Disclosure review and de-identification of quantitative data

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Managing and sharing research data: best practice for data protection

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Protecting Confidentiality – the “5 Safes”

The **‘Five Safes’** framework enables **safe access to data** that meet the needs of **data protection** yet fulfils the demands for **open science and transparency**

Safe data - treat data to protect confidentiality

Safe people - educate researchers to use data safely

Safe projects - research projects for ‘public good’

Safe settings – Secure Lab system for sensitive data

Safe outputs – Secure Lab projects outputs screened

5 Safes Animation

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Type of identifiers

Direct identifiers: directly identify participants such as:

- **names**
- **addresses (physical, e-mail)**
- **telephone numbers**
- **account numbers**
- **vehicle identifiers**

Indirect identifiers: can provide enough information in combination to deduce identity of participants:

» **Sensitive information**: medical conditions; crime records; income etc. (consider access control)

» **Less sensitive?:** age; education; employment; household size; geographic area etc.

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De-identification and Anonymisation

De-identification – refers to a process of removing or masking *direct identifiers* in personal data

Anonymisation - refers to a process of ensuring that the risk of somebody being identified in the data is negligible. This invariably involves doing more than simply de-identifying the data, and often requires that data be further altered or masked. Anonymisation allows data to be shared ethically and legally while preserving confidentiality

Types of Anonymisation

1. **Formal Anonymisation**
2. **Guaranteed Anonymisation**
3. **Statistical Anonymisation**
4. **Functional Anonymisation**

Statistical Disclosure Control and Disclosure Events

The concept of statistical anonymization is part of the technical field *statistical disclosure control (SDC)*

The basic principle of SDC is that it is impossible to reduce the probability of re-identification to zero, and so instead one needs to control or limit the risk of disclosure events.

Disclosure occurs when a person/organisation (also known as an **intruder**) **uses published data** in order to **find and revel sensitive and/or unknown information** about a data subject

The **main goal of SDC is to minimize the potential risk of disclosure** to an appropriate level **while sharing as much data as possible**

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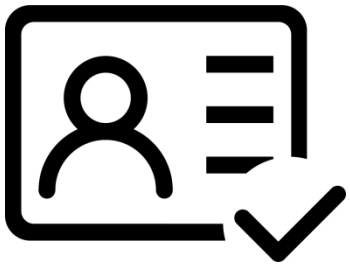
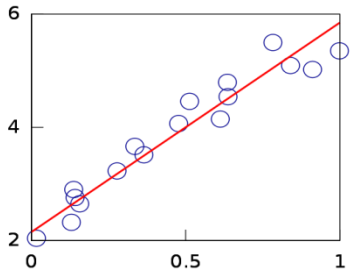
Types of Disclosure



Identity Disclosure – the intruder successfully associates an individual/organisation with the released data – through direct identifiers, combinations of key identifying variables, linking with other available data (outliers and rare combinations increase the risk)

Attribute Disclosure – the intruder is able to determine unknown/sensitive features of an individual/organization based on the info in the released data – high certainty –



Inferential Disclosure - the intruder is able to determine more accurately sensitive features of an individual/organization with the use of the released data than it would be possible without - low certainty –

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Why is Disclosure Review important?

Response Rates

Legal

Financial

Reputation

Future Research

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SDC Freeware

- **R tool - sdcMicro (scripting + GUI)**
  - R package (and free dependable software R and RStudio)
  - reference manual
  - new Shiny GUI – in detailed vignette
  - SDC methods and sdcMicro

- **μ-Argus**
  - standalone software recommended by Eurostat for government statisticians
  - software and manual

- **ARX**
  - comprehensive open source software for anonymizing sensitive personal data
  - software and documentation

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Evaluation Tools

- Useful for **providing comparison** between SDC methods
- **Quick and easy** to explore what changes have biggest effect
- More **problematic** when trying to **define absolute risk** - the numbers might have no real meaning –

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Variables from the SDC Perspective

Direct identifiers – variables that identify directly an individual such as NINo, names, addresses, IP, etc. . Beware of string variables (open ended questions, “other” string variables)

Key variables – combinations of variables (indirect identifiers) that when taken together can identify a respondent. Geographical scope and sample size are of extreme importance as disclosure risk will be highly dependable on them

Non-identifying variables – neither direct nor indirect identifiers (however in the bigger picture each piece of data does contribute to the disclose risk of a dataset)

Exercise: Type of Variables

Occupation	VAT Number	Ethnicity
Gender	Highest Qualification	Newspaper Readership
Local Authority	Life Satisfaction	Age

Exercise: Type of Variables

Direct Identifiers:

- VAT Number

Key Variables:

- Occupation
- Ethnicity
- Highest Qualification
- Gender
- Local Authority
- Age

Non-identifying variables:

- Newspaper Readership
- Life Satisfaction

De-identification

Currently no available automated software to detect direct identifiers.

However:

- Understanding and knowing the data (have **good metadata**)
- Paying attention to **string variables**
- Packages like SPSS provide the find (**find and replace**) function
- **Frequencies, frequencies, frequencies!**

SDC Approaches

Types of SDC approaches:

Perturbative methods (*data-distortion controls)* - including an element of error

- adding noise - typically continuous variables
- micro-aggregation - continuous variables
- post-randomization (PRAM) - categorical variables
- cell or value suppression

Non-perturbative methods (*metadata-level controls)* - detail reduction

- recoding
- sampling
- choice of variables

Hybrid method: local suppression

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Exercise: Key Variables

Occupation	
Accountant	67
Ambulance Officer	56
Baker	97
Cook	109
Electrical Engineer	51
Locksmith	32
Middle School Teacher	46
Plumber	19
Pressure Welder	11
Registered Nurse (Aged Care)	22
Registered Nurse (Child and Family Health)	14
Registered Nurse (Community Health)	9
Registered Nurse (Critical Care and Emergency)	7
Roof Plumber	2
Secondary School Teacher	36
Software Engineer	105
Statistician	21
Zookeeper	41

Which categories pose a disclosure risk?

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Exercise: Key Variables

Occupation	
Accountant	67
Ambulance Officer	56
Baker	97
Cook	109
Electrical Engineer	51
Locksmith	32
Middle School Teacher	46
Plumber	21
Pressure Welder	11
Registered Nurse	52
Secondary School Teacher	36
Software Engineer	105
Statistician	21
Zookeeper	41

Exercise: Key Variables

Ethnicity	
White - English/Welsh/Scottish/Northern Irish/British	339
White - Irish	210
White - Gypsy or Irish traveller	1
Any other White	3
Mixed - White and Black Caribbean	120
Mixed - White and Black African	170
Any other Mixed	42
Asian / Asian British - Indian	87
Asian / Asian British - Pakistani	82
Asian / Asian British - Bangladeshi	63
Asian / Asian British - Chinese	61
Any other Asian	22
Black / African / Caribbean / Black British - African	89
Black / African / Caribbean / Black British - Caribbean	102
Any other Black / African / Caribbean	82
Other ethnic group - Arab	31
Any other ethnic group	1

Exercise: Key Variables

Ethnicity	
White - English/Welsh/Scottish/Northern Irish/British	339
White - Irish	210
White - Gypsy or Irish traveller	0
Any other White	0
Mixed - White and Black Caribbean	120
Mixed - White and Black African	170
Any other Mixed	42
Asian / Asian British - Indian	87
Asian / Asian British - Pakistani	82
Asian / Asian British - Bangladeshi	63
Asian / Asian British - Chinese	61
Any other Asian	22
Black / African / Caribbean / Black British - African	89
Black / African / Caribbean / Black British - Caribbean	102
Any other Black / African / Caribbean	82
Other ethnic group - Arab	31
Any other ethnic group	0

Before applying any SDC methods

What is the **disclosure scenario**?

- **Who**?
- **What**?
- **Why**?

What are the **needs of secondary users**?

What are the key characteristics of the data:

- **Population vs Sample**
- **Geographical Coverage**
- **Level of non-response**

What is the **acceptable risk**?

Intended outcome: **Safe data with high utility**

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Key Variables – combinations and patterns

Geographical Coverage	Gender	Age
Ethnicity	Occupation	Highest Qualification

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Uniqueness

Uniqueness - one of the fundamental concepts in disclosure review

A record is unique on a set of key variables if no other record shares its combination of values for those variables.

Two types of uniqueness on a set of key variables:

- **population uniqueness** — a unit is unique in the population (or within a population data file such as a census);
- **sample uniqueness** — a sample unit is unique within the sample file.

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K-anonymity

K-anonymity is a statistical method used to **evaluate whether or not a case is unique in the data;** is a hybrid disclosure risk assessment and disclosure control technique.

"A dataset is regarded as k-anonymised if – on all sets of key variables – each combination of possible values of those variables has at least k records that have that combination of values"

Depending on the level of access of a study the k is usually set to 3 or 5. Example: if k=3 all the patterns that are unique in the data (f=1) and the patterns that have a duplicate (f=2) will violate 2- and 3-anonymity assumptions and will be considered to pose a higher risk of disclosure.

patterns=records/cases with the same key identifiers

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K-anonymity

Gender	Ethnicity	Occup.	fk
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British - Indian	Baker	2
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British - Indian	Baker	2
Female	Asian / Asian British - Pakistani	Baker	2
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British - Pakistani	Baker	2
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Black / African / Caribbean / Black British - African	Baker	3
Female	Black / African / Caribbean / Black British - African	Baker	3
Female	Black / African / Caribbean / Black British - African	Baker	3

K-anonymity

Gender	Ethnicity	Occup.	fk
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British	Baker	4
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British	Baker	4
Female	Asian / Asian British	Baker	4
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Asian / Asian British	Baker	4
Female	White - English/Welsh/Scottish/Northern Irish/British	Baker	4
Female	Black / African / Caribbean / Black British - African	Baker	3
Female	Black / African / Caribbean / Black British - African	Baker	3
Female	Black / African / Caribbean / Black British - African	Baker	3

Exercise: Key Variables – k-anonymity

1 record (fk=1):

2 records (fk=2)

3 records (fk=3)

16 records (fk=16)

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Key Variables – combinations: sample and population

Basildon

Occupation and highest level of education

Sample 70% of a population of 170,000

fk=1	Male	84	Bangladeshi	Baker	MA, MSc
fk=5	Male	65 or over		Baker	MA, MSc

England

Ethnicity, occupation , highest level of education

Sample 10% of a population of 5.3 million

fk=1	Male	84	Bangladeshi	Baker	MA, MSc
Fk=23	Male	84	Bangladeshi	Baker	MA, MSc

Where fk= sample frequencies and Fk=population frequencies

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L-diversity

L-diversity is an **extension of k-anonymity** - there has to be at least l different values for each sensitive variable within each pattern on the key variables. If no sensitive variables are present in the data l-diversity is not needed.

Examples of sensitive variables:

- stress level: low, normal, high
- HIV positive: yes, no

Gender	Ethnicity	Occup.	HIV	L-diversity	Count
Female	Asian / Asian British	Baker	no	2	4
Female	Asian / Asian British	Baker	no	2	4
Female	Asian / Asian British	Baker	yes	2	4
Female	Asian / Asian British	Baker	no	2	4
Female	Black / African / Caribbean / Black British - African	Baker	Yes	1	2
Female	Black / African / Caribbean / Black British - African	Baker	Yes	1	2

Information Loss

use
da

Data quality is important for all parties involved in this process from data producers to data providers and to So, while applying SDC methods the utility and information loss must always be of **utmost importance**

The sdcMicro package/GUI **calculates the information loss each time a new SDC method is applied** to the data, which is one of the fantastic features that ease the process of SDC when using this package/GUI

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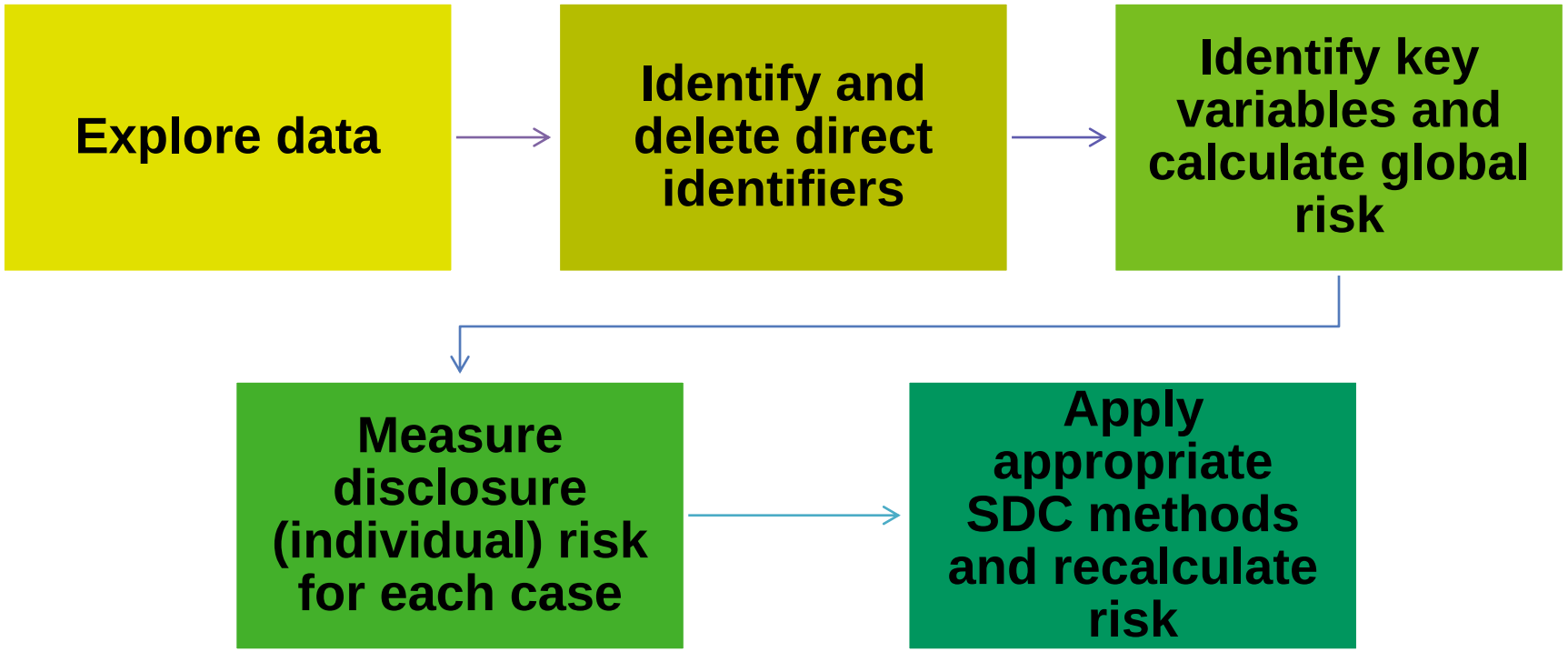
SDC Workflow



Functional Anonymization

Data does not exist in isolation

A data environment

- **Data** – what (other) data exist in the data environment?
- **Data users** – who is accessing the data?
- **Governance processes** – are data access controls licensing arrangements and policies in place?
- **Infrastructure** – how is the data stored, exchanged and provided?

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Access conditions

Open	• No real risk. Under open licence; almost no restrictions on reuse
Safeguarded	• Zero to low real risk. Requires authentication and authorisation e.g. registered user and End User Agreement
Controlled	• Real risk. Requires project approval, user vetting and training; access via a safe setting; output checking

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Conclusion

SDC is a complex topic - **an active research field**

- Be aware of the **issues and considerations of statistical disclosure**
- Be able to **make principled judgements** about the disclosiveness of your data
- Be able to **find the balance** between minimizing disclosure risk and maintaining high data utility; what's the point in safe but unusable data?

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Questions

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