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ORIGINAL ARTICLE – CANCER RESEARCH

An overview on the methodological and reporting quality of dose–response meta-analysis on cancer prevention

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Abstract

Background Dose–response meta-analysis (DRMA) has been widely used in exploring cancer risk factors. Understanding the quality of published DRMAs on cancer risk factors may be beneficial for informed prevention for cancer.

Methods We searched eligible DRMAs from 1st January 2011 to 31st-July-2017. The modified AMSTAR 1.0 (15 items) and PRISMA checklist (26 items) were used to evaluate the methodological and reporting quality of included DRMAs. We compared the adherence rate of these items by journal type, publication years, region, and funding information, in prior.

Results We included 260 DRMAs. Colorectal, breast, prostate, and lung were the four most commonly investigated cancers. For methodological quality, 6 out of 15 items were adhered by less than 30% of the DRMAs, 2 by less than 60%, only 7 of which by 80% or more. For reporting quality, 3 out of 26 items were adhered by less than 30% of the DRMAs, 1 by less than 80% (> 30%), and 20 of which by 80% or more. Those published in general journal, published more recently, and received any financial support have better methodological (Rate differences, RDs = 10–36%; $P < 0.05$) and reporting adherence (RDs = 12–36%; $P < 0.05$). DRMAs by Asian author tend to be less qualified than by European and American.

Conclusions The methodological quality of DRMAs on cancer risk factors is worrisome that the findings of them may be deflective; more efforts are needed to improve the validity of it.

Keywords Cancer prevention · Dose–response meta-analysis · Methodological quality · Reporting quality

Introduction

Cancer is a major non-communicable diseases of malignant condition that affects 24.6 million people worldwide (Ferlay et al. 2015). As a leading cause of death, it accounts for 8.7 million death annually according to the estimation of

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Global Disease Burden 2015 (GBD 2015 Risk Factors Collaborators 2016). The number of cancer cases has increased 33% during the past 10 years and the globally burden by cancer continues to grow over time (Fitzmaurice et al. 2017).

An increasing body of evidence from epidemiological studies has attempted to find out potential risk factors and its causal connection for cancer development to achieve a better cancer prevention. Dose–response relationship is one of the key components for the establishment of this relationship (Berlin et al. 1993). It allows investigators to determine whether there are different effects for presence and absence of exposure as well as whether the effects vary according to doses of exposure for a certain outcome. Dose–response meta-analysis (DRMA) is currently the most comprehensive way to detect the potential dose–response relationship (Orsini et al. 2012; Xu and Doi 2018). In a DRMA, exposure (e.g., smoking) was treated as dependent variable, while the outcome (e.g., risk of cancer) was treated as independent variable, and then, a linear or non-linear regression was established between them under the "one-stage" (based on multilevel regression) or "two-stage" (multivariate meta-analysis) framework (Xu and Doi 2018; Xu et al. 2019a).

In the past decades, DRMA is increasingly employed in cancer epidemiological studies and the evidences from DRMAs were widely used in clinical guidelines for cancer prevention [e.g., the EAU guideline for prostate cancer (Mottet et al. 2017) and the SEOM Clinical Guideline for bladder cancer (Lazaro et al. 2016)]. However, the qualities of these DRMAs were not well understood (Xu et al. 2018, 2019b). The previous literature has highlighted the importance of the quality of systematic reviews and meta-analyses for clinical guideline development and healthcare decision (Page et al. 2016). Understanding the overall quality of these DRMAs would benefit for the informed decision and cancer prevention practice. Unfortunately, there was currently no research which investigated the quality of these studies.

In this study, we conducted a comprehensive survey on DRMAs of cancer risk factors which aimed to outline the quality of them.

Materials and methods

The current study was based on a comprehensive survey that examined epidemiological characteristics, methodological, and reporting quality of published DRMAs, which has been illustrated elsewhere (Xu et al. 2018, 2019b).

Eligibility criteria

We included published dose–response meta-analyses of cancer (or tumor) risk factors of aggregate data. We defined dose–response meta-analysis (DRMA) as a special type of meta-analysis that combines the dose–response relationship (dose ≥ two categories) between exposure and outcome from similar studies (Bagnardi et al. 2004; Liu et al. 2009; Orsini et al. 2012; Xu and Doi 2018). DRMA with outcomes as any cancer or tumor will be eligible for this study. We did not include conference abstracts, brief reports, and research letters, because these reports generally contain insufficient information regarding study design, conduction, and reporting.

Search strategy and literature search

We searched Medline, Embase, and Wiley online Library for DRMAs published from 1st January 2011 to 31st July 2017 using a pre-developed search strategy (Online Appendix 1). The primary literature search was conducted in 31 Dec 2015 and it was updated in 1st Aug 2017. This period was employed because of the limited DRMAs published before 2011. We defined the term "published" as an article with formal volume, issue, and page number. Search strategy and literature search were conducted by one experienced author (XC).

Literature screen

Two qualified investigators (XC and LY) conducted the literature screen independently. We first removed the duplicates through reference management software (Endnote X7). We then viewed titles and abstracts to exclude records obviously not met the criteria. Finally, the full texts of the remaining literatures were examined for the final decision. Any disagreement was solved by consensus.

Data extraction

The basic information of eligible DRMAs was extracted. These include the year of publish, name of the first author, region of the first author, number of authors, cancer or tumor site, databases source and number, design of source study (e.g., cohort, case–control), number of studies included, funding information, and journal information. Two authors extracted the information and a third author checked it.

Quality assessment

We used two different tools: a measurement tool to assess systematic reviews (AMSTAR) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), to assess the methodological and reporting quality of the eligible DRMAs, respectively (Moher et al. 2010; Shea et al. 2007, 2017). These two instruments were wildly used in such type of studies and have been proved to be valid for the assessment of quality.

Because AMSTAR and PRISMA were primary developed for standardization of the design and conduct of general meta-analysis, we did some minor changes of them to make the items be more suitable for DRMA. For AMSTAR, some items were split as they generally contain two methodological issues. They were "*Was there duplicate study selection and data extraction?*", "*Was a comprehensive literature search performed?*", "*Was a list of studies (included and excluded) provided?*", and "*Was the scientific quality of the included studies assessed and documented?"*. For example, the original item "*Was there duplicate study selection and data extraction?*" clarified the process of study selection and data extraction, after our modification, it split into two —*"was there duplicate study selection?" and "was there duplicate data extraction?"*. For PRIMSA, we removed the item "structured abstract", since many academic journals have its fixed abstract format. In addition, we changed the term "meta-analysis" into "dose–response meta-analysis" for all of related items. Finally, there were 15 items for modified AMSTAR and 26 items for modified PRISMA (Table S1).

Towards each item, we defined three response options, say, "Yes", "No", and "Unclear". We selected "Yes" for each item if it met the requirement and 1 score was assigned; Otherwise, "No" or "Unclear" options would be selected (0 score was assigned) according to the description of the context (Vaughn et al. 2018). It is notable that "Unclear" can possibly be positive response and negative response, though the previous evidence showed that most of the situation were negative (Schulz et al. 1995); this may underpowered of the positive rate.

Two investigators (XC and LY) with deep understanding on DRMA assessed the methodological and reporting quality separately through the Excel 2010 software (Microsoft, USA). One investigate (XC) was the co-primary developer of the robust error meta-regression method for dose–response meta-analysis (REMR model), a "one-stage" approach for combining dose–response data (Xu and Doi 2018); another investigator has 3 years' experience on practice of DRMA.

Statistical analysis

Baseline information (i.e., cancer and tumor site, publication year, number of authors, database searched, number of studies included, region of the first author, and funding information) was illustrated by descriptive statistics, which refers to the median value (first quartile to third quartile) and percentage.

The adherence rate and corresponding 95% confidence interval of each methodological and reporting item was estimated to reflect the extent of adhering of these items. The adherence rate was calculated by the following formula:

$$\text{Adherance rate} = \frac{\text{number of DRMAs meet the item}}{\text{total number of DRMAs}} \times 100\%.$$

Considering that the methodological and reporting quality may influenced by journal, publication time, region, and funding status, we compared the adherence rate of journal type (general journal versus specialist journal), publication years (2015 and after versus before 2015), region (Asian versus European/America), and funding (yes versus not) through two-tailed *t* test in prior. Rate difference (RD) was used to measure the absolute discrepancy.

All the statistical analyses were conducted in Stata/SE 14.0 (STATA, College Station, TX, Serial number: 10699393), with P value < 0.05 as statistically significant.

Results

We originally retrieved 7061 records and after the screen process, 529 of which were identified as potential dose–response meta-analysis (DRMA). We further separated 260 eligible DRMAs of cancer (or tumor) risk factors (Fig. 1).

Baseline characteristics

The 260 DRMAs were published in 87 difference academic journals, with 69 (26.54%) published in general journals, while 191 (73.46%) in specialist journals. The number of DRMAs increased by years, 126 (48.43%) of which published from 2011 to 2014 and 134 (51.54%) published from 2015 to 2017 (up to July 30 2017). There were 148 (56.92%) DRMAs who received financial support and 30 (11.54%) did not and 82 (31.54%) did not report the financial information.

For these DRMAs, the median number of authors was 6 [first and third quartiles (Q1, Q3): 4–8], the median number of databases searched was 2 (Q1, Q3: 2 to 3), and the median number of studies included was 15 (Q1, Q3: 11 to 24). Authors from Asia contributed the majority of the DRMAs ($n = 186$, 70.99%). Cohort study ($n = 128$, 49.23%) was the most common type of study included and very few DRMAs included case–control study ($n = 6$, 2.31%) solely.

More than 16 types of cancers (or tumor) were identified. Digestive cancer was the most commonly one by sites ($n = 90$, 34.62%). For single cancer type, colorectal cancer ($n = 40$, 15.38%), breast cancer ($n = 41$, 15.77%), prostate cancer ($n = 27$, 10.38%), and lung cancer ($n = 16$, 6.15%) were the four most commonly cancers. There was only one study with outcome as tumor (uterine leiomyoma), while other 259 were cancer. Table 1 presents the detailed baseline information.

Adherence of methodological quality items

For the adherence of methodological tips by AMSTAR (Fig. 2), 6 (40%) out of 15 items were adhered by less

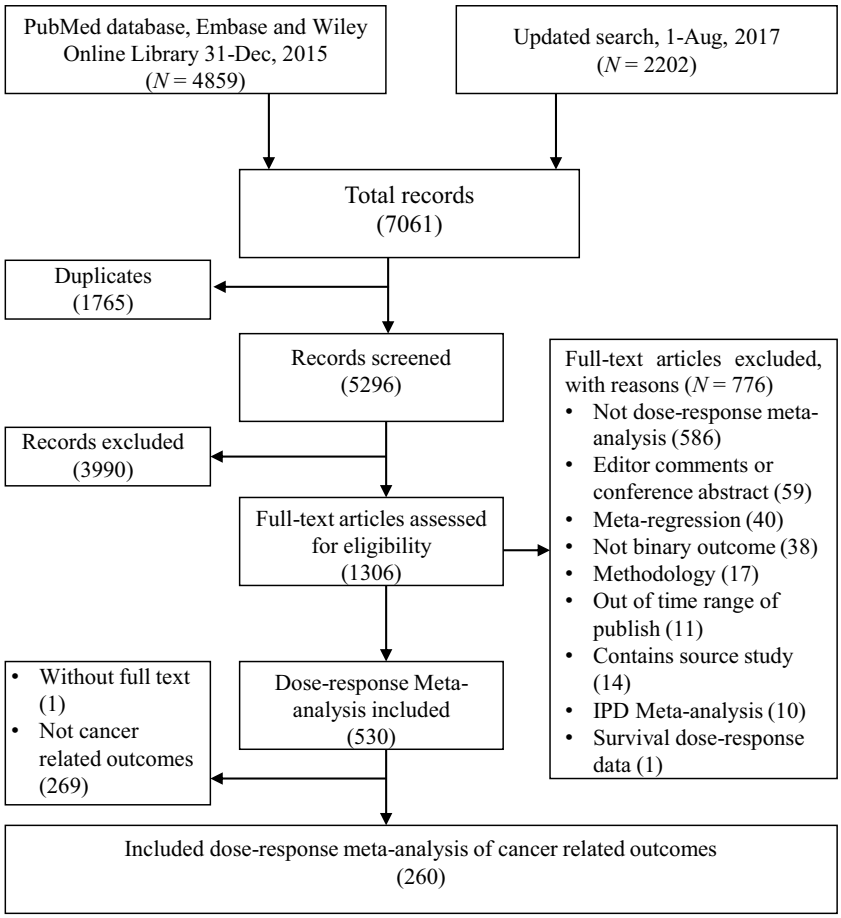

Fig. 1 The flowchart (Xu et al. 2018). This indicates the process of literature screen, with a total of 260 eligible DRMAs included

than 30% of the DRMAs, they were: provision of priori design [Item 1 ($n = 27$, 10.38%)], documentation of search strategy [Item 5 ($n = 48$, 18.64%)], use of publication status (grey literature) as inclusion criterion [Item 6 ($n = 55$, 21.15%)], documentation of excluded studies [Item 8 ($n = 43$, 16.54%)], documentation of scientific quality [Item 11 ($n = 65$, 25.00%)], and appropriately use of scientific quality for conclusions [Item 12 ($n = 27$, 10.38%)].

Two (13.33%) out of fifteen items were adhered by less than 80% (> 30%) DRMAs; they were: duplicate study selection [Item 2 ($n = 109$, 41.92%)] and scientific quality assessment [Item 10 ($n = 135$, 51.92%)].

There were 7 (46.67%) items were adhered by 80% or more of the DRMAs: duplicate data extraction [Item 3 ($n = 209$, 80.38%)], search of at least two databases [Item 4 ($n = 220$, 84.62%)], presentation of a list of included studies [Item 7 (n = 248, 95.38%)], presentation of characteristics of included studies [Item 9 ($n = 255$, 98.08%)], use of appropriate synthesis methods [Item 13 ($n = 233$, 89.62%)], assessment of publication bias [Item 14 ($n = 249$, 95.77%)], and statement of conflict of interest [Item 15 ($n = 232$, 89.23%)].

Adherence of reporting quality items

Amongst the 26 items, 3 (11.54%) were adhered by less than 30% of the DRMAs, they were: provision of review protocol [Item 4 ($n = 27$, 10.38%)], presentation of full search strategy [Item 7 ($n = 57$, 21.92%)], and presentation of process for selecting studies [Item 8 ($n = 46$, 17.69%)] (Fig. 3).

Three (11.54%) out of twenty-six items were adhered by less than 80% (> 30%) DRMAs, which include: presentation of the methods for risk of bias [Item 11 ($n = 135$, 51.92%)], presentation of the results of risk of bias [Item 18 ($n = 128$, 49.23%)], and clarification of the funding information [Item 26 ($n = 178$, 68.46%)].

There were 20 items (76.92%) which were adhered by 80% or more of the DRMAs. They were: identification of dose–response meta-analysis on the title [Item 1 ($n = 255$, 98.08%)], presentation of the rationale of the review [Item 2 ($n = 252$ 96.92%)], presentation of the explicit objective [Item 3 ($n = 260$, 100%)], development of the eligibility criteria [Item 5 ($n = 256$, 98.46%)], explication of the database source [Item 6 ($n = 258$, 99.23%)], presentation of the data extraction method [Item 9 ($n = 216$, 83.08%)], description of

Table 1 Baseline characteristics of DRMAs of cancer-related outcomes

Category by items	All publications ($N=260$)
Cancer and tumor site	
All cancer types ($n=25$)	21 (8.08%)
Digestive system ($n = 90$)	
Colorectal cancer	40 (15.38%)
Esophageal cancer	10 (3.85%)
Gastric cancer	11 (4.23%)
Liver cancer	12 (4.62%)
Pancreatic cancer	12 (4.62%)
Other digestive cancers	5 (1.92%)
Urinary system ($n=43$)	
Prostate cancer	27 (10.38%)
Bladder cancer	10 (3.85%)
Renal cancer	5 (1.92%)
Other urologic cancers	1 (0.38%)
Female and reproductive system ($n=62$)	
Endometrial cancer	13 (5.00%)
Breast cancer	41 (15.77%)
Ovarian cancer	7 (2.69%)
Uterine leiomyoma (tumor)	1 (0.38%)
Respiratory system ($n = 16$)	
Lung cancer	16 (6.15%)
Hemic and lymphatic system ($n=8$)	
Leukemia and lymphoma	8 (3.08%)
Head and neck cancers ($n=9$)	
Thyroid cancer	4 (1.54%)
Nasopharyngeal cancer	2 (0.77%)
Oropharyngeal cancer	1 (0.38%)
Laryngeal cancer	1 (0.38%)
Brain cancers	1 (0.38%)
Others ($n=7$)	7 (2.69%)
No. of authors [median (first and third quartiles)]	6 (4–8)
≤ 4	80 (30.77%)
5–8	141 (54.23%)
>8	39 (15.00%)
Year of publish	
2011–2014	126 (48.46%)
2015–2017 (up to July 30 2017)	134 (51.54%)
Journal information	
General journal	69 (26.54%)
Specialist journal	191 (73.46%)
Databases searched [median (first and third quartiles)]	2 (2 to 3)
≤ 1	42 (16.16%)
2–3	178 (68.46%)
>3	40 (15.38%)
Design of source study	
Cohort	128 (49.23%)
Case–control	6 (2.31%)
Mixed (cohort, case–control, and cross-sectional)	126 (48.46%)
No. of included studies [median (first and third quartiles)]	15 (11–24)
≤ 10	57 (21.92%)
11–24	143 (55.00%)

Table 1 (continued)

Category by items	All publications ($N=260$)
> 24	60 (23.08%)
Region	
Asian (Eastern)	186 (71.54 %)
European	55 (21.15%)
American (North)	19 (7.31%)
Funding	
Yes	148 (56.92%)
No	30 (11.54%)
Not reported	82 (31.54%)

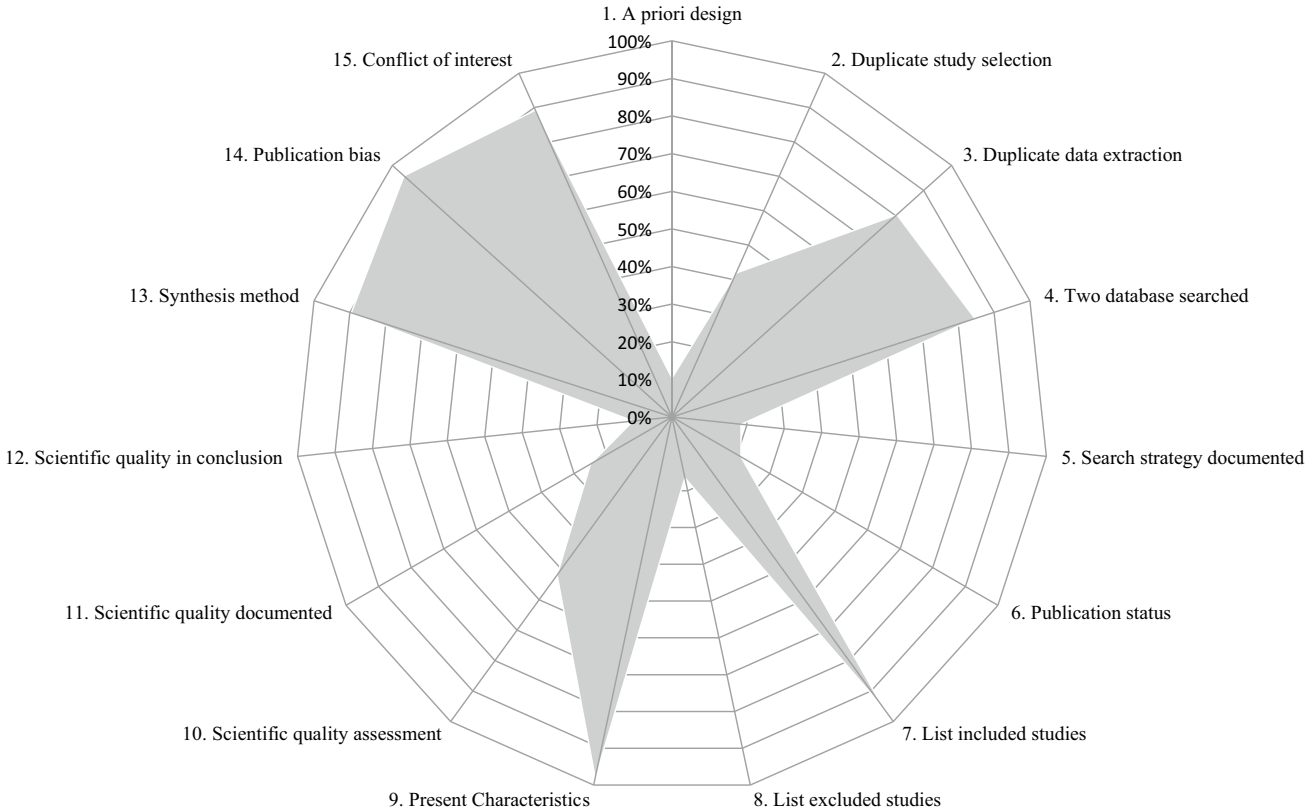

Fig. 2 The adherence of methodological items based on modified AMSTAR. Each spoke represents one of the items, and the blue area represents the adherence rate of each item

data assumption [Item 10 ($n=239$, 91.92%)], definition of summary measures [Item 12 ($n=210$, 80.77%)], description of data pooling method [Item 13 ($n=258$, 99.23%)], description method of publication bias detection [Item 14 ($n=252$, 96.92%)], description of method for additional analysis [Item 15 ($n=251$, 96.54%)], presentation of flow diagram [Item 16 ($n=245$, 94.23%)], presentation of baseline characteristics [Item 17 ($n=255$, 98.08%)], presentation of summarized dose–response results [Item 19 ($n=252$, 96.92%)], provision of forest plot [Item 20 ($n=260$, 100%)], presentation of the results of publication bias [Item 21 ($n=248$, 95.38%)], presentation of the results of additional analysis [Item 22 ($n=254$, 97.69%)], summarization of main findings [Item 23 ($n=254$, 97.69%)], discussion of limitations [Item 24 ($n=248$, 95.38%)], and presentation of general interpretation [Item 25 ($n=226$, 86.96%)].

Comparison

We compared the adherence rate of methodological and reporting items by journal type, publication year, region, and funding information. Our results showed that, compared

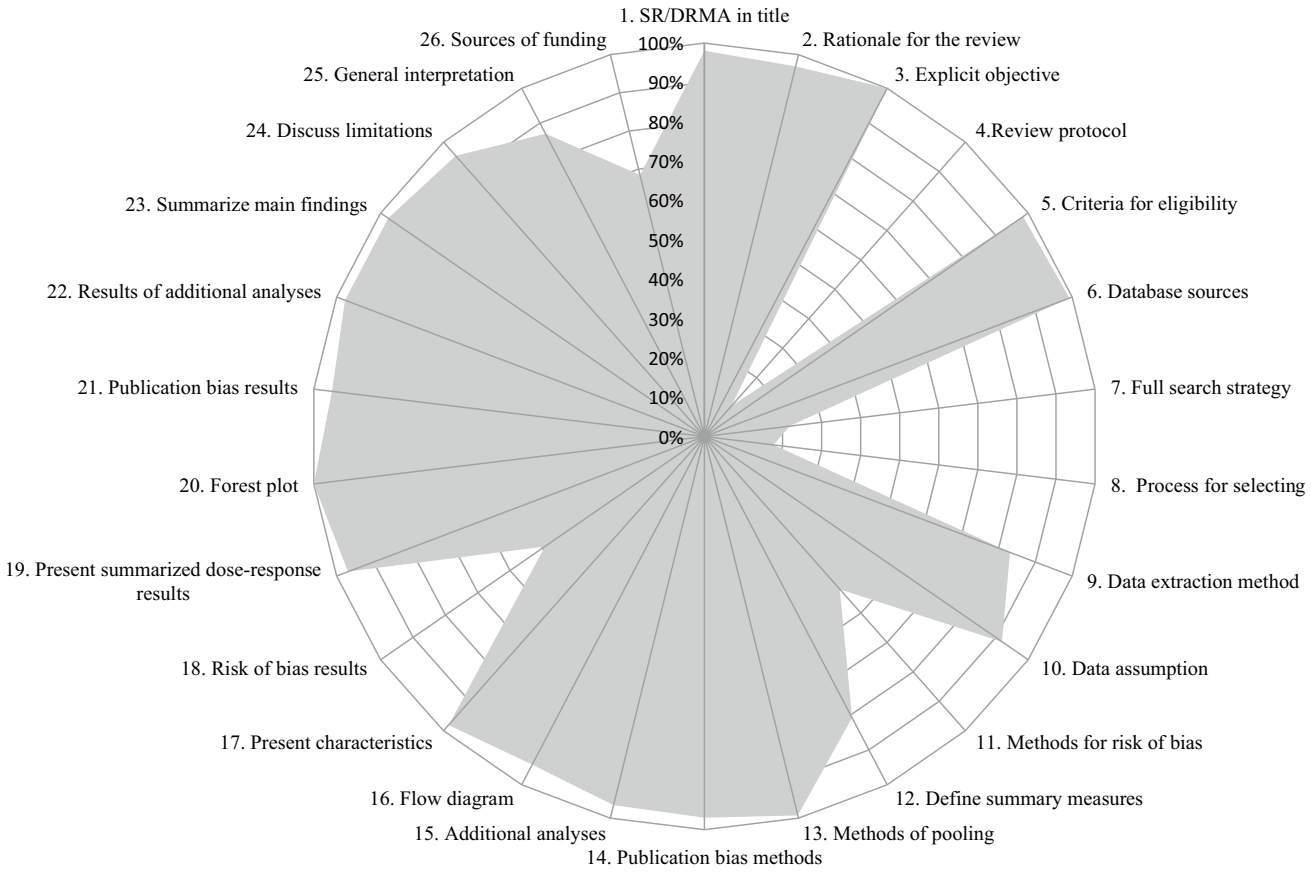

Fig. 3 The adherence of reporting items based on the modified PRISMA. Each spoke represents one of the items and the blue area represents the adherence rate of each item

to specialist journal, general journal has a significant higher adherence rate [(rate differences, RDs = 13–18%; P < 0.05)] on 3 out of the 15 methodological items and 3 out of the 26 reporting items (RDs = 17–26%; $P < 0.05$) (see Table 2). For publication year, the results showed that, compared to DRMAs published before 2015, those published in 2015 or after have a significant higher adherence rate on 6 out of the 15 methodological items (RDs = 10–40%; $P < 0.05$) and 7 out of the 26 reporting items (RDs = 4–41%); however, for the item of "A priori design", DRMAs published in 2015 and after have a significant lower adherence rate to those published before 2015 (RD = − 0.08; 95%CI: − 0.15, − 0.00) (Table 3). For DRMAs by Asian authors, 4 out of the 15 methodological items were worse complied than those by European/America (RDs = − 20 to − 37%; $P < 0.05$), while 3 item was better complied (RD = 12–31%; $P < 0.05$); for reporting, 5 out of 26 were worse complied (RDs = − 4 to − 49%; $P < 0.05$), while 4 were better complied (RDs = 15–33%; $P < 0.05$) (Table S2). For DRMAs received and not revived the financial support, 2 out of the 15 methodological items were better complied than those funded (RDs = 14–19%; $P < 0.05$); for reporting, 2 out of 26 were better complied (RDs = 14–24%; $P < 0.05$), while 2 were worse complied (RDs = − 6 to − 7%; $P < 0.05$) (Table S3).

Discussion

In the current study, we conducted a comprehensive survey on the methodological and reporting quality of the published dose–response meta-analyses (DRMA) of cancer risk factors from 2011 to 2017. We observed that more than half of the methodology items were under complied, while most of the reporting items were well complied. Our further comparison suggested that, for DRMAs of cancer risk factors, those published in general journal have better methodological and reporting adherence than those in specialist journal, those published in 2015 and after generally were better adhered on methodology and reporting than those before 2015, and those by Asian authors generally have worse methodological quality than those by European/American. We did not observe substantial differences on the quality for those received financial support to those not.

Table 2 Complied rate differences between DRMA published in general and specialist journals

Methodological items	General journal	Specialist journal	Rate difference	*P* value
1. A priori design	6/69	21/191	−0.02 (−0.10 to 0.06)	0.573
2. Duplicate study selection	34/69	75/191	0.10 (−0.04 to 0.24)	0.152
3. Duplicate data extraction	58/69	151/191	0.05 (−0.05 to 0.15)	0.345
4. Two databases searched	65/69	155/191	**0.13 (0.05 to 0.21)**	**0.001**
5. Search strategy documented	11/69	37/191	−0.03 (−0.14 to 0.07)	0.514
6. Publication status	11/69	44/191	−0.07 (−0.18 to 0.03)	0.185
7. List included studies	68/69	180/191	0.04 (−0.00 to 0.09)	0.052
8. List excluded studies	11/69	32/191	−0.01 (−0.11 to 0.09)	0.875
9. Present characteristics	69/69	186/191	0.03 (−0.00 to 0.06)	0.099
10. Scientific quality assessment	45/69	90/191	**0.18 (0.05 to 0.31)**	**0.008**
11. Scientific quality documented	23/69	42/191	0.11 (−0.01 to 0.24)	0.077
12. Scientific quality in conclusion	7/69	20/191	−0.00 (−0.09 to 0.08)	0.939
13. Synthesis method	61/69	172/191	−0.02 (−0.10 to 0.07)	0.710
14. Publication bias	67/69	182/191	0.02 (−0.03 to 0.07)	0.474
15. Conflict of interest	68/69	164/191	**0.13 (0.07 to 0.18)**	**0.000**
Reporting items				
1. SR/DRMA in title	68/69	187/191	0.01 (−0.03 to 0.04)	0.716
2. Rationale for the review	66/69	186/191	−0.02 (−0.07 to 0.04)	0.524
3. Explicit objective	69/69	191/191	0.00 (−0.02 to 0.02)	1.000
4. Review protocol	6/69	21/191	−0.02 (−0.10 to 0.06)	0.573
5. Criteria for eligibility	68/69	188/191	0.00 (−0.03 to 0.03)	0.943
6. Database sources	68/69	190/191	−0.01 (−0.04 to 0.02)	0.545
7. Full search strategy	10/69	47/191	−0.10 (−0.20 to 0.00)	0.055
8. Process for selecting	18/69	28/191	0.11 (−0.00 to 0.23)	0.052
9. Data extraction method	61/69	155/191	0.07 (−0.02 to 0.17)	0.129
10. Data assumption	65/69	174/191	0.03 (−0.04 to 0.10)	0.373
11. Methods for risk of bias	46/69	89/191	**0.20 (0.07 to 0.33)**	**0.003**
12. Define summary measures	56/69	154/191	0.01 (−0.10 to 0.11)	0.923
13. Methods of pooling	68/69	190/191	−0.01 (−0.04 to 0.02)	0.545
14. Publication bias methods	67/69	185/191	0.00 (−0.04 to 0.05)	0.919
15. Additional analyses	68/69	183/191	0.03 (−0.01 to 0.07)	0.180
16. Flow diagram	67/69	178/191	0.04 (−0.01 to 0.09)	0.151
17. Present characteristics	69/69	186/191	0.03 (−0.00 to 0.06)	0.099
18. Risk of bias results	47/69	81/191	**0.26 (0.13 to 0.39)**	**0.000**
19. Present summarized dose–response results	68/69	184/191	0.02 (−0.02 to 0.06)	0.263
20. Forest plot	69/69	191/191	0.00 (−0.02 to 0.02)	1.000
21. Publication bias results	67/69	181/191	0.02 (−0.03 to 0.07)	0.366
22. Results of additional analyses	68/69	186/191	0.01 (−0.02 to 0.05)	0.527
23. Summarize main findings	68/69	186/191	0.01 (−0.02 to 0.05)	0.527
24. Discuss limitations	68/69	180/191	0.04 (−0.00 to 0.09)	0.052
25. General interpretation	69/69	191/191	0.00 (−0.02 to 0.02)	1.000
26. Sources of funding	56/69	122/191	**0.17 (0.06 to 0.29)**	**0.003**

Rate difference was the absolute difference of the adherence rate of the two groups, and the statistical inference was conducted by *t* test. Those in bold were statistically significant

Our survey suggested that, for the methodological quality, the following items were of greatest concern: provision of priori design, documentation of search strategy, use of publication status (grey literature) as inclusion criterion, documentation of excluded studies, documentation of scientific quality, appropriately use of scientific quality for conclusions, duplicate study selection, and scientific quality assessment. Indeed, these items were of the most important

Table 3 Complied rate differences between DRMA published over time (years)

Methodological items	2015 and later	Before 2015	Rate difference	*P* value
1. A priori design	9/134	18/126	**−0.08 (−0.15 to −0.00)**	**0.046**
2. Duplicate study selection	62/134	47/126	0.09 (−0.03 to 0.21)	0.141
3. Duplicate data extraction	117/134	92/126	**0.14 (0.05 to 0.24)**	**0.003**
4. Two databases searched	120/134	100/126	**0.10 (0.01 to 0.19)**	**0.023**
5. Search strategy documented	26/134	22/126	0.02 (−0.07 to 0.11)	0.686
6. Publication status	27/134	28/126	−0.02 (−0.12 to 0.08)	0.683
7. List included studies	128/134	119/126	0.01 (−0.04 to 0.06)	0.691
8. List excluded studies	17/134	26/126	−0.08 (−0.17 to 0.01)	0.085
9. Present characteristics	131/134	123/126	0.00 (−0.04 to 0.04)	0.939
10. Scientific quality assessment	95/134	39/126	**0.40 (0.29 to 0.51)**	**0.000**
11. Scientific quality documented	50/134	15/126	**0.25 (0.15 to 0.35)**	**0.000**
12. Scientific quality in conclusion	21/134	6/126	**0.11 (0.04 to 0.18)**	**0.003**
13. Synthesis method	113/134	119/126	**−0.10 (−0.17 to −0.03)**	**0.007**
14. Publication bias	128/134	120/126	0.00 (−0.05 to 0.05)	0.913
15. Conflict of interest	127/134	104/126	**0.12 (0.05 to 0.20)**	**0.002**
Reporting items				
1. SR/DRMA in title	133/134	121/126	0.03 (−0.00 to 0.07)	0.088
2. Rationale for the review	129/134	122/126	−0.01 (−0.05 to 0.04)	0.806
3. Explicit objective	134/134	125/126	0.01 (−0.01 to 0.03)	0.471
4. Review protocol	9/134	18/126	**−0.08 (−0.15 to −0.00)**	**0.046**
5. Criteria for eligibility	134/134	121/126	**0.04 (0.00 to 0.08)**	**0.036**
6. Database sources	134/134	123/126	0.02 (−0.01 to 0.05)	0.126
7. Full search strategy	31/134	26/126	0.02 (−0.08 to 0.13)	0.626
8. Process for selecting	27/134	19/126	0.05 (−0.04 to 0.14)	0.282
9. Data extraction method	120/134	96/126	**0.13 (0.04 to 0.22)**	**0.004**
10. Data assumption	120/134	118/126	−0.04 (−0.11 to 0.03)	0.231
11. Methods for risk of bias	94/134	40/126	**0.38 (0.27 to 0.50)**	**0.000**
12. Define summary measures	121/134	89/126	**0.20 (0.10 to 0.29)**	**0.000**
13. Methods of pooling	134/134	123/126	0.02 (−0.01 to 0.05)	0.126
14. Publication bias methods	130/134	121/126	0.01 (−0.03 to 0.05)	0.666
15. Additional analyses	131/134	119/126	0.03 (−0.01 to 0.08)	0.168
16. Flow diagram	130/134	114/126	**0.07 (0.01 to 0.12)**	**0.029**
17. Present characteristics	130/134	124/126	−0.01 (−0.05 to 0.02)	0.448
18. Risk of bias results	92/134	35/126	**0.41 (0.30 to 0.52)**	**0.000**
19. Present summarized dose–response results	131/134	120/126	0.03 (−0.02 to 0.07)	0.270
20. Forest plot	134/134	125/126	0.01 (−0.01 to 0.03)	0.471
21. Publication bias results	128/134	119/126	0.01 (−0.04 to 0.06)	0.691
22. Results of additional analyses	131/134	122/126	0.01 (−0.03 to 0.05)	0.643
23. Summarize main findings	128/134	125/126	−0.04 (−0.08 to 0.00)	0.059
24. Discuss limitations	131/134	116/126	**0.06 (0.00 to 0.11)**	**0.037**
25. General interpretation	134/134	125/126	0.01 (−0.01 to 0.03)	0.471
26. Sources of funding	94/134	83/126	0.04 (−0.07 to 0.16)	0.460

Rate difference was the absolute difference of the adherence rate of the two groups, and the statistical inference was conducted by *t* test. Those in bold were statistically significant

tips for performing a well-designed and conducted meta-analysis. We even observed that more than 10% of the DRMAs may employ a wrong synthesis method. These findings suggested that the internal validity of these DRMAs was suboptimal and likely to be poor and the evidence from them may be substantially biased by systematic errors.

Our findings suggested that the reporting of DRMAs of cancer risk factors was of informative. In our survey, the

reporting quality of these DRMAs was generally good that 70% of the items were sufficiently reported by 80% or more DRMAs. However, some information was still insufficiently reported, mainly focused on the literature search, study selection, risk of bias assessment, and funding information. Further studies should take more attention on reporting of this information.

In our study, colorectal cancer, breast cancer, prostate cancer, and lung cancer were the four most commonly cancers focused by DRMAs. Indeed, these four cancers were the most prevalent cancer types for male or females worldwide; that lung cancer and prostate cancer were the most and second most frequently diagnosed cancers for male, while breast cancer and colorectal cancer were the most and second most frequently diagnosed cancers for female (Torre et al. 2015, 2016). We found that the first author of these DRMAs was from three regions: Asia, Europe, and the America. Similarly, this may be due to the high cancer incidence and mortality of the three regions. According to the cancer statistics 2012 (Torre et al. 2015), the age-standardized cancer incidence was 225.4 for Eastern Asia, 344.2 for North America, and 260.0 ~ 343.7 for Europe, among every 100,000 people. The previous literature has demonstrated that the high incidence cancer rate was closely linked with several established factors such as the aging population, smoking, overweight, and physical inactivity (Torre et al. 2015). In addition, the smoking prevalence is particularly high in southwest China (Anderson Johnson et al. 2006). Due to the limited number of DRMAs of each types of cancer, we did not summarize and compare the quality. However, this is worth to be conducted in further overviews.

DRMA is the major and most credible tool for investigating the potential risk factors for diseases. Establishing high-quality evidence on the relationship of potential risk factors and cancer has been an imperative task for global cancer prevention. In this study, we investigated the methodological and reporting quality of DRMAs on cancer risk factors which may helpful for further evidence production and utilization for a better cancer prevention. To the best of our knowledge, this is the first study taken a comprehensive survey and evaluation on the methodological and reporting quality of meta-analysis on cancer risk factors. We included almost the entire sample of DRMAs related to cancer risk factors published during the past 7 years; the representativeness of current survey is expected to be sufficient. We employed a rigorous design, conduction, quality assessment, and analysis of the data to make the results more credible.

There are three limitations of our study. First, we used AMSTAR (Shea et al. 2007) and PRISMA (Moher et al. 2010) to assess the methodological and reporting quality of our included studies; the internal validity of our research largely relies on the validity of the two instruments. Though these checklists used widely, some additional quality domains reflecting methodology and reporting of DRMA may still be missed (Burda et al. 2016; Moher et al. 2010). In addition, our quality assessment was based on the documented context of the meta-analysis, how the author drafted the context may have substantial impact on our results (Jia et al. 2018). Moreover, we did not summarize the overall quality, because the weight of each item is unclear. However, it may be sufficient enough to reflect the quality by adherence of each item instead of the overall quality score.

In conclusion, based on our systematic survey, the methodological quality of DRMAs of cancer risk factors is worrisome, but the reporting is generally good. DRMAs published in general journals, published more recently, and conducted by European and American authors have a better methodological and reporting quality. Though these DRMAs were informative, the results of them may be deflective. Substantial efforts are needed to improve it.

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Data availability The primary data can be obtained from the data owners (X.C).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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