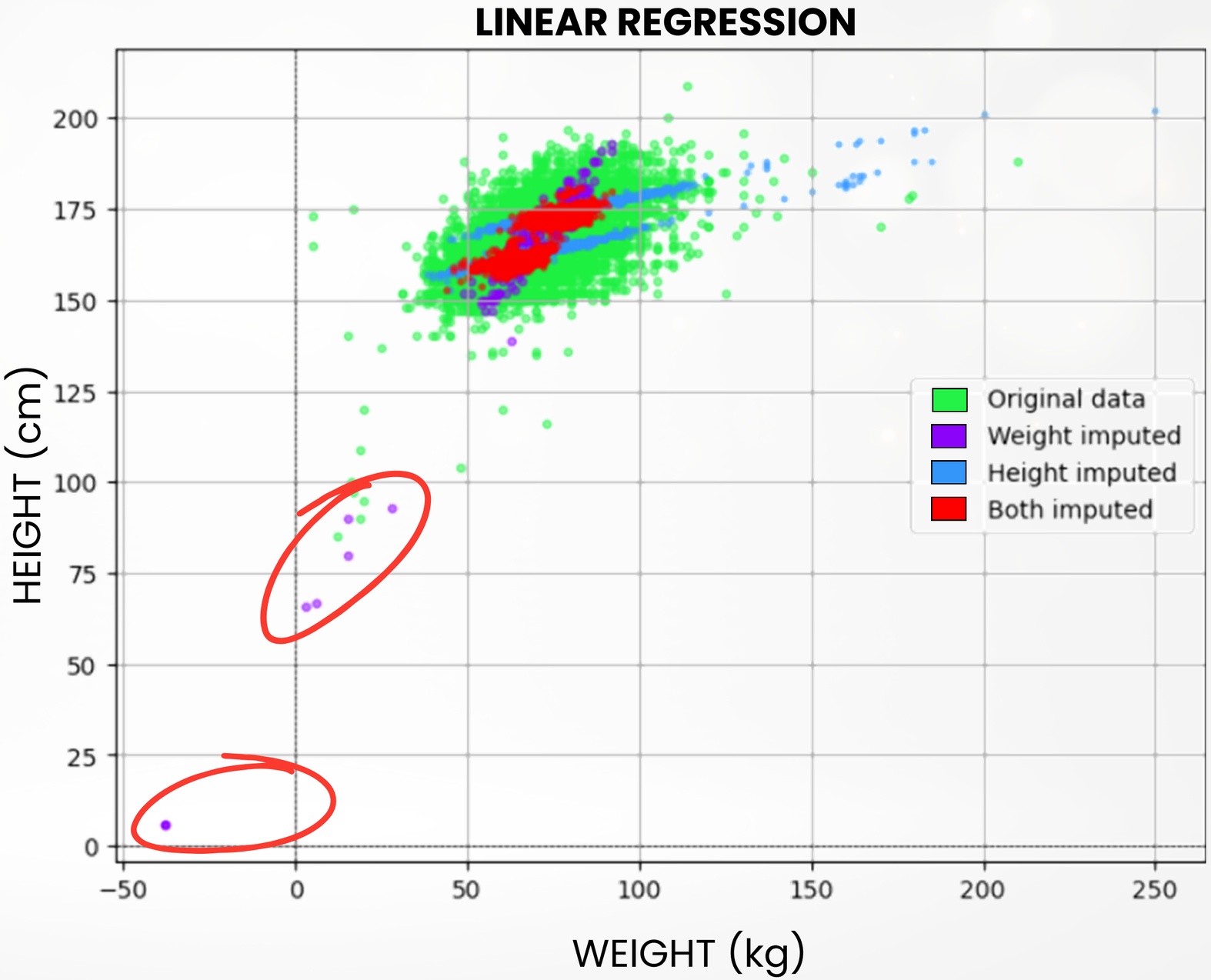

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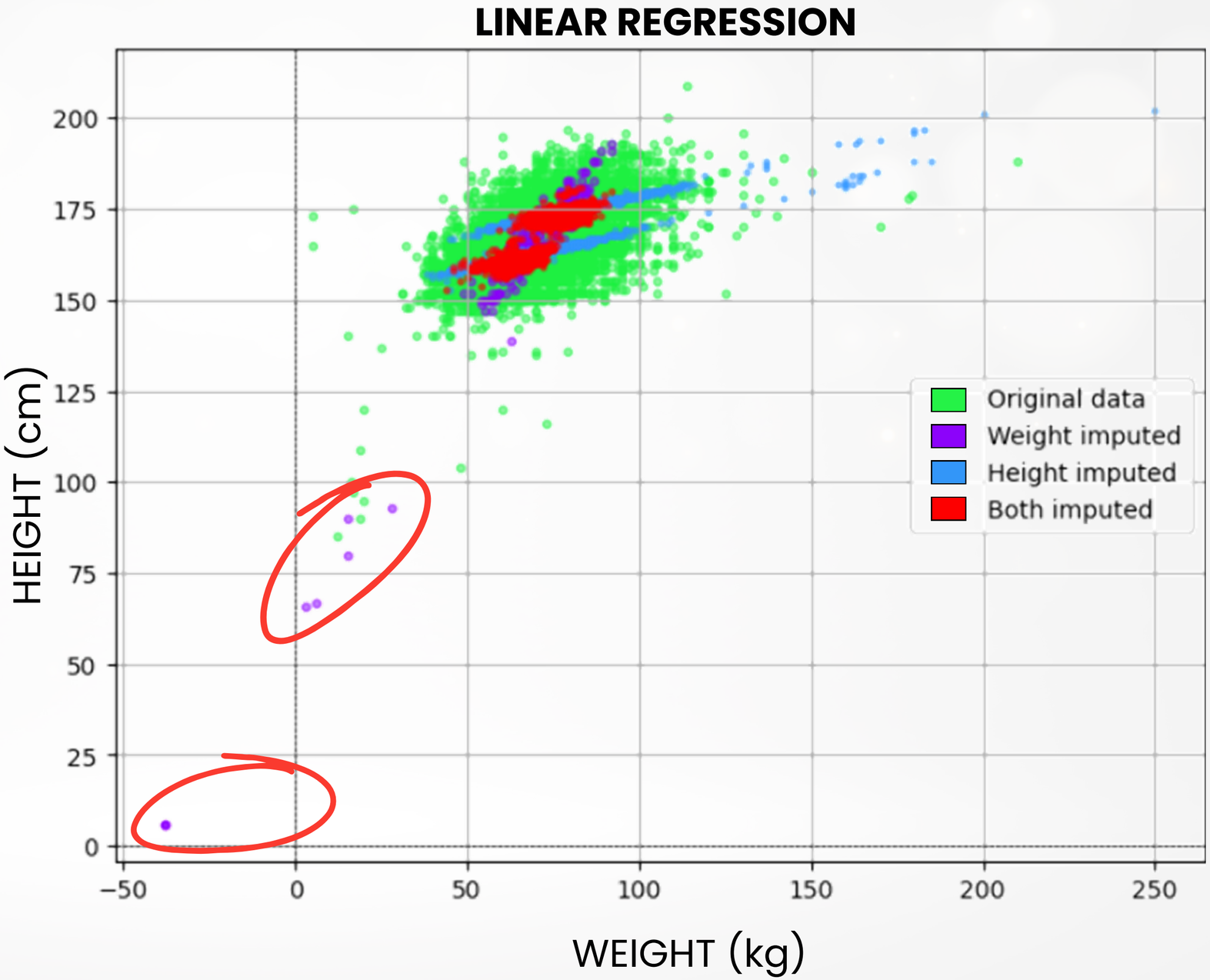
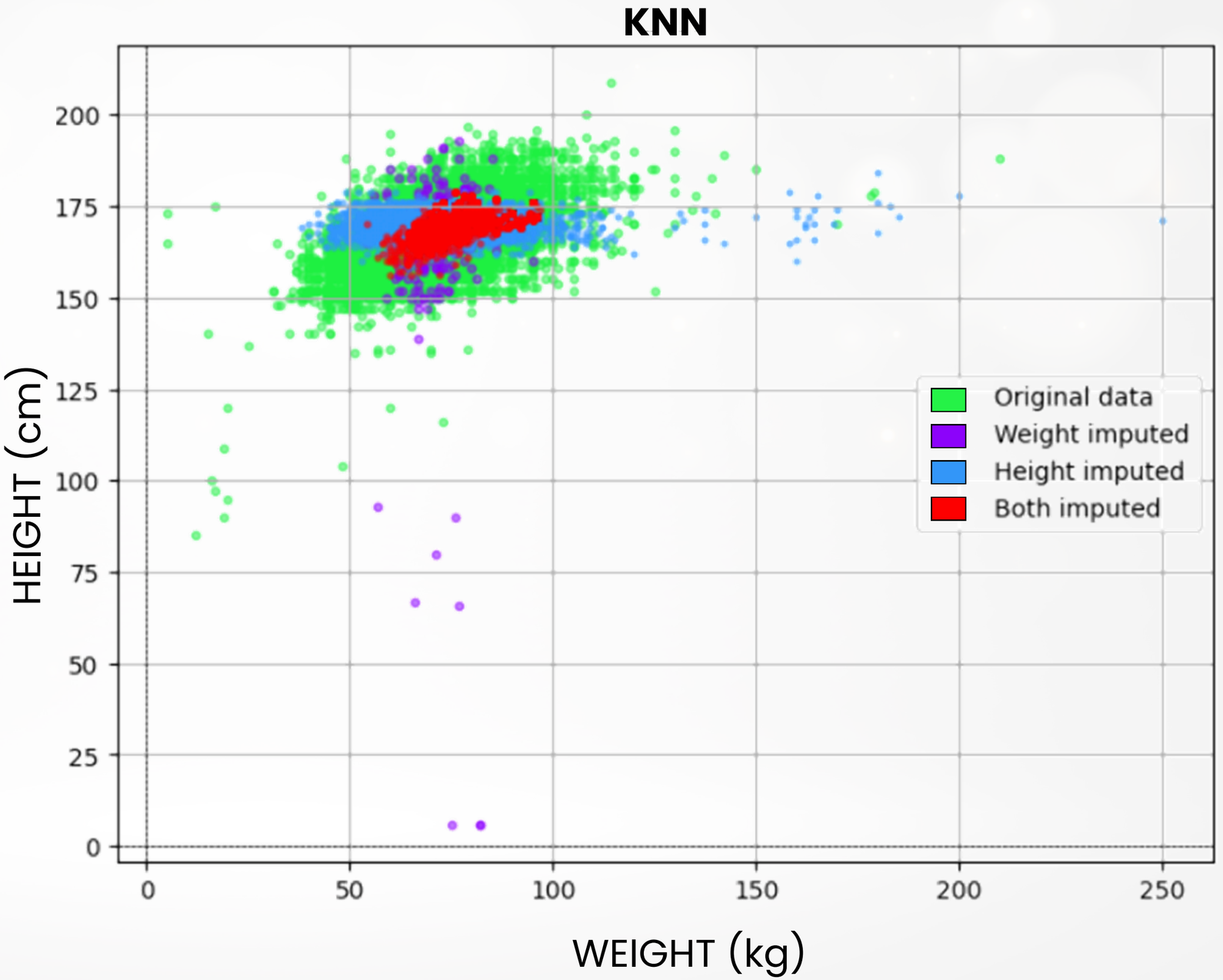


KNN

K-Nearest Neighbors fills in missing values by using the values of the **k most similar** instances in the dataset, based on the values computed **using the available** (non-missing) **features**.

$$d(p, q) = \sqrt{\Sigma_i (q_i - p_i)^2}$$



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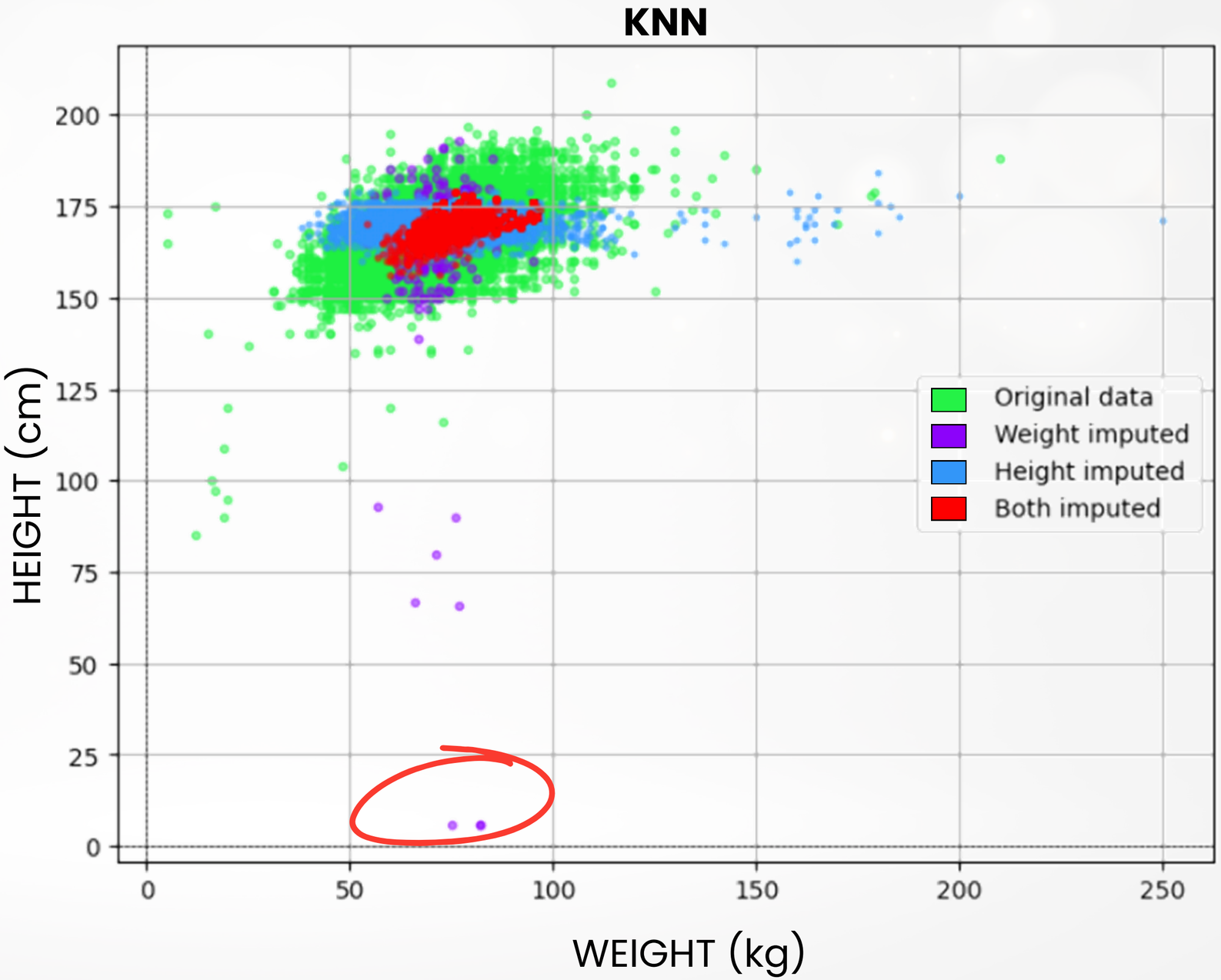

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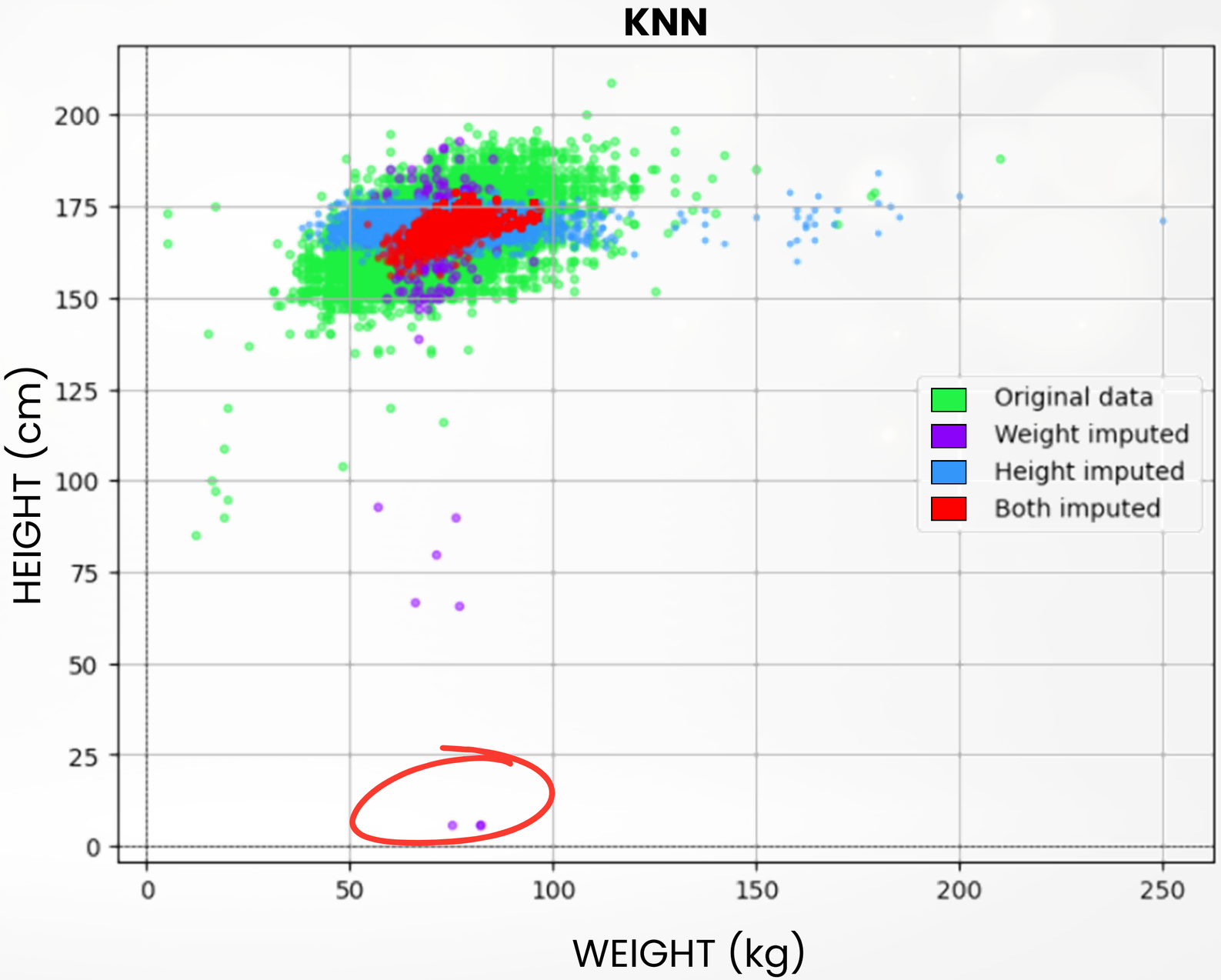


CONCEPT OF

MISS FOREST

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

CONCEPT OF

MISS FOREST

data missing

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

CONCEPT OF

MISS FOREST

data observed
data missing

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

CONCEPT OF

MISS FOREST

- data observed
- data missing
- result

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	70.5	175
patient_3	65	66	nan

CONCEPT OF

MISS FOREST

data observed
data missing

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	70.5	175
patient_3	65	66	nan

CONCEPT OF

MISS FOREST

- data observed
- data missing
- result

	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

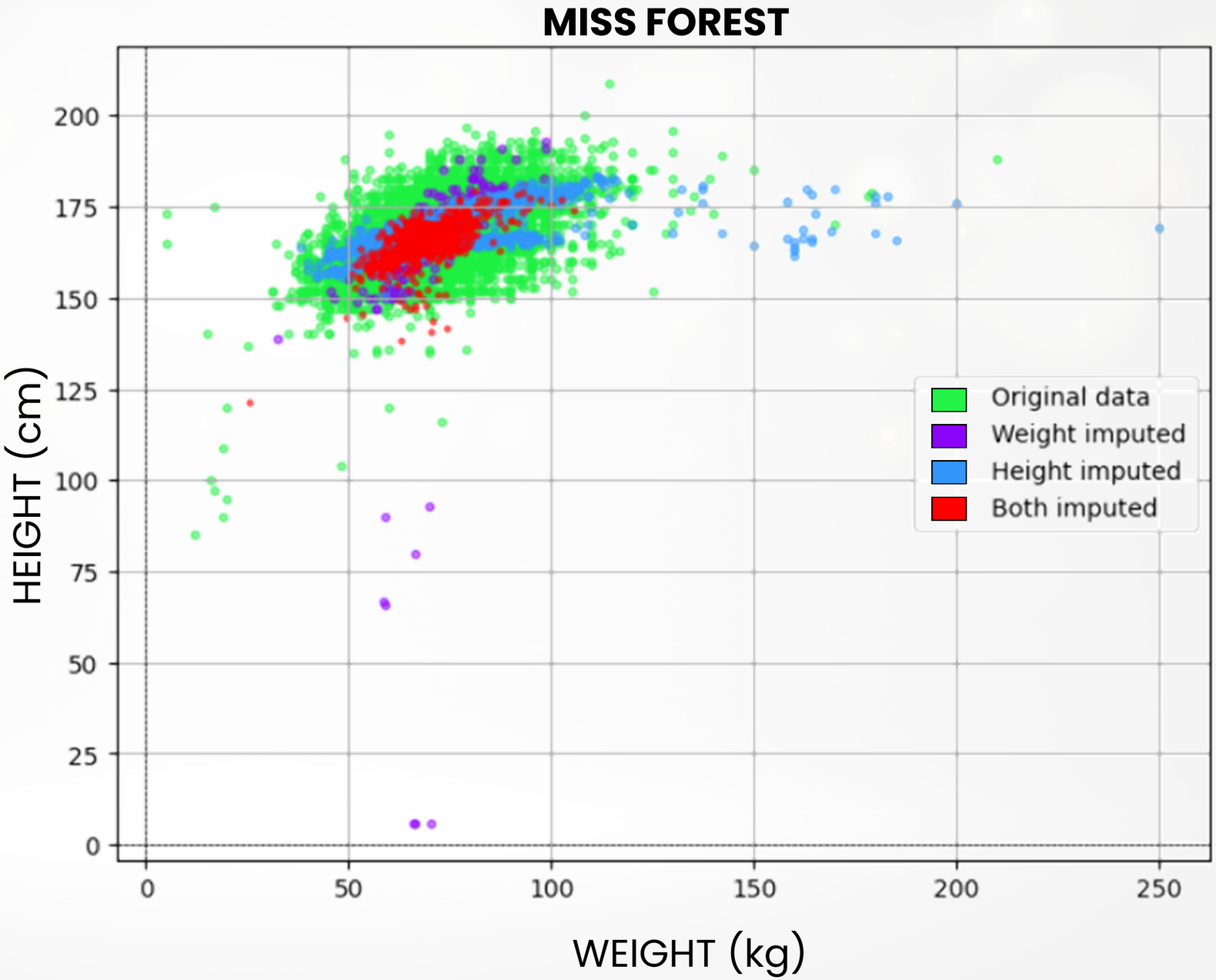
	age	weight	height
patient_1	45	75	nan
patient_2	30	nan	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	nan
patient_2	30	70.5	175
patient_3	65	66	nan

	age	weight	height
patient_1	45	75	170
patient_2	30	70.5	175
patient_3	65	66	169

MISS FOREST

MissForest fills in missing data by iteratively **training Random Forest** models to predict missing values based on the observed relationships among all other variables (both continuous and categorical variables).



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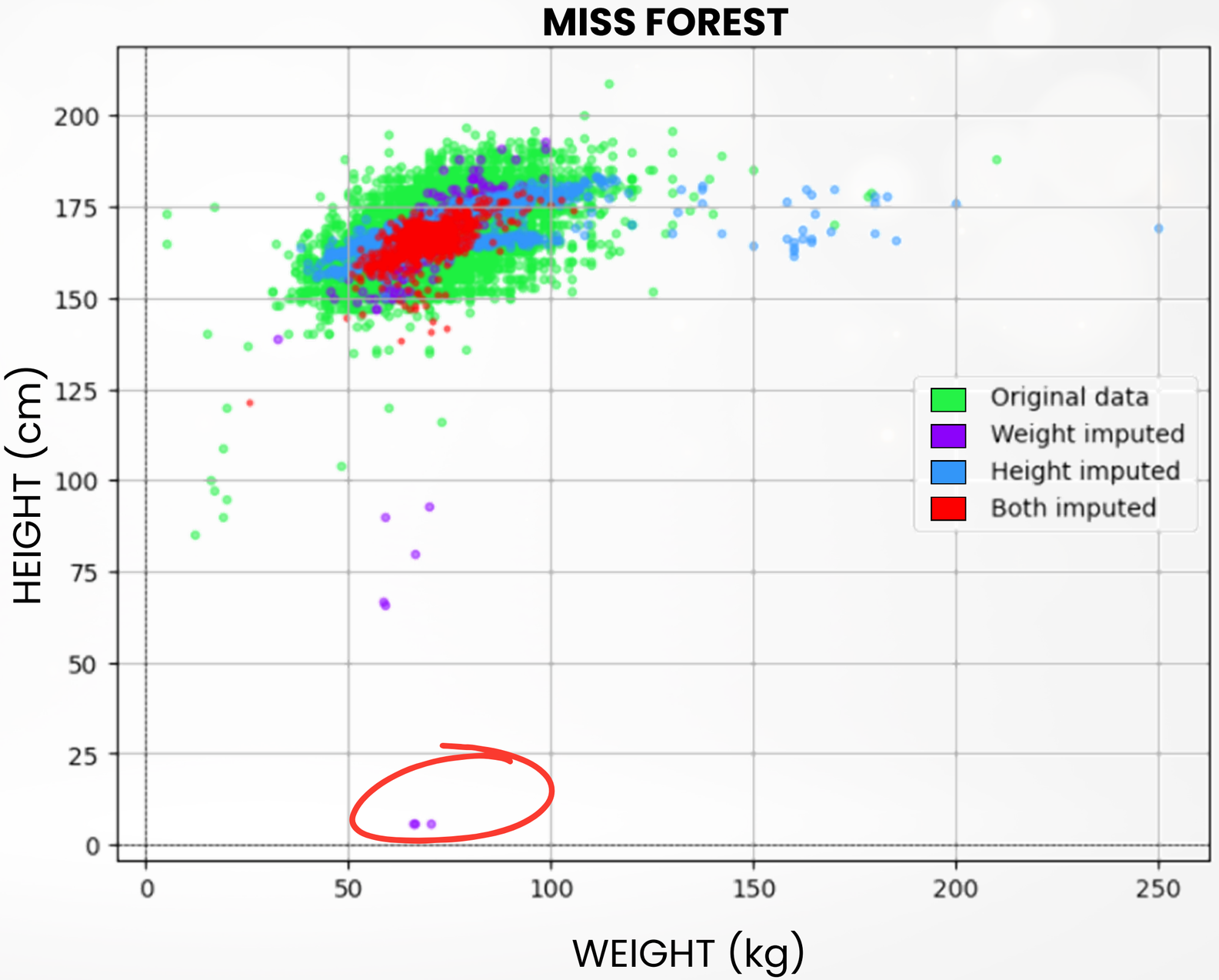

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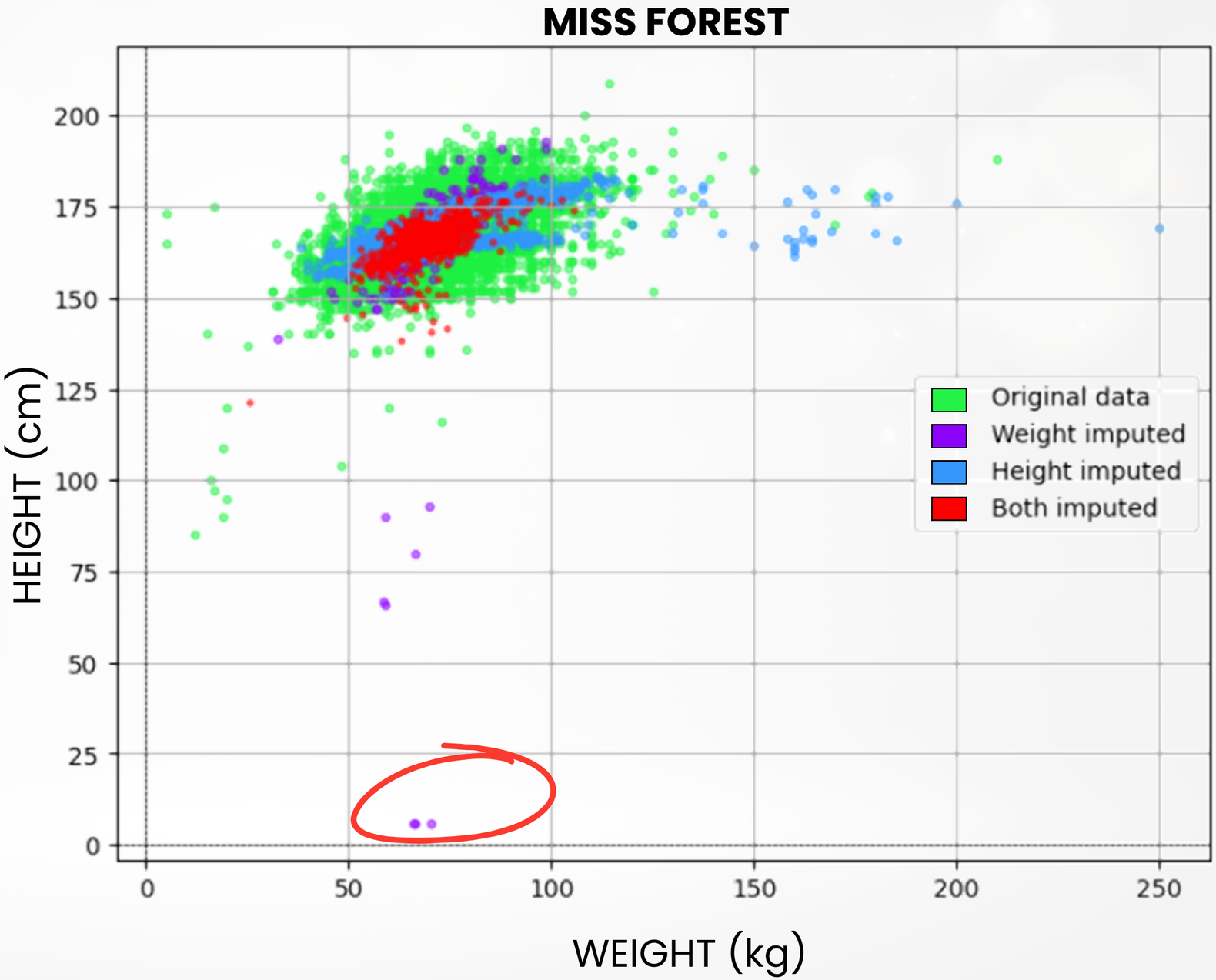
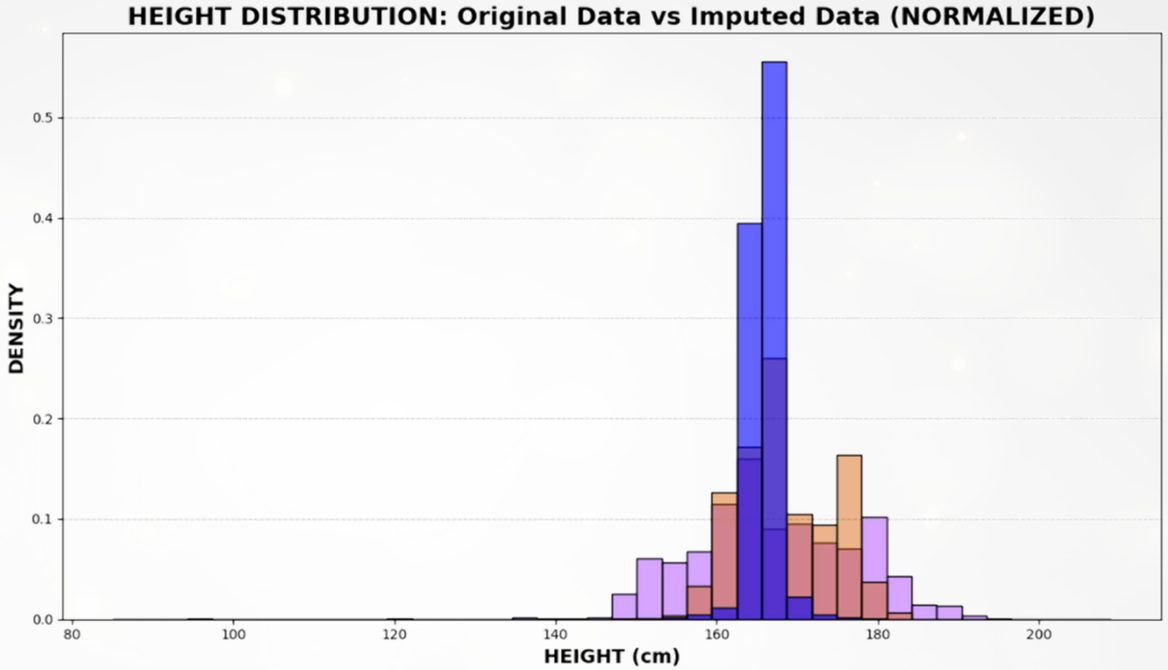
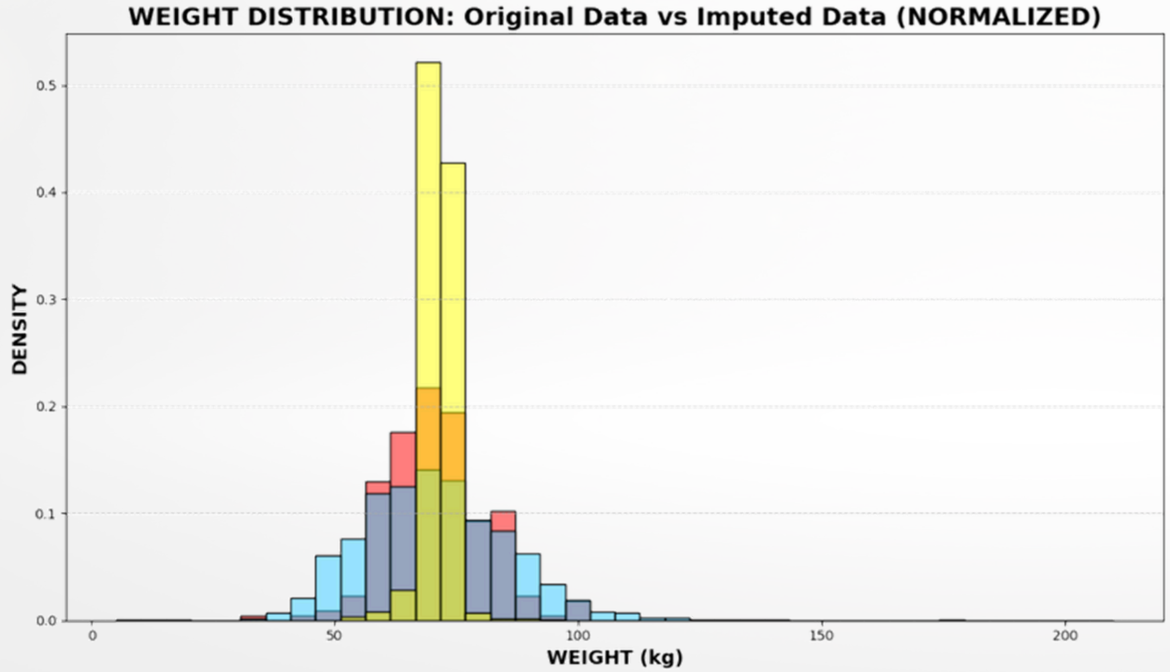


ACTUAL **IMPUTED DATA** DISTRIBUTION



Original data
Imputed **height**
Both missing

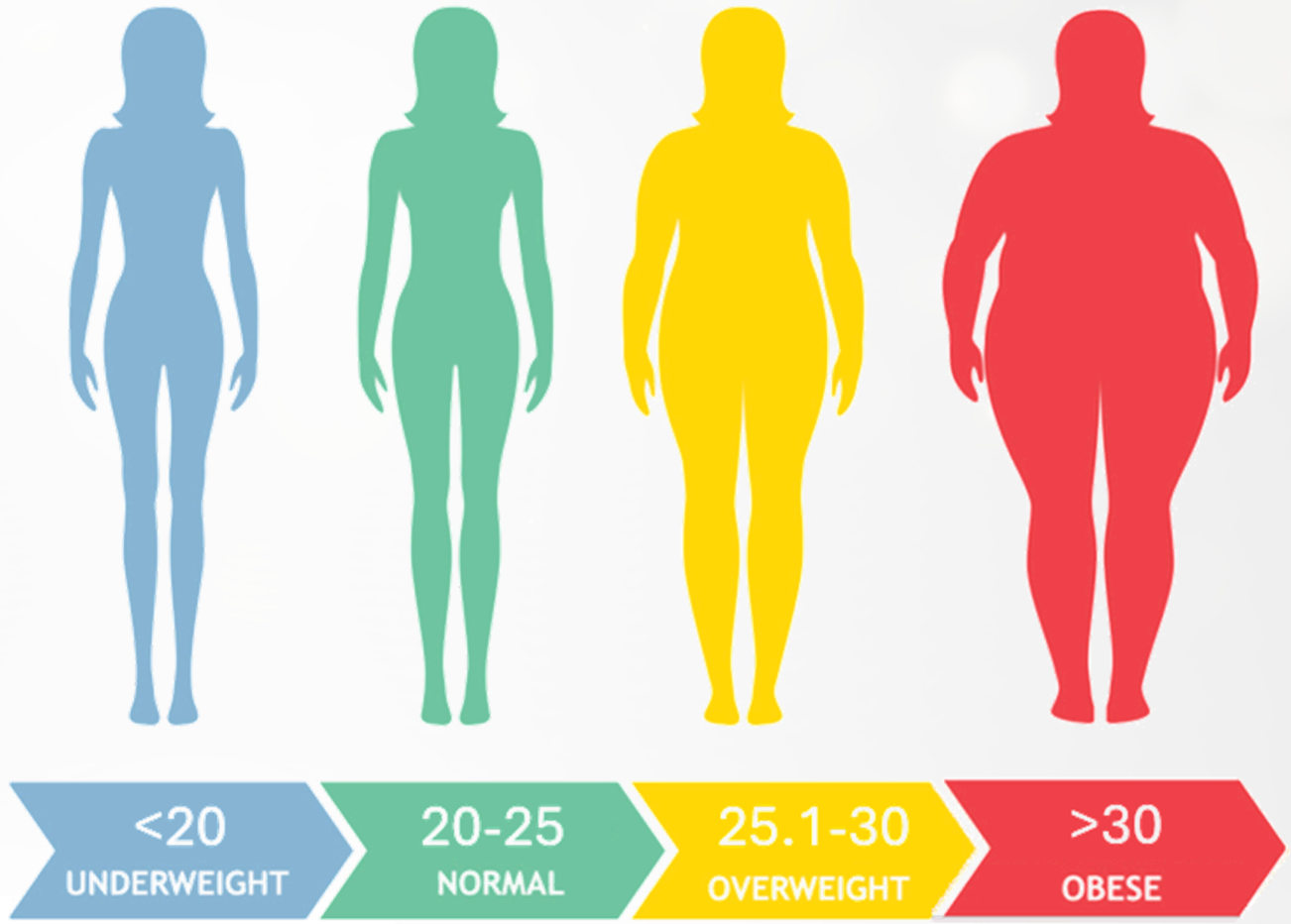


Original data
Imputed **weight**
Both missing

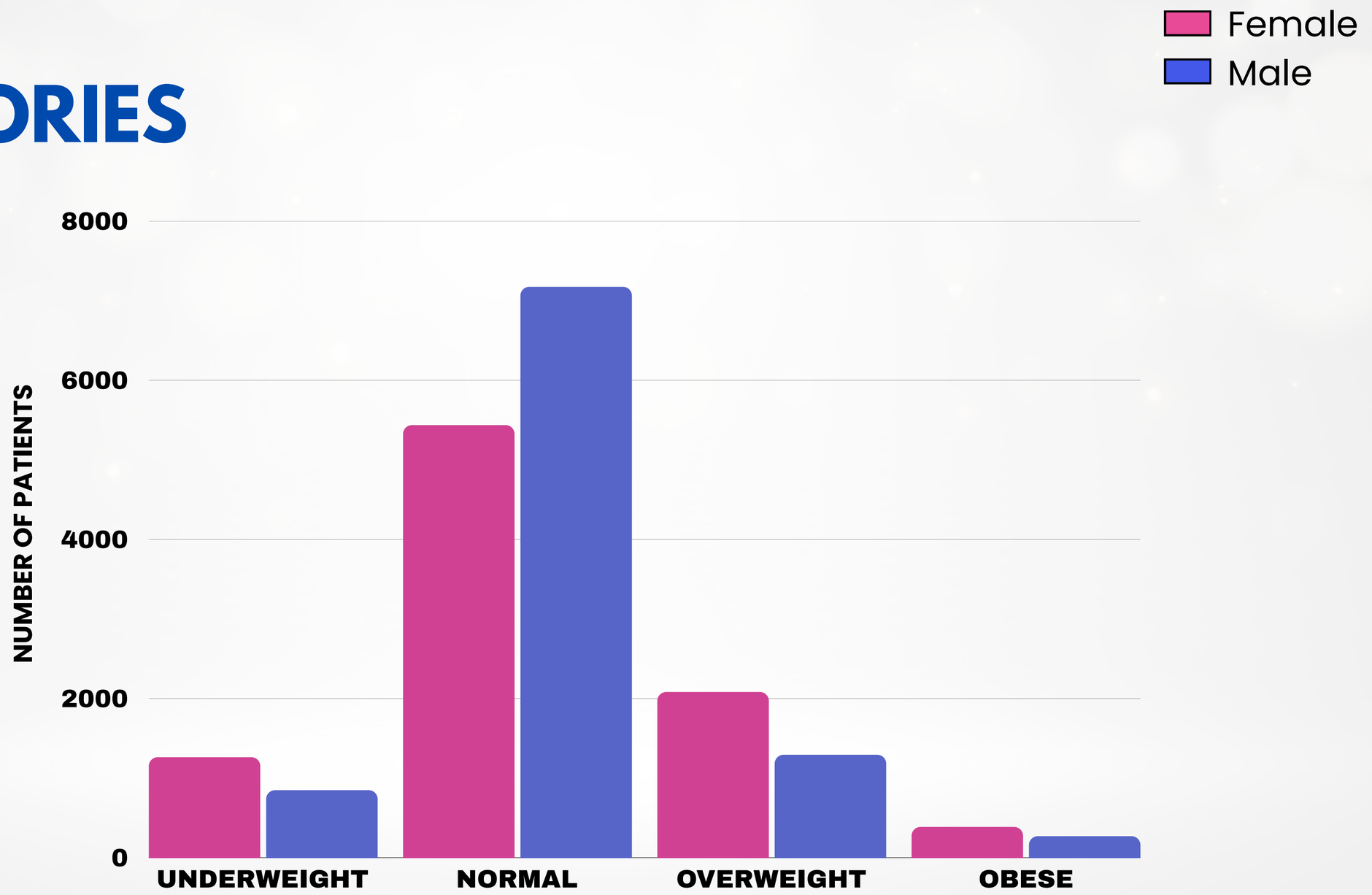
3 BMI

Body Mass Index (BMI) is a numerical value that estimates a **person's body fat** based on their weight relative to height.

$$BMI = \frac{weight(kg)}{(height(m))^2}$$

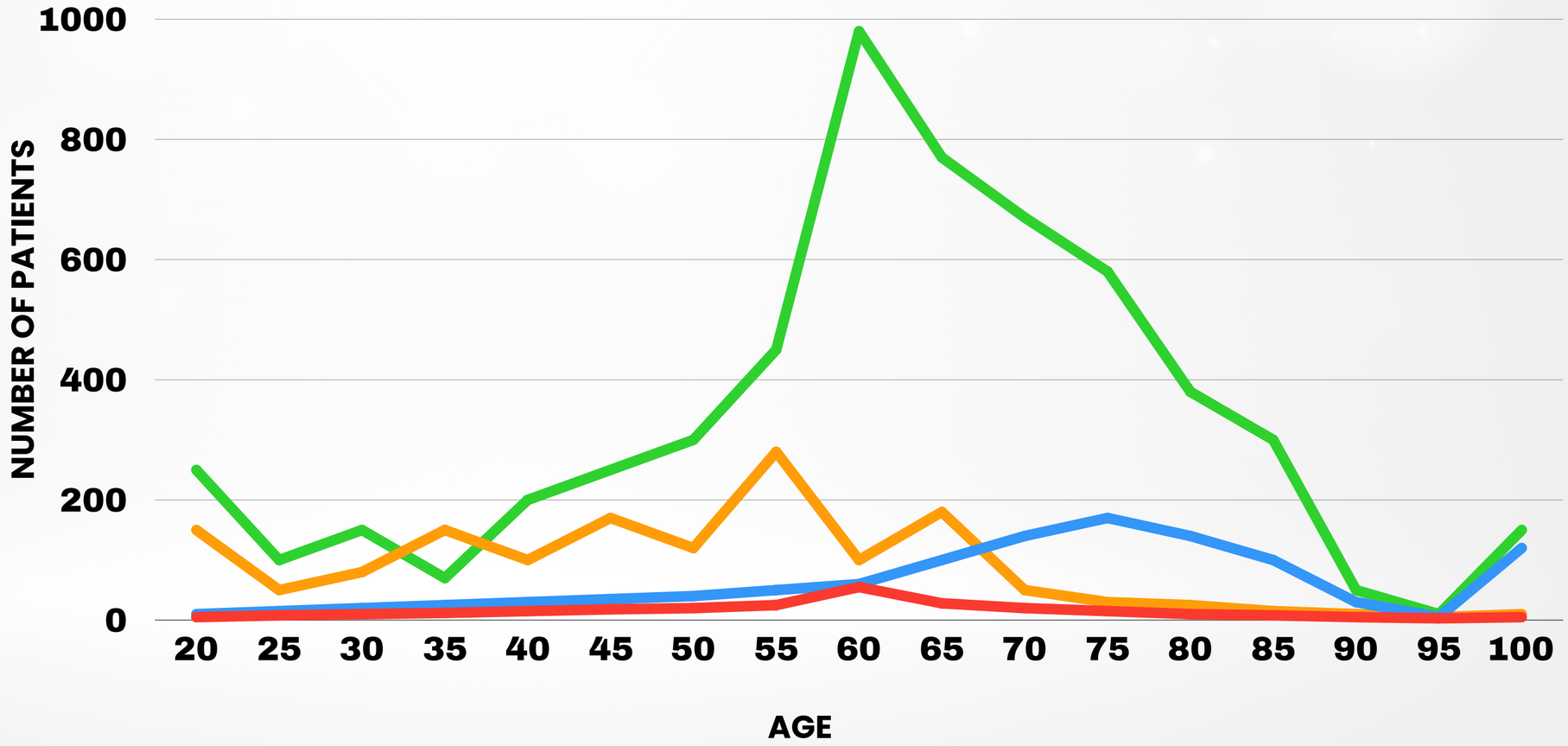


BMI **CATEGORIES** BY SEX



BMI **CATEGORIES** BY AGE

- Underweight
- Normal Weight
- Overweight
- Obese



4 BMI & PATHOLOGIES

In which BMI category is it most common to **develop** a specific heart **disease**?

$$\text{Enrichment} = \frac{P(\text{disease}|\text{category})}{P(\text{disease})}$$

$$P(\text{disease}) = \frac{\text{total number of patients with the disease}}{\text{total number of patients overall}}$$

OUR **CONCLUSIONS**

Is the Body Mass Index (**BMI**) related to the appearance of particular **cardiovascular diseases**?

We discovered that some heart diseases are more linked to the extreme BMI categories: **underweight** and **obese**.

For example:

- Sinus tachycardia (STACH) - **increased heart rate** that occurs when the heart has to work harder, even with minimal effort.
- Atrial Overload/Enlargement (AO/AE) - **atrium muscle** becomes **thicker** because it works harder than normal.

Other pathologies, like Myocardial Infarction (MI), become more frequent as we **age**.

THANK YOU