Dhaka Univ. J. Sci. 69(3): 143-148, 2022 (June)
Centennial Special Issue

ISSN 1022 - 2502, E-ISSN 2408-8528
DOI: https://doi.org/10.3329/dujs.v69i3.60023

The Benefits of Green-Space Exposure on Fifteen Health Outcomes: A Meta-Analysis

Md. Hasibul Islam and Md. Belal Hossain*

Department of Statistics, University of Dhaka, Dhaka 1000, Bangladesh

(Received : 18 October 2021 ; Accepted: 14 February 2022)

Abstract

The main objective of this research is to quantify evidence of the impact of green-space on fifteen health outcomes. Four databases-MEDLINE, EMBASE, AMED and CINAHL from January, 2000 to June, 2019 were searched. In this meta-analysis 63 observational studies were included for the investigation where 15 health outcomes (e.g., Type-2 Diabetes, Incidence of Hypertension, Incidence of Asthma, Stroke, Preterm Birth, Cardiovascular Mortality, All-cause Mortality, Salivary Cortisol and self-identified well-being etc) are considered. Our meta-analysis results revealed increased green-space exposure is associated with decreased heart rate (standardized mean difference (SMD)=−0.67), salivary cortisol (SMD = −0.31), along withreduced risk of preterm birth (OR = 0.87), type II diabetes (OR =0.76), hypertension (OR =0.77), coronary heart disease (OR = 0.85), all-cause mortality (OR = 0.69), cardiovascular mortality (OR =0.82), and an increased incidence of self-identified well-being (OR =1.15). Green-space exposure is found to be connected with the above mentioned health outcomes.

Keywords: Green-space exposure, Health outcomes,Odds ratio, Standardized mean difference, Random effects model, Meta-analysis

I. Introduction

The benefits of green-space exposures on health have demanded the attention of ecologists, scientists, doctors and policy makers. In Centers for Disease Control, 2013 the term green-space (GS) is considered as an open, undeveloped area with natural greenery[1]. GS can also be found asparks, rooftop gardens and road side trees[2]. Health outcome terms were defined accordingly with help of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) produced by the World Health Organization[3].

The annual prevalence of mental illness in Bangladesh is soaring, with conditions such as depression affecting approximately one in 20 of the world's population; particularly the first national survey on mental health in Bangladesh conducted between 2003 and 2005 documented a terrible scenario[4]. In this survey, depression was found in 4.6% (about 5 million) among the adult population of Bangladesh[4]. Both of these negative health issues are penance of modern lifestyles in a more and more urbanized world. As a result, it has become extremely important to better understand the factors of urban health in today's urbanized world.

Nonetheless over the pastfew years, there has been an increasing appreciation of the possible worth of green-space interventions. It is hoped that some of the mental health problems that arise in today's society and physical health challenges resulting from modern diets and sedentary lifestyles can be improved through numerous physical activities undertaken in green environments. Research related to urban green-space has increased rapidly, particularly with respect to its possible health benefits together with approaches to optimizing them. It is a reality that all the studies have not found exactly same results.In recent years, increasing evidence shows the substantial health benefits of green-spaces in cities. For instance, green spaces have been found to be associated with lower mortality[5, 6] and morbidity[7].

Even though there is a lot of research trying to explore and determine the links between green space and better health, systematic reviews and meta-analysis in this area have broadly demonstrated on the association between green-space and a specific health outcome[2] or habit for example, mortality[6],obesity[8], birth weight[9], physical wellbeing[10] along with crucial benefits of limited exposure to green-space on health[11]. Researchers have found that physical activity in green-spaces is linked to adecrease"negative emotions" and "fatigue", increasedenergy[10,11], improved attention, in addition better satisfaction, enjoyment and a greater intent to repeat the activity[11]. Moreover, other meta-analyses have shown significant relationship with increased residential green-space and reduced cardiovascular and all-cause mortality[9], and increased birth weight[9]. But the fact is that there are a very few meta-analysis that have attempted to determine the impact of green-space on these fifteen selected health outcomes under the same umbrella. There is still scope of further research in Bangladesh on how green-space exposure is connected with good health and well-being through meta-analysis on these selected health outcomes.

In this paper we conduct a meta-analysis to identify and quantify the evidence of the impact of green-space on fifteen selected health outcomes such as Type-2 Diabetes, Incidence of Hypertension, Systolic Blood Pressure, Diastolic Blood Pressure, Incidence of Asthma, Stroke, Preterm Birth, Heart Rate, Gestational Age, Coronary Heart Disease, Cardiovascular Mortality, All-cause Mortality, Salivary Cortisol and self-identified well-being.

*Author for correspondence. e-mail: bjoardar2003@yahoo.com

II. Data and Variables

Important electronic databases including MEDLINE, EMBASE, AMED, and CINAHL were searched. The search was conducted to include studies published from January, 2000 to June, 2019. "Databases were selected to best represent source materials in health, allied health and human science". Besides, "reference lists from included studies and previous systematic reviews on green-space and health related outcomes were also hand searched".

Search Strategy

Search items related with green-space are consideredin accordance tothe article of Lachowycz and Jones, 2011 on green-space exposure and obesity[8]."The search strategy identified studies that contained at least one keyword or Medical Subject Heading (MeSH) from each list of search terms". Besides, the search was piloted to ensure known studies are identified and search terms are adapted. The search strategy also has assimilated only to studies conducted on "humans", studies written in "English" and studies published from January 2000 to June, 2019.

Inclusion criteria

"All empirical studies where the outcome could be directly attributable to green-space were included". Participants: Male and female, no age restrictions, Intervention: Exposure to green-space, Outcomes**:** Fifteen selected health outcomes.

Exclusion Criteria

Studies are excluded "that do not look at empirical evidence, do not use human participants, studies where BMI/mental health/communicable disease/birth weight are the only outcome(s) or the study does not report a health outcome, papers and documents that are not written in English". A complete flowchart of search strategy and the study selection process is shown in Fig. 1.

III. Statistical Analysis

This meta-analysis is carried out using Statistical environment R (meta package) and Microsoft Excel spreadsheet for data input. Pooled odds ratio (OR) for binary health outcomes and weighted standardized mean difference (SMD) for continuous outcomes and their 95% confidence interval are estimated by random effects model[12]. Random effects model has been used in this analysis because there exists heterogeneity[12]. Q statistic is calculated to find the presence of heterogeneity among the studies, τ^2 is calculated to find between study variance and I^2 is calculated to quantify the percentage of variation among the included studies[13]. Funnel plot is used in this meta-analysis to check publication bias among the included studies[14].

IV. Results and Discussion

In this meta-analysis 63 observational studies were included for the investigation where 15 health outcomes are considered. Here, two separate summary meta-analyses have been discussed using ORs (Table 1) and SMDs (Table 2) for binary and continuous outcomes respectively. Overall situations of heterogeneity as well as its underlying causes have also been shown. Whilst previous meta-analyses have examined the relationship between green-space and specific health outcomes or behaviors, this meta-analysis has demonstrated the possible influence of green-space on fifteen selected health outcomes including "Type-2 Diabetes", "Incidence of Hypertension", "Systolic Blood Pressure", "Diastolic Blood Pressure", "Incidence of Asthma", "Stroke", "Preterm Birth", "Heart Rate", "Gestational Age", "Coronary Heart Disease", "Cardiovascular Mortality", "All-cause Mortality", "Salivary Cortisol" and "self-identified well-being". During extracting data from various papers for meta-analysis, "high" and "low" green-space exposure was considered based on the highest and lowest exposure categories provided in each paper. These were usually the "highest" or the "lowest quartile" or "quintile" of exposure.Above mentioned 15 different health outcomes are considered for meta-analysis. Statistically significant relationships between "high" versus "low" green-space exposure group have been found for "Type-2 Diabetes", "Preterm Birth", "Coronary Heart Disease", "Cardiovascular Mortality", "Self-identified well-being", "All-cause Mortality", "Heart Rate" and "Salivary Cortisol". With the exposure of high green-space, reductions are also found for "Hypertension", "Incidence of Stroke" and "Incidence of Asthma" as well as improvements in "Systolic Blood Pressure", "Diastolic Blood Pressure" and "Gestational Age". These findings are statistically insignificant. We have found zero heterogeneity only for the variable Gestational Age. Besides, one analysis reports low heterogeneity (i.e. 28% for 'Salivary Cortisol') and seven studies are found to have substantial heterogeneity (>70%). Substantial heterogeneity between studies are found for incidence of stroke, cardiovascular mortality, small size for gestational age, self-identified well-being, all-cause mortality, heart rate, and diastolic blood pressure. The rest six analyses are found to report heterogeneity between 60%–70%. This high heterogeneity can be interpreted as the consequence of the high level of inclusivity. In this meta-analysis, studies are not excluded based on study design or type of the green-space. Hence a variety of green-space exposures and health outcomes are found by the 63 included studies which entails higher amount of between study heterogeneity.

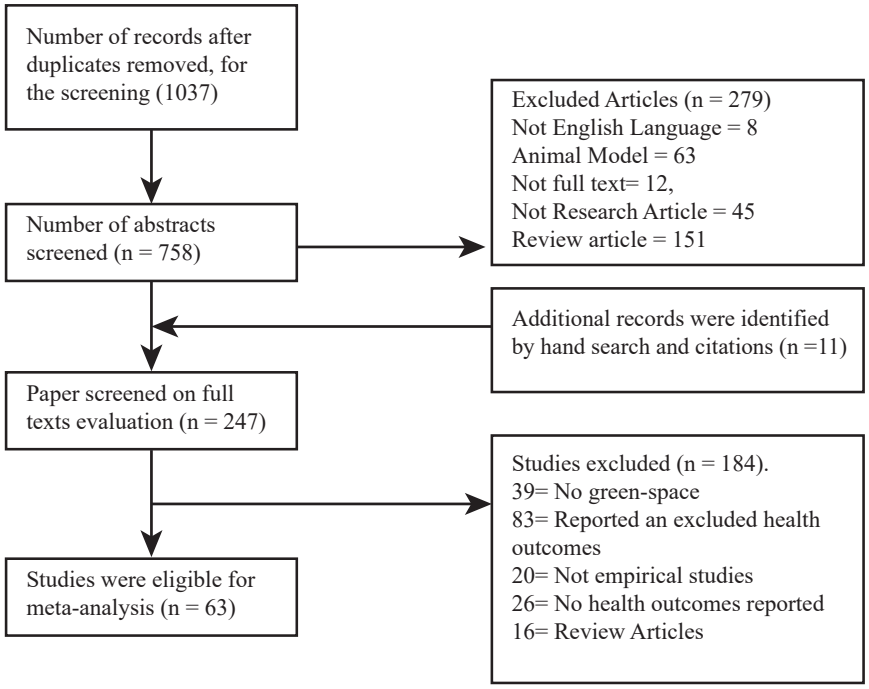

Fig.1. Flowchart of search strategy and the study selection process

Table 1. Summary meta-analysis table (ORs)

"Health Outcomes"	N (Participants)	OR(95% CI)	I^2	p-value
Type-2 Diabetes	8 (629481)	0.76 [0.69, 0.84]	63%	0.01
Hypertension	6 (173824)	0.77 [0.77, 1.00]	63%	0.05
Preterm Birth	6 (1593471)	0.87 [0.80, 0.94]	68%	< 0.01
Stroke	5 (431232)	0.80 [0.58, 1.11]	84%	0.18
Asthma	4 (5324)	0.99 [0.72, 1.37]	67%	0.96
CHD*	4 (431670)	0.85 [0.73, 0.98]	68%	0.02
Cardiovascular Mortality	4 (4175748)	0.82 [0.75, 0.90]	81%	< 0.01
SGES*	4 (1576253)	0.79 [0.69, 0.90]	91%	< 0.01
Self-identified well-being	8 (22572501)	1.15 [0.96, 1.39]	92%	0.14
All-cause Mortality	4 (4000975)	0.69 [0.55, 0.87]	96%	< 0.01

*CHD= Coronary Heart Disease, SGES= Small Size for Gestational Age

Table 2. Summary meta-analysis table (SMDs)

"Health Outcomes"	N(Participants)	SMD (95% CI)	I^2	p-value
SBP*	10 (7267)	-0.11 [-0.22, 0.00]	61%	0.05
DBP*	10 (7267)	-0.14 [-0.27, 0.00]	74%	0.05
Heart Rate	10 (1020)	-0.67 [-1.12,-0.23]	87%	< 0.01
Gestational Age	3 (22908)	-0.00 [-0.03, 0.03]	0%	0/97
Salivary Cortisol	5 (770)	-0.31 [-0.54,-0.08]	28%	< 0.01

*SBP=Systolic Blood Pressure, DBP= Diastolic Blood Pressure

Our meta-analyses have found statistically significant relationships between green-space exposure and the incidences of "type-2 diabetes"(OR 0.76; 95% CI: 0.69, 0.84), "coronary heart disease" (OR 0.85; 95% CI: 0.73, 0.98), "cardiovascular mortality"(OR 0.82; 95% CI: 0.75, 0.90), all-cause "mortality" (OR 0.69; 95% CI: 0.55, 0.87),"salivary cortisol" (SMD −0.06; 95% CI −0.07, −0.04), "heart rate"(SMD −3.47; 95% CI −4.04, −2.90), as well as pregnancy outcomes "preterm birth"(OR 0.87; 95% CI: 0.80, 0.94), and "small size for gestational age"(OR 0.79; 95% CI: 0.69, 0.90). A significant increase in self-identified well-being is also found OR 1.15; 95% CI: 0.96, 1.39). Some of the meta-analyses results had high levels of heterogeneity and should therefore be interpreted these with caution. Our findings are consistent with previous meta-analyses results that suggest that green-space exposure is beneficial for health[2,11]. However our meta-analysis results are different from other meta-analyses in terms of degree of association but similar in the direction of the association.It suggests that our findings are consistent with other research on the topic. Another issue of meta-analysis- publication bias is also checked using funnel plots for all the analysis we have carried out. Funnels plot in Fig. 4. for 'Type-2 Diabetes Outcome' doesn't provide strong evidence in favor of the presence of publication bias whereas funnel plot for 'Heart Rate' provides evidence in favor of the existence of publication bias.

One of the strengths of this meta-analysis is- all the studies are selected based on the checklist of Lachowycz and Jones (2018)[8]. This meta-analysis has thoroughly searched out studies demonstrating the relation between green-space and the selected fifteen above mentioned health outcomes.

One of the limitations of this meta-analysis is- the search was restricted to "manuscripts" published only in the "English language". In addition, meta-analyses regarding to several health outcomes have been investigated with a very little number of studies due to scarcity, limiting comparability of results. There exists a huge difference among the study populations; the largest study consists of above 63 million populations and the smallest study consists of 9 participants only.

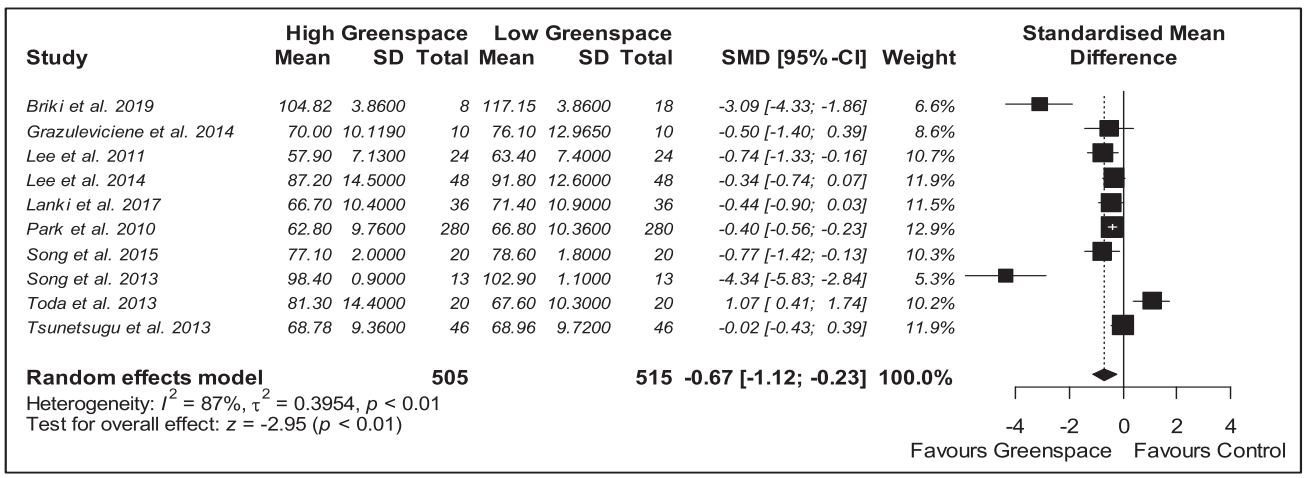

Fig. 2. Forest plot for 'Type-2 Diabetes Outcome' shows that odds of having type-2 diabetes is 24% lower in the experimental group (High GS) comparing to the controlled group (Low GS).

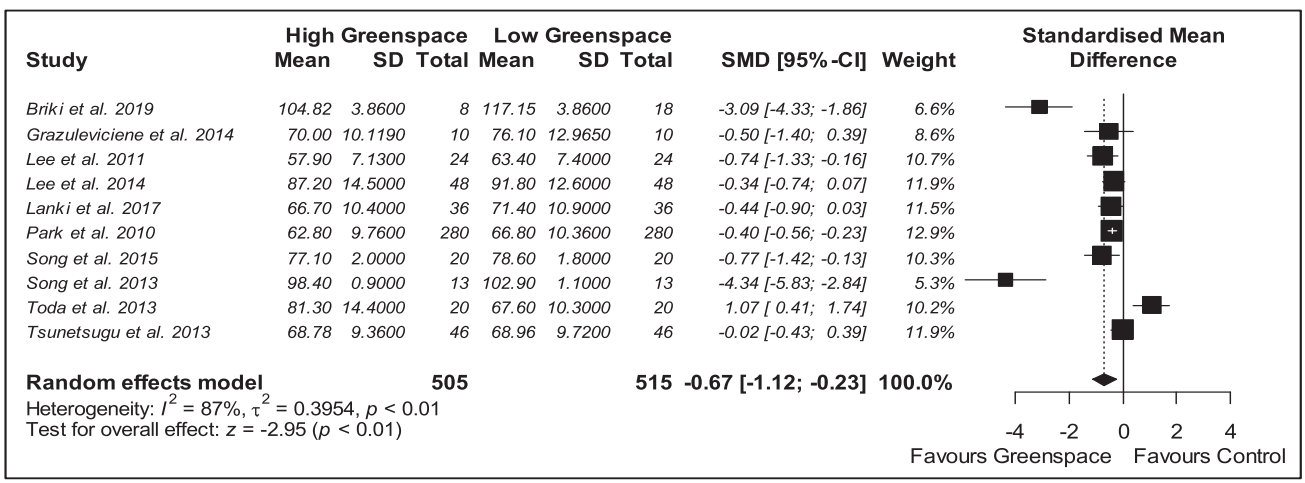

Fig. 3. Forest plot for 'Heart Rate' shows that heart rate in the 'High GS' group is 0.67 bpm lower than the 'Low GS' group on an average.

The findings of this meta-analysis suggest that green-space is beneficial for health. Currently, green-space may not be properly valued as a resource for health. There is a considerable gap in understanding how the relationship between green-space and health works.

Although this meta-analysis has revealed findings on the relationship between green-space and health, there is a lack of research on how this relationship works. It is also challenging to make understand the common people how green-space can be beneficial to health. Moreover, population growth and development authorities possess the real risk to green-space and hence health. Therefore further research is needed on this topic specially when green-spaces are reducing rapidly and deforestation is a direct consequence of the population growth and urbanization. The associations between green-space and mental health outcomes and communicable diseases, could also be explored.Furthermore, doctors can take into account these findings to suggest to patients, which may help improving the health inequalities between rich and poor.

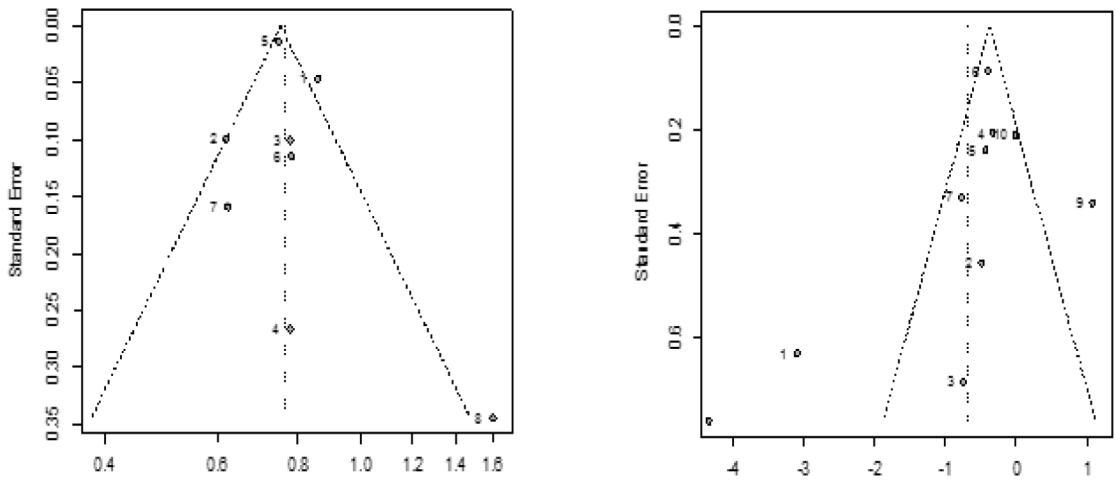

Fig. 4. Funnel plot on the left for 'Type-2 Diabetes Outcome' doesn't Provide strong evidence in favour of the presence of publication bias while funnel plot on the right for 'Heart Rate' provides evidence in favour of the presence of publication bias.

V. Conclusion

This meta-analysis concludes that green-space exposure is related with the fifteen health outcomes. Meta-analyses results of this study are showing statistically significant associations with reduced heart rate, salivary cortisol, coronary heart disease, incidence of type-2 diabetes and stroke, all-cause and cardiovascular mortality. This study also suggests beneficial associations with pregnancy outcomes and self-identified well-being. Though, some meta-analyses results have become weak by significant heterogeneity, not good study quality and publication bias, therefore special attention is needed for interpretation. The findings of this meta-analysis obviously make a sign that the preservation of existing green-spaces, plantation of trees in open unused spaces, rooftop gardens and street greenery should be treated as an effective intervention for the improvement of health.

Online Supplement: Forest plots of 15 health outcomes.

References

1. Centers for Disease Control, 2013. Public Health Terms for Planners & Planning Terms for Public Health Professionals. Available: ⟨https://www.cdc.gov/healthyplaces/ terminology.htm⟩.

2. Twohig-Bennett, C., and A. Jones, 2018. The health benefits of the great outdoors: A systematic review and meta-analysis of green space exposure and health outcomes. *Environmental Research***166**, 628–637.

3. Centers for Disease Control and Prevention. 2015. International Classification of Diseases,Tenth Revision (ICD-10). https://www.cdc.gov/nchs/icd/icd10.htm.

4. WHO-AIMS Report On Mental Health System in Bangladesh 2007. https://apps.who.int/iris/handle/10665/206149.

5. Hu Z, Liebens J, Rao KR. 2008. Linking stroke mortality with air pollution, income, and greenness in northwest Florida: an ecological geographical study. *Int. J. Health Geogr*. **7**: 20.

6. Gascon, M, Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A. 2016. Residential green spaces and mortality: a systematic review. *Environ. Int.***86**, 60–67.

7. Maas, J, Verheij, R.A., Groenewegen, P.P.,Vries, S.D.; Spreeuwenberg, P. 2006. Green space, urbanity, and health: How strong is the relation? *J. Epidemiol. Community Health,***60**, 587–592.

8. Lachowycz, M, and A.P. Jones, 2011.Greenspace and obesity: a systematic review of the evidence.*Obes. Rev.*, **12**, 183-189.

9. Dzhambov, AM, Dimitrova, D.D., and E.D.Dimitrakova, 2014. Association between residential greenness and birth weight: systematic review and meta-analysis. *UrbanFor. Urban Green.***13**, 621–629.

10. Thompson Coon JB, K., Stein, K., Whear, R., Barton, J., and M.H. Depledge, 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environ. Sci. Technol.* **45**, 1761–1772.

11. Bowler, DE, Buyung-Ali, L.M., Knight, T.M., and A.S. Pullin, 2010. A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health.***10**, 456.

12. DerSimonian, R and N. Laird,1986. Meta-analysis in clinical trials. *ContrClin Trials*. **7(3)**, 177–88.https://doi.org/10.1016/0197-2456(86)90046-2.

13. Higgins, J P T and S.G. Thompson ,2002. Quantifying heterogeneity in a meta-analysis. *J Stat Med***21(11)**, 1539–58. https://doi.org/10.1002/sim.1186.

14. Sutton, AJ, Abrams K.R., Jones D.R., Sheldon T.A. and F. Song, 2000. Methods for meta-analysis inmedical research. Chichester, West Sussex, P019 IUD, England: John Wiley &Sons,LTD, Baffins Lane.