



Mahidol University

# Methods for depicting overlap in overviews of systematic reviews: An introduction to static tabular and graphical displays

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## Cochrane Handbook for Systematic Reviews of Interventions

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# Overviews of Systematic Reviews

- Cochrane Overviews of Reviews (Overviews)
- Umbrella reviews
- Reviews of reviews
- Meta-reviews

# Overviews of Systematic Reviews

- Explicit and systematic methods to search for and identify multiple systematic reviews on related research questions
- For the purpose of extracting and analysing their results across important outcomes.
- The unit of searching, inclusion and data analysis is the systematic review.

# Five components of Cochrane Overviews

- Contain a clearly formulated objective designed to answer a specific research question
- Intend to search for and include only systematic reviews (with/without meta-analyses).
- Use explicit and reproducible methods to identify multiple systematic reviews that meet the Overview's inclusion criteria and assess the quality/risk of bias of these systematic reviews.

# Five components of Cochrane Overviews

- Intend to collect, analyse and present the following data from included systematic reviews:
  - Descriptive characteristics of the systematic reviews and their included primary studies
  - Risk of bias of primary studies
  - Quantitative outcome data
  - Certainty of evidence for pre-defined, clinically important outcomes.
- Discuss findings as they relate to the purpose, objectives and specific research questions of the overview.

# Methods for conducting a Cochrane Overview of Reviews

- Defining the research question(s)
- Developing criteria for including systematic reviews
- Selecting systematic reviews for inclusion
  - Identifying systematic reviews that meet the inclusion criteria
  - Conducting supplemental searches for primary studies

# Methods for conducting a Cochrane Overview of Reviews

- Assessing **primary study overlap** within the included systematic reviews
- Collecting, analysing, and presenting data from included systematic reviews and primary studies
- Assessing certainty of evidence of quantitative outcome data using the GRADE tool





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ORIGINAL ARTICLE

Methods for depicting overlap in overviews of systematic reviews: An introduction to static tabular and graphical displays

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Methods for depicting overlap in overviews of systematic reviews: An introduction to static tabular and graphical displays

# Introduction

- The primary aim of OoSRs is to integrate evidence from multiple SRs within the same field and address a broad spectrum of research questions using explicit and systematic methods.
- To address these challenges, reporting guidelines have recently been published, to support the reporting and conduct of OoSRs.
- Lack of consensus regarding many of the more complex phases of the overview process, such as dealing with **primary study overlap**.

# Introduction

- One of the key challenges, unique to OoSRs, is addressing multiple overlapping SRs.
- Cochrane recently updated their guidance for conducting OoSRs highlighting that it is important to “map out which primary studies are included in which systematic reviews”.
- Different approaches are used by the authors.

# Introduction

- **Data visualization** is an excellent method for exploring and presenting the extent to which multiple relevant SR include the same primary studies.
- However, there is limited knowledge and applicability of data visualization methods in OoSRs.
- A recent study assessing 50 OoSRs with health care interventions found that only 8% (4/50) of these OoSRs reported methods for visualizing overlap (e.g., using a citation matrix).

# Introduction

- The authors aimed to introduce potential static tabular and graphical techniques for visually presenting overlap between SRs that may assist methodologists and overview authors in exploring and communicating the degree of overlap in OoSRs.

Methods

# Protocol and registration

- A protocol for this study was developed a priori and was registered with the Open Science Framework

# Taxonomy of graphical displays and Mathematical background

- The authors reviewed articles and work on set visualization to choose tabular and graphical displays for depicting overlap in OoSRs.
- Criteria for inclusion were
  - The applicability in OoSRs
  - The visual complexity (the amount of detail or intricacy in a picture)
  - The potential of these graphs to be used as a stand-alone static visual display



# Taxonomy of graphical displays and Mathematical background

- The authors applied a classification system to group the different types of tabular and graphical displays as per pertinent taxonomy.
  - (a) Venn and Euler diagrams
  - (b) Matrix-based techniques
  - (c) Node-link techniques
  - (D) Aggregation-based techniques

# Empirical illustration

- The overlap can be investigated across all included SRs or/and at the outcome level.
- The authors implemented the proposed tabular and graphical displays to empirical examples of published health care OoSRs using the R programming language (version 4.0.2).
- They used three OoSRs for illustrating Venn and Euler diagrams and the study by Miyazaki et al. for the remaining graphs to allow for greater comparability.

# Example

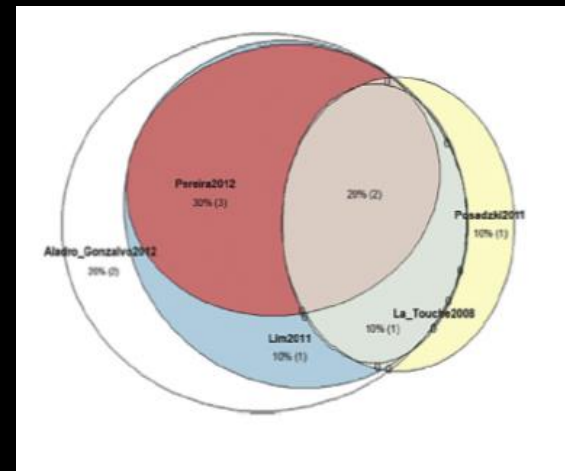
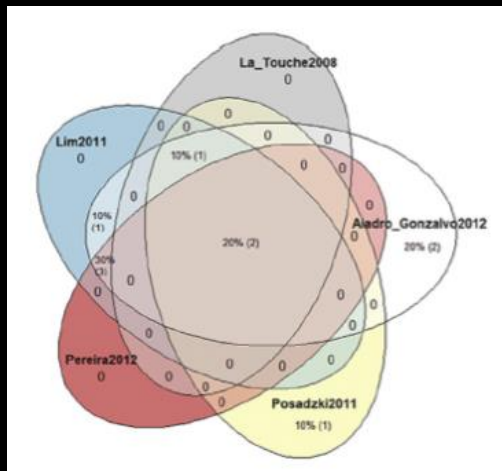
- **Miyazaki et al. 2017** summarize the evidence from
  - 6 SRs that include 14 unique randomized control trials
  - evaluating three outcomes: the incidence of type 2 diabetes mellitus (T2DM), the glycemic load, and the anthropometric changes (see Appendix 2).
- The selection of the examples was based on the usefulness of the articles in demonstrating specific aspects of the proposed visual techniques.
- No judgment of study quality is implied by this selection.

Results

# 1. Venn and Euler diagrams

- **Venn diagram** depicts all possible intersections between the SRs, even if some of them are empty
- can work for up to five SRs.

- **Euler diagram** depicts only intersections that are not empty.



Overview of systematic reviews

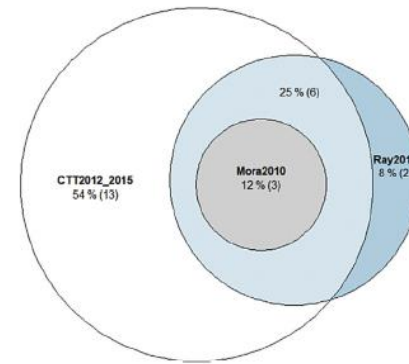
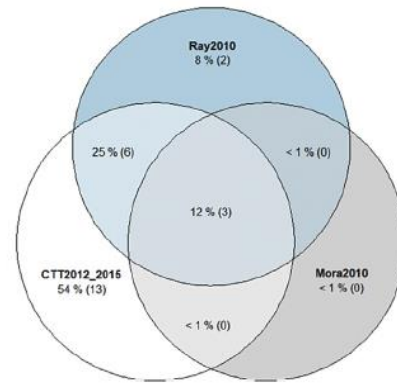
No. of SRs (primary studies)

Venn diagram

Euler diagram

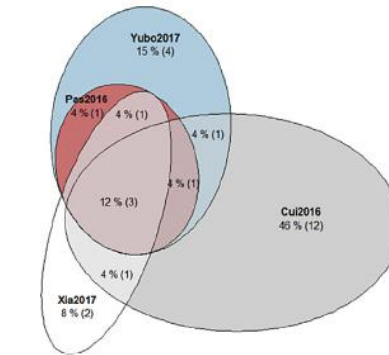
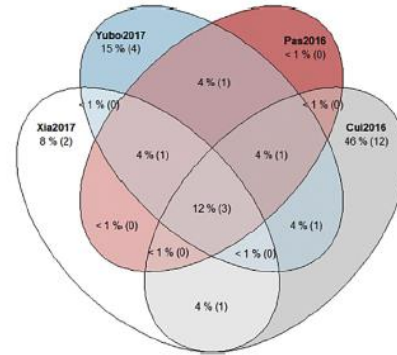
Byrne et al. 2019 [28]

3 (24)



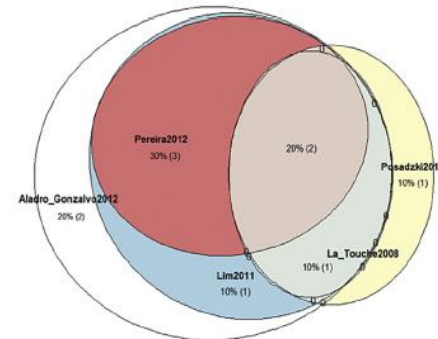
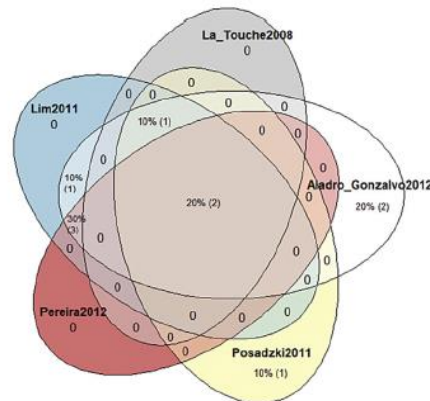
Xing et al. 2018 [29]

4 (26)



Wells et al. 2013 [30]

5 (10)



# 2. Matrix-based techniques

2.1 The citation matrix of OoSs

2.2 Upset plot

2.3 Pairwise intersection heatmap

## 2.1 The citation matrix of OoSRs

- A citation matrix is a two-dimensional cross table, consisting of columns with the individual SRs and rows with unique primary studies.
- For each primary study, a check mark ( ✓ ) is used to indicate the SRs in which it has been cited.



# 2.1 The citation matrix of OoSRs

		Systematic Reviews						No. of times included
		StudyID	Chasan2014	Gilinsky2015	Guo2016	Middleton2014	Morton2014	
Primary Studies	Cheung2011	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes	4
	Clark2009	✗ No	✗ No	✗ No	✓ Yes	✗ No	✗ No	1
	Ferrara2011	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes	4
	Hu2012	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✗ No	3
	Ji2011	✗ No	✗ No	✓ Yes	✗ No	✗ No	✗ No	1
	Kim2012	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes	4
	McIntyre2012	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes	4
	Peterson1995	✗ No	✓ Yes	✗ No	✗ No	✗ No	✗ No	1
	Ratner2008	✓ Yes	✓ Yes	✓ Yes	✗ No	✓ Yes	✓ Yes	5
	Reinhardt2012	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes	4
	Shek2014	✗ No	✓ Yes	✓ Yes	✗ No	✓ Yes	✗ No	3
	Shyam2013	✓ Yes	✓ Yes	✓ Yes	✗ No	✓ Yes	✗ No	4
	Wein1999	✓ Yes	✓ Yes	✓ Yes	✗ No	✓ Yes	✗ No	4
	Yu2012	✗ No	✗ No	✓ Yes	✗ No	✗ No	✗ No	1
<b>Total studies included</b>		<b>9</b>	<b>11</b>	<b>12</b>	<b>1</b>	<b>4</b>	<b>6</b>	

## 2.2 Upset plot

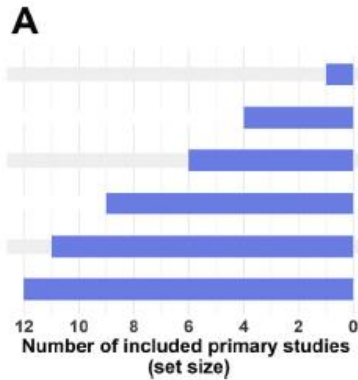
- When the number of SRs exceeds five, Venn and Euler diagrams become difficult to read and interpret.
- Another effective approach to visualize overlapping reviews is the Upset plot which depicts exclusive intersections.

## 2.2 Upset plot

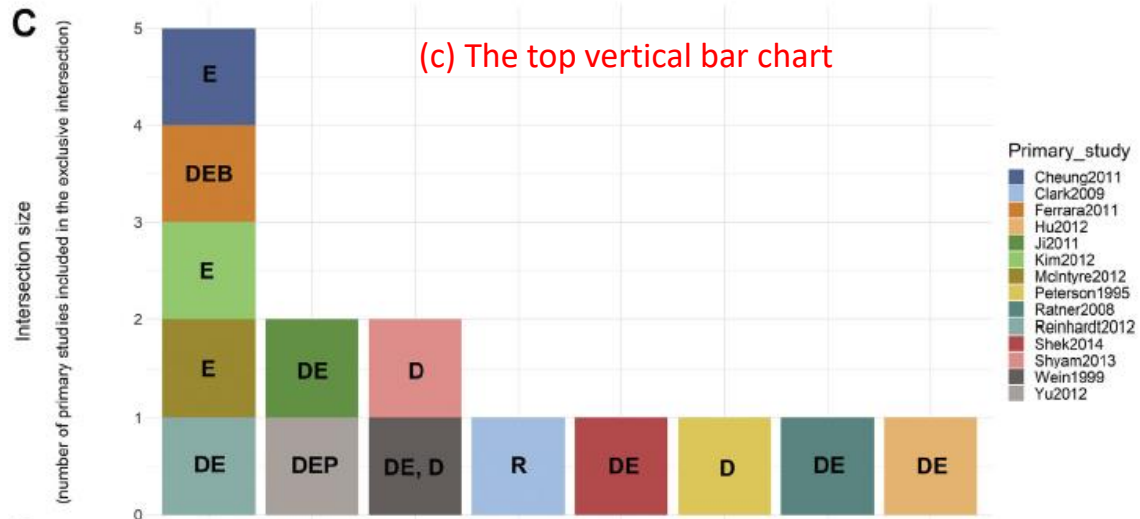
- The Upset plot consists of three parts
  - (a) The horizontal bar chart
  - (b) The intersection matrix
  - (c) The top vertical bar chart

# 2.2 The Upset plot

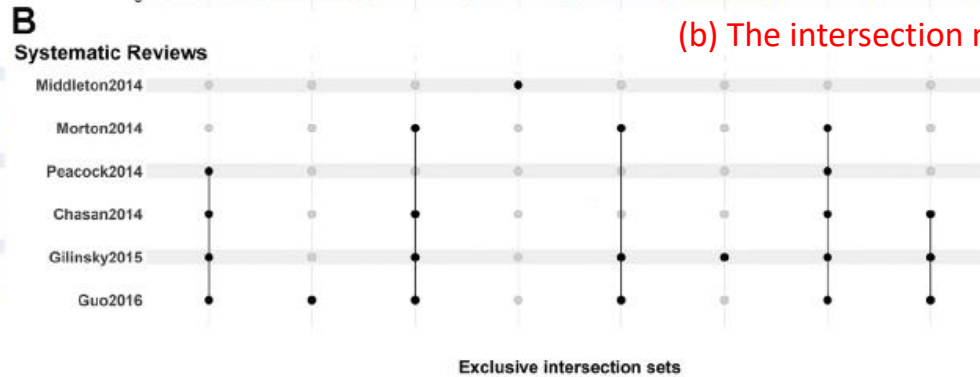
(a) The horizontal bar chart



(c) The top vertical bar chart



(b) The intersection matrix



## 2.3 Pairwise intersection

- With an increasing number of studies, visualizing all possible intersections becomes impractical by using Venn and Euler diagrams or Upset plots.
- To visualize pairwise intersections with heatmaps.
- The cells within the triangular matrix contain color-coded data that demonstrate the degree of overlap between pairs of SRs.
- Either the number of primary studies that are common between pairs of SRs or the CCA formula can be used as a measure of the overlap.

# Corrected covered area (CCA) formula

$$CCA = \frac{N - r}{r \cdot c - r}$$

Table 1. Interpretation of CCA

CCA	Overlap
0–5	Slight
6–10	Moderate
11–15	High
>15	Very high

Abbreviation: CCA, corrected covered area.

where  $N$  is the number of included publications (including double counting) in evidence synthesis (this is the sum of the ticked boxes in the citation matrix); where  $r$  is the number of rows (number of index publications) and  $c$  is the number of columns (number of reviews).

# Corrected covered area (CCA) formula

	Review 1	Review 2	Review 3	Review 4
Primary publication 1	x			
Primary publication 2	x			x
Primary publication 3	x	x	x	x
Primary publication 4	x	x	x	
Primary publication 5	x	x		x
Primary publication 6	x			
Primary publication 7	x	x	x	
Primary publication 8	x			
Primary publication 9		x		
Primary publication 10		x		
Primary publication 11				x
Primary publication 12				x

$$CCA = \frac{N - r}{r \cdot c - r}$$

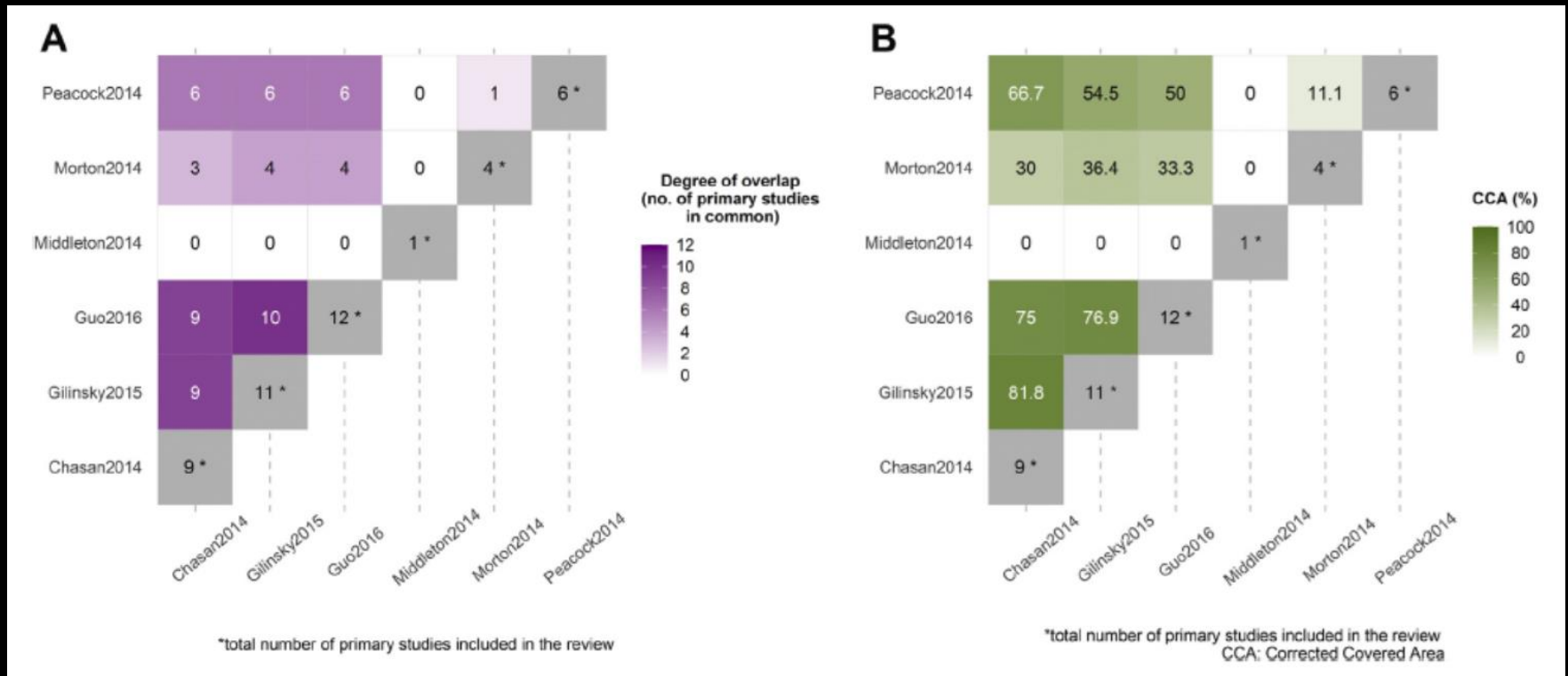
$$N = 22$$

$$R = 12$$

$$C = 4$$

$$CCA: (22 - 12)/(48 - 12) = 10/36 = 0.28$$

# 2.3 Pairwise intersection heatmap





# 3. Node-link techniques

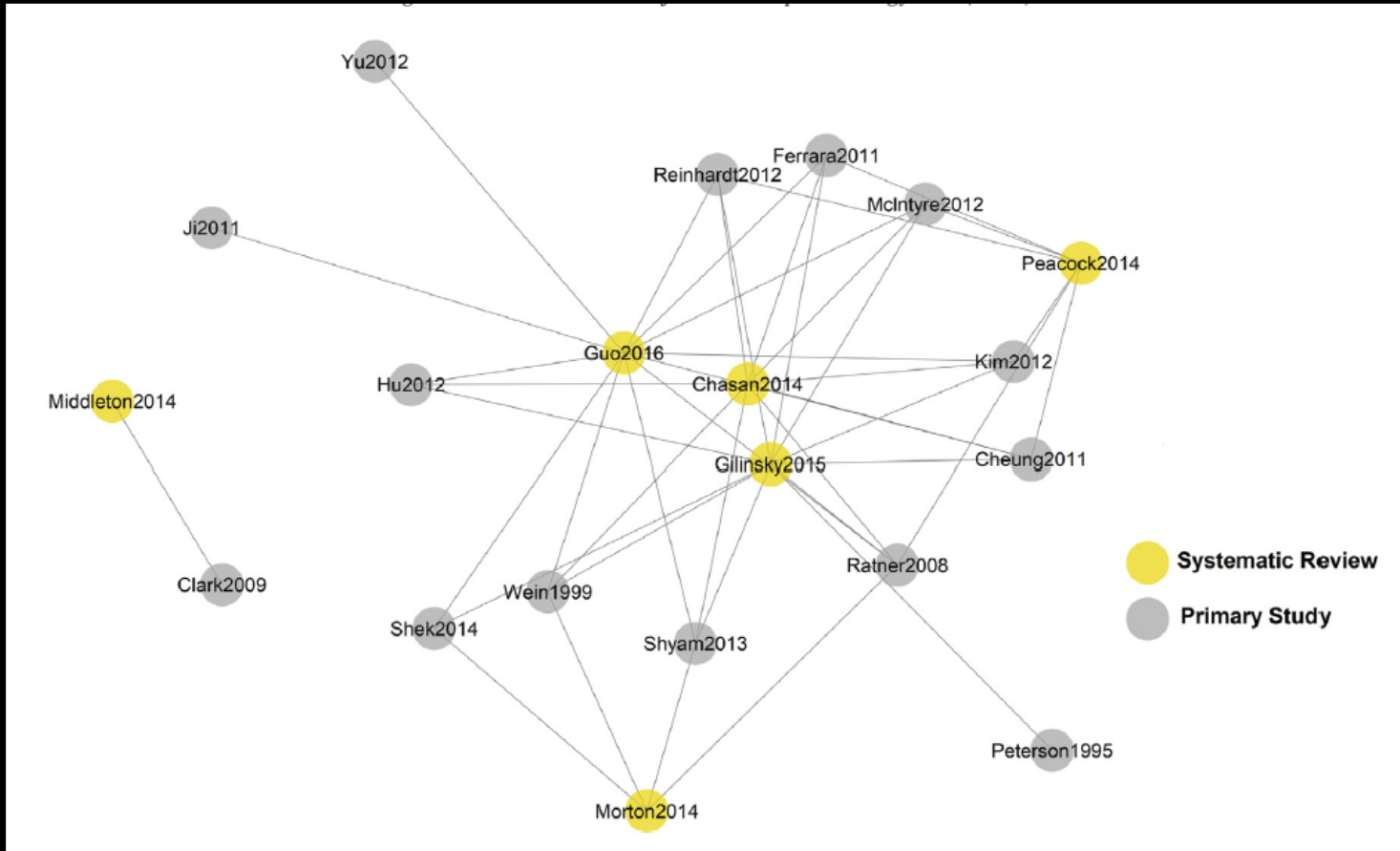
3.1 Bipartite citation network

3.2 Node-link graph with systematic reviews

# 3.1 Bipartite citation network

- A network consists of nodes and links.
- The nodes are divided into **two sets** such that connection is only allowed between two nodes in different sets.
- The one set of nodes represents the **SRs** and the other set represents the **primary studies**.
- Each SR is connected by a link with the primary studies that are part of it.

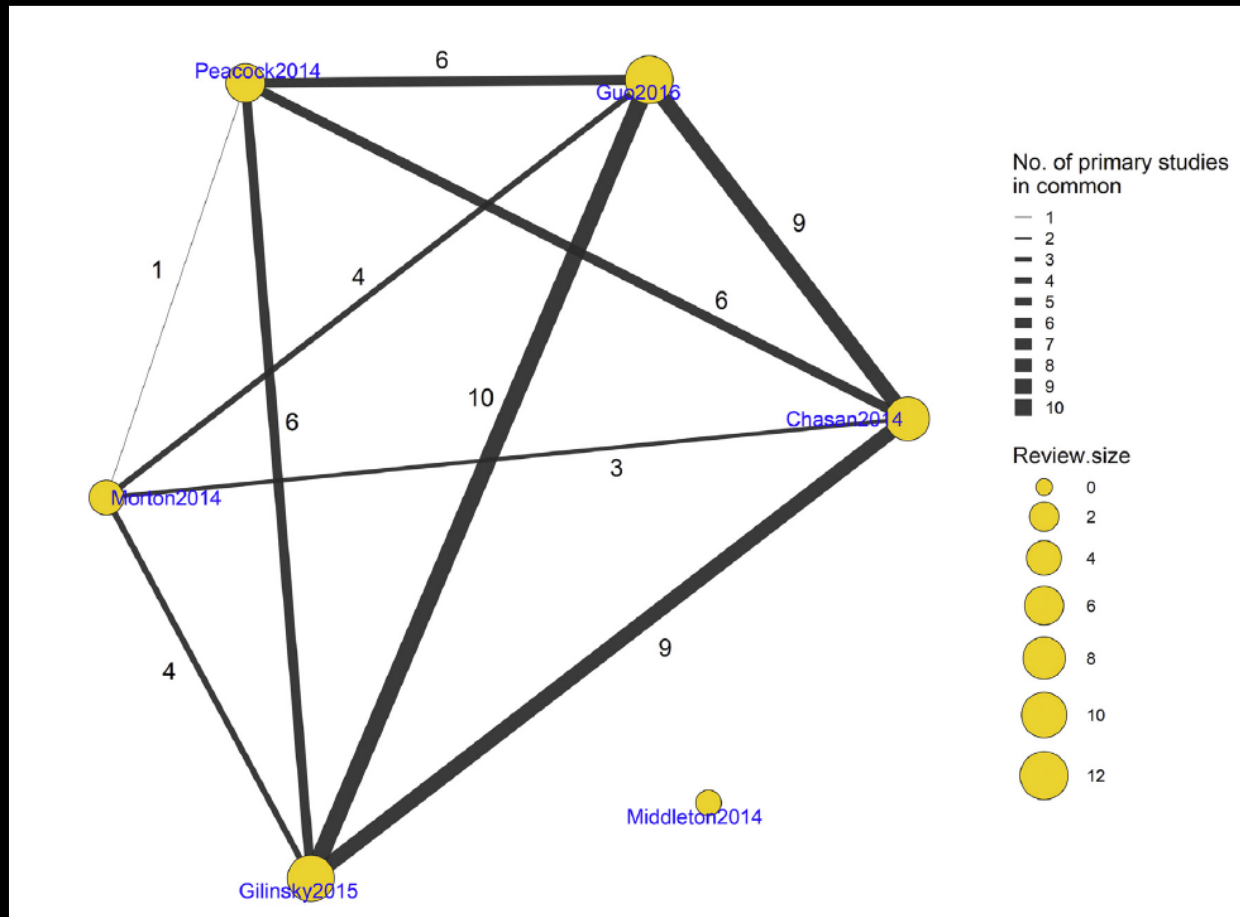
# 3.1 Bipartite citation network



## 3.2 Node-link graph with SR

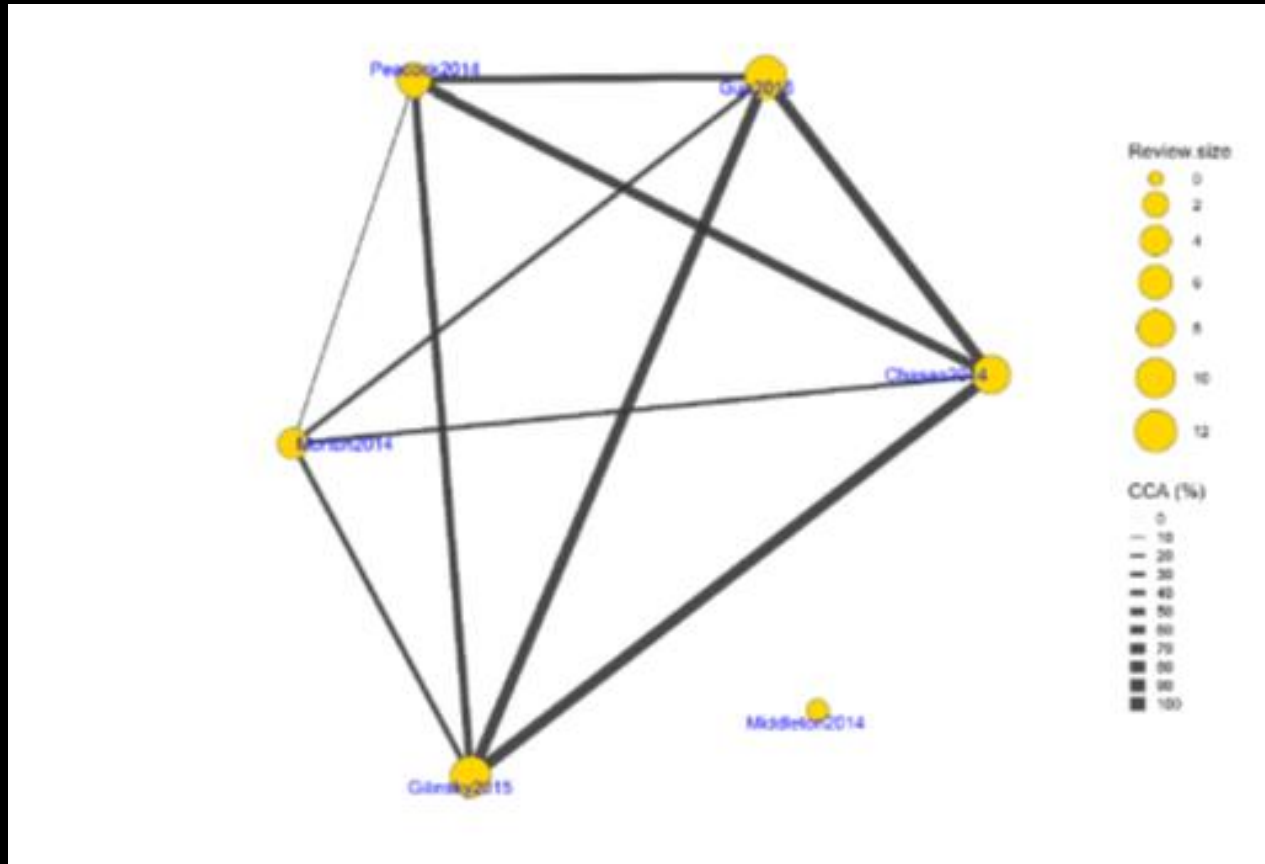
- This type of graph contains **only SR nodes**, where two SR nodes are connected when they have at least one common primary study node.
- The thickness of links represents the number of primary studies that are common between two linked SRs or alternatively the corresponding CCA.
- The size of nodes represents the number of primary studies included in SRs.
- This type of visualization is an alternative approach to heatmaps.

## 3.2 Node-link graph with systematic reviews



## 3.2 Node-link graph with systematic reviews

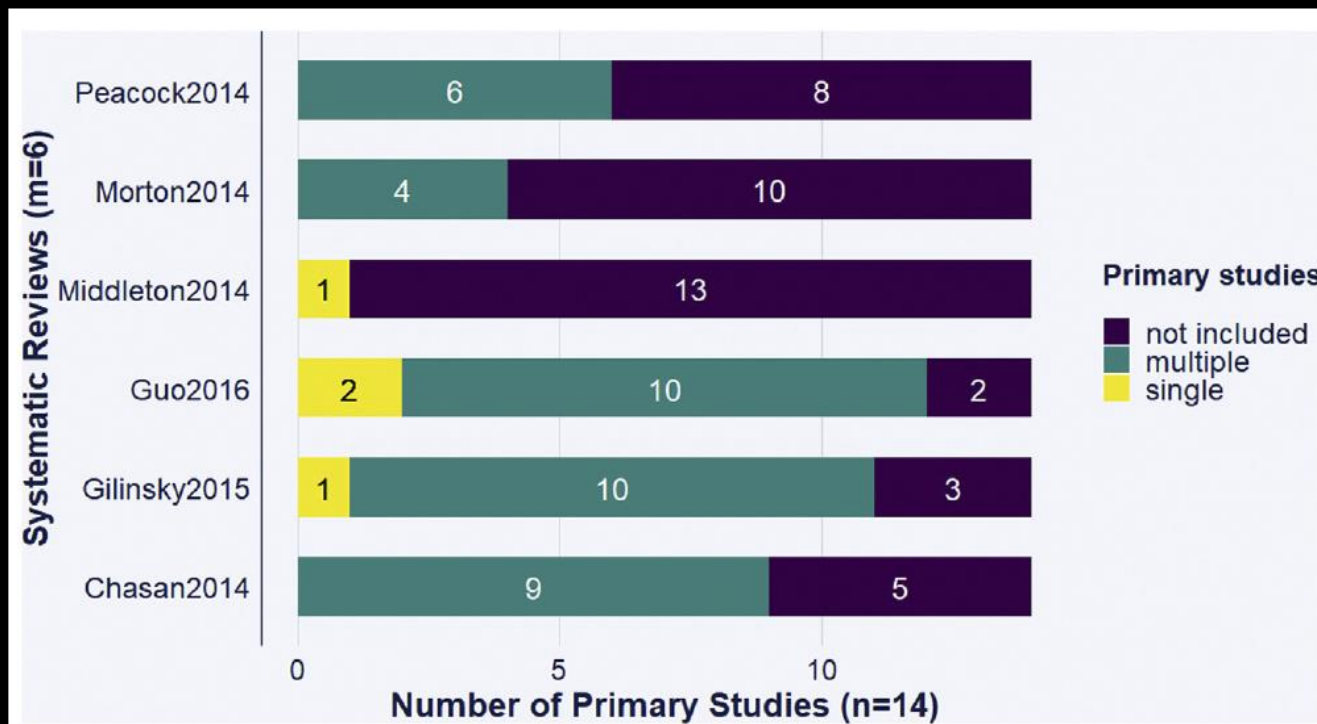
use the corrected covered area (CCA) formula



## 4. Aggregation-based techniques (bar plot)

- Some OoSRs include many SRs and a large number of primary studies, the aforementioned graphical displays are unfeasible.
- Aggregation techniques can be used by using frequency representations to exhibit the number of primary studies in each SR and the proportion of them that are part of more than one SR.

# 4. Aggregation-based techniques (bar plot)





# Discussion

- Overlapping SRs is a methodological issue unique to OoSRs.
- If improperly handled, may lead to inaccurate results or misleading conclusions.

# Discussion

## High degree of overlap

- The conclusions of each SR should be examined to evaluate the degree of their agreement.
- If **discordance** in conclusions exists, **potential reasons** should be sought.

## Low degree of overlap

- To be expected for broad-scope OoSRs
- To **explore the scope** of the OoSRs. (eligibility criteria, search strategies, interventions, and outcomes)
- To **assess the comprehensiveness and the quality of the included SRs** to identify the underlying reasons.

# Discussion

- This study provides an introduction to different visualization methods for depicting overlap in OoSRs. We classified and described the proposed graphical displays highlighting some advantages and limitations for each of them.
- The most common graphical representation of overlap in OoSRs is citation matrices to date.

# Strengths and weaknesses of the visual techniques

Visual technique	Strengths	Weaknesses
Venn and Euler diagrams	<ul style="list-style-type: none"><li>• The classic approach to show intersections between a small number of SRs (up to five).</li><li>• They are generally easy to understand.</li></ul>	<ul style="list-style-type: none"><li>• Beyond five SRs, strange shapes need to be used to represent all the intersection combinations and understanding the diagrams can be misleading or nearly impossible.</li><li>• It is not possible to know which same primary studies are included in reviews.</li></ul>

# Strengths and weaknesses of the visual techniques

Visual technique	Strengths	Weaknesses
Matrix-based techniques		
Citation matrix	<ul style="list-style-type: none"><li>• Most commonly used visual approach for illustrating overlapping reviews.</li><li>• It presents which same primary studies are included in reviews.</li><li>• Useful for calculating the CCA.</li></ul>	<ul style="list-style-type: none"><li>• It can often become overwhelming, especially when a large number of SRs and primary studies need to be displayed and difficult to follow.</li></ul>
Upset plot	<ul style="list-style-type: none"><li>• A comprehensive way to identify overlap between SRs.</li><li>• It may present all the exclusive intersections. In instance of a large overview, the number of intersections can be reduced by setting the degree of intersection (i.e., degree of intersection <math>\geq 2</math>).</li><li>• It may present which same primary studies are included in reviews using different colors for the primary studies.</li><li>• It may present the interventions described in the included SRs</li></ul>	<ul style="list-style-type: none"><li>• Theoretically, Upset plots can display more than 25 different SRs and 40 intersections. However, in practice plotting all intersections of 10 or more SRs at once may not be feasible [25].</li><li>• If there is a large number of primary studies (<math>&gt; 30</math>), it can be difficult to distinguish between a wide variety of colors. In this case, the Upset plot can illustrate only the number of primary studies included in the intersections.</li><li>• Needs familiarity—for an inexperienced reader, it can be difficult to interpret this composite graph at first.</li></ul>
Pairwise intersection heatmap	<ul style="list-style-type: none"><li>• An easy way to identify patterns of high or low overlap between pairs of SRs at a glance using a color scheme with increasing saturation.</li><li>• It is suitable when OoSRs include many SRs and a large number of primary studies.</li><li>• Either the number of primary studies that are common between pairs of SRs or the calculation of CCA for each pair of SRs can be used as a measure of the overlap.</li></ul>	<ul style="list-style-type: none"><li>• It is not possible to know which same primary studies are included in the pairs of reviews.</li><li>• It does not provide information on intersections of SRs with degree of intersection higher than two.</li></ul>

# Strengths and weaknesses of the visual techniques

Visual technique	Strengths	Weaknesses
Node-link techniques		
Bipartite “cloud-like” citation network	<ul style="list-style-type: none"> <li>• It is generally easy to understand. When many primary studies are part of multiple SRs, there are more links, indicating higher degree of overlap in the OoSRs.</li> <li>• It can identify clusters of reviews with many links to primary studies.</li> <li>• It can display exactly which primary studies are connected to which SRs.</li> </ul>	<p>A large number of primary studies and SRs can often lead to a complex or even chaotic visualization due to edge crossing and overplotting.</p>
Node-link graph with systematic reviews	<ul style="list-style-type: none"> <li>• An easy way to identify high or low overlap between pairs of SRs at a glance using the size of the nodes and the thickness of the links.</li> <li>• It can identify clusters of highly connected reviews.</li> <li>• Either the number of primary studies that are common between pairs of SRs or the calculation CCA for each pair of SRs can be used as a measure of the overlap.</li> <li>• Alternative graph to pairwise intersection heatmap</li> </ul>	<ul style="list-style-type: none"> <li>• It is not possible to know which same primary studies are included in the pairs of reviews.</li> <li>• It does not provide information on intersections of SRs with degree of intersection higher than two.</li> <li>• Due to edge crossing, node-link graphs suffer from increasing clutter as the number of links increases.</li> </ul>

# Strengths and weaknesses of the visual techniques

Visual technique	Strengths	Weaknesses
Aggregation-based techniques		
Bar plot	<ul style="list-style-type: none"><li>• Simple chart choice. It is generally easy to understand.</li><li>• It is suitable when OoSRs include many SRs and a very large number of primary studies.</li><li>• It constitutes an aggregative method of presenting overlap. The potential differences in the length of the sub-bars corresponding to each SR are explained by clinical or methodological differences (e.g., different research question, eligibility criteria for study inclusion, and search dates) among the SRs included in the OoSRs.</li></ul>	<ul style="list-style-type: none"><li>• It is not possible to depict the specific SRs that are in overlap.</li><li>• It is not possible to know which same primary studies are included in reviews.</li></ul>

# Discussion

- Limitations of the study
  - Firstly, this study might have overlooked some potentially relevant options for graphical displays.
  - Second, as this is an introductory article, they did not use examples from the literature to test different scenarios and conditions for each proposed visualization technique, and we acknowledge that some of them may require more evaluation or/and refinement.
  - Furthermore, they did not present interactive plots and any software or apps that can be used for visualization other than R were not investigated.



# Discussion

- Future research could further investigate the potential uses as well as the limitations for each proposed diagram, for different scenarios and conditions.
- In addition, automation of exploring overlap among SRs is essential to support the production of the proposed graphical displays.

# Conclusion

- The degree of overlap among reviews should be explored for the entire study and for specific outcomes of interest.
- This study is the first to introduce several potential techniques for depicting overlap in OoSRs that can assist methodologists and overview authors in exploring and communicating the degree of overlap in OoSRs.

# Conclusion

- The proposed static tabular and graphical displays have the potential to improve validity and transparency of the conduct and reporting of OoSRs.
- However, more research is needed to understand which technique would be most useful and easiest to understand

Thank you