

Pneumonia

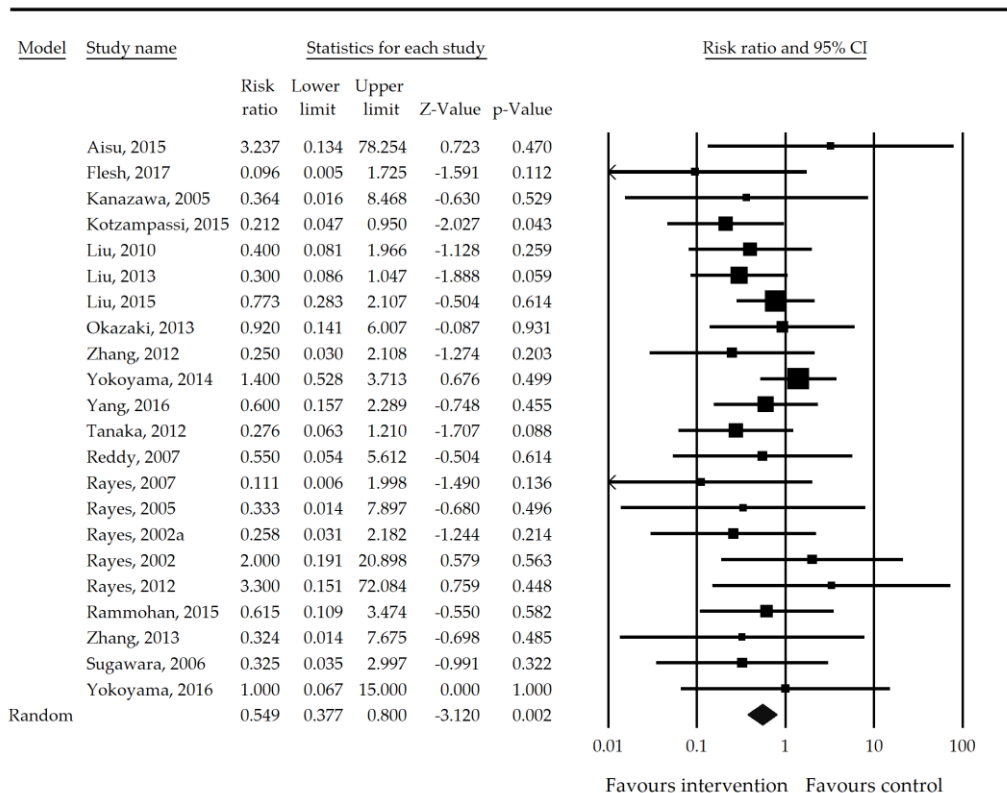


Figure S1. The effect size (risk ratio) for the overall effects of probiotics in the prevention of pneumonia.

SSI

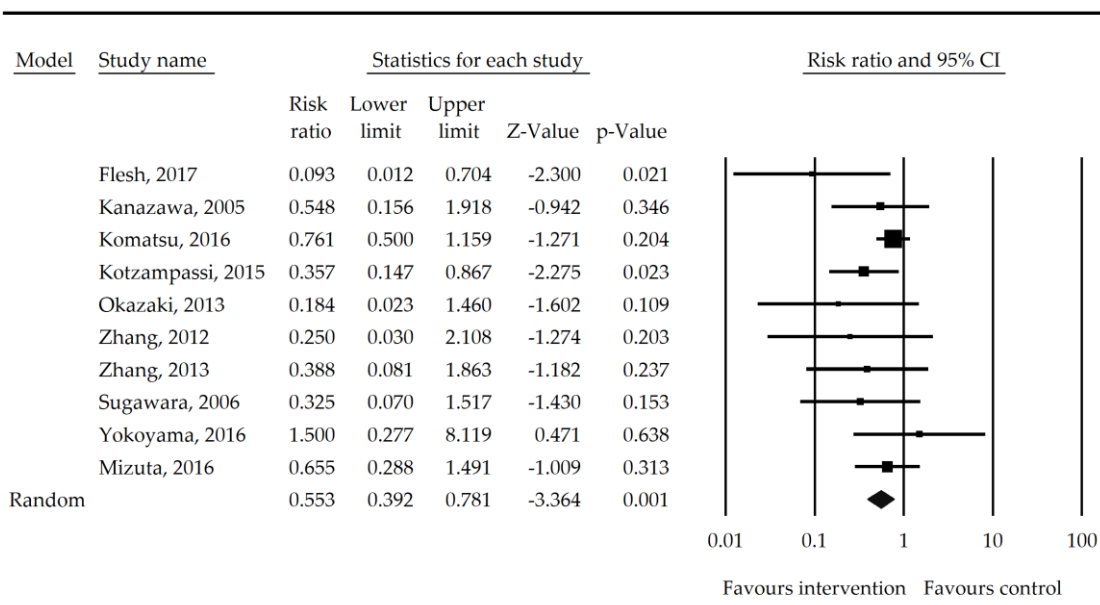


Figure S2. The effect size (risk ratio) for the overall effects of probiotics in the prevention of surgical site infection.

Table S1. The efficacy of probiotics to counteract surgery related complications (SRCs).

Outcome	RR (95% CI)	Z-value	References	Heterogeneity	Tau	Intercept (95%CI)†	Meta-regression coefficients
Abdominal distention	0.64 (0.47, 0.86)	-2.93 p=0.003	Liu, 2010 Liu, 2015 Yang, 2016 Zhang, 2013	Q=0.247 p=0.970 (df=3) I ² =0	$\tau^2=0$ $\tau=0$	-0.47 (-2.07, 1.13) p=0.334	Dose: -0.03 (p=0.820) Intervention (Synbiotic vs. Probiotic): -0.29 (p=0.672) Operation (Hepatobiliary vs. Gut): -0.29 (p=0.672) ROB (Low vs. High): -0.29 (p=0.672) Duration: 0.01 (p=0.855) Timing (Post vs. Peri) : -0.29 (p=0.672)
Anastomotic leakage	0.73 (0.43, 1.24)	-1.17 p=0.244	Komatsu, 2016 Kotzampassi, 2015 Zhang, 2012 Yokoyama, 2014 Yang, 2016 Tanaka, 2012 Sadahiro, 2014 Rayes, 2007 Mizuta, 2016	Q=8.31 p=0.404 (df=8) I ² =3.69	$\tau^2=0.027$ $\tau=0.163$	-1.38 (-2.97, 0.22) p=0.080	Dose: 0.27 (p=0.484) Intervention (Synbiotic vs. Probiotic): 0.95 (p=0.082) Operation (Hepatobiliary vs. Gut): 0.11 (p=0.899) ROB (Low vs. High): -0.29 (p=0.640) Duration: 0.01 (p=0.889) Timing (Pre vs. Peri): -1.32 (p=0.400)
Deep organ space	0.62 (0.31, 1.25)	-1.34 p=0.180	Aisu, 2015 Komatsu, 2016 Okazaki, 2013 Sadahiro, 2014 Mizuta, 2016	Q=0.553 p=0.968 (df=4) I ² =0	$\tau^2=0$ $\tau=0$	-1.83 (-2.85, -0.81) p=0.011	Dose: NOT ESTIMABLE Intervention (Synbiotic vs. Probiotic): -0.19 (p=0.799) Operation (Mixed vs. Gut): 0.78 (p=0.509) ROB (Low vs. High): -0.38 (p=0.598) Duration: 0.001 (p=0.992) Timing: NOT ESTIMABLE
Diarrhea	0.49 (0.37, 0.67)	-4.59 p=0.000004	Diepenhorst, 2011 Liu, 2010 Liu, 2013 Liu, 2015 Yang, 2016 Tanaka, 2012 Zhang, 2013	Q=3.61 p=0.730 (df=6) I ² =0	$\tau^2=0$ $\tau=0$	-0.27 (-1.92, 1.38) p=0.691	Dose: 0.05 (p=0.688) Intervention (Synbiotic vs. Probiotic): -0.29 (p=0.714) Operation (Hepatobiliary vs. Gut): -0.76 (p=0.438) ROB (Low vs. High): -0.32 (p=0.659) Duration: -0.09 (p=0.223) Timing (Post vs. Peri): 1.39 (p=0.250)
Intraabdominal abscess	0.69 (0.35, 1.37)	-1.07 p=0.285	Flesh, 2017 Kanazawa, 2005 Zhang, 2012 Yokoyama, 2014 Usami, 2011 Rayes, 2012 Sugawara, 2006 Yokoyama, 2016	Q=5.07 p=0.651 (df=7) I ² =0	$\tau^2=0$ $\tau=0$	0.31 (-1.97, 2.59) p=0.749	Dose: -0.004 (p=0.993) Intervention (Synbiotic vs. Probiotic): -1.17 (p=0.350) Operation (Hepatobiliary vs. Gut): -0.66 (p=0.457) ROB (Low vs. High): -0.82 (p=0.356) Duration: -0.04 (p=0.381) Timing (Post vs. Peri): -0.06 (p=0.952), (Pre vs. Peri): 1.24 (p=0.334)

Mortality	1.17 (0.54, 2.57)	0.40 p=0.691	Anderson, 2003 Eguchi, 2011 Mangell, 2012 McNaught, 2002 Nomura, 2007 Sommecal, 2015 Rayes, 2007	Q=7.54 p=0.274 (df=6) I ² =20.4	$\tau^2=0.226$ $\tau=0.476$	-2.03 (-4.15, 0.10) p=0.058	Dose: -1.10 (p=0.327) Intervention (Synbiotic vs. Probiotic): -0.31 (p=0.745) Operation (Hepatobiliary vs. Gut): -0.67 (p=0.487) ROB (Low vs. High): 0.54 (p=0.557) Duration: 0.20 (p=0.340) Timing: NOT ESTIMABLE
MRSA infection	0.34 (0.11, 1.06)	-1.87 p=0.062	Eguchi, 2011 Komatsu, 2016 Kotzampassi, 2015 Usami, 2011	Q=0.891 p=0.828 (df=3) I ² =0	$\tau^2=0$ $\tau=0$	-1.97 (-2.96, -0.97) p=0.014	Dose: NOT ESTIMABLE Intervention (Synbiotic vs. Probiotic): 0.09 (p=0.944) Operation (Hepatobiliary vs. Gut): -1.06 (p=0.402) ROB (Low vs. High): -1.02 (p=0.526) Duration: -0.08 (p=0.540) Timing: NOT ESTIMABLE
Peritonitis	0.34 (0.09, 1.32)	-1.56 p=0.119	Zhang, 2012 Rayes, 2007 Zhang, 2013 Grat, 2017	Q=1.75 p=0.625 (df=3) I ² =0	$\tau^2=0$ $\tau=0$	-3.67 (-21.8, 14.5) p=0.475	Dose: -0.57 (p=0.422) Intervention (Synbiotic vs. Probiotic): -1.67 (p=0.229) Operation (Hepatobiliary vs. Gut): -0.56 (p=0.699) ROB (Low vs. High): -1.67 (p=0.229) Duration: NOT ESTIMABLE Timing: NOT ESTIMABLE
Pneumonia	0.55 (0.38, 0.80)	-3.12 p=0.002	Aisu, 2015 Flesh, 2017 Kanazawa, 2005 Kotzampassi, 2015 Liu, 2010 Liu, 2013 Liu, 2015 Okazaki, 2013 Zhang, 2012 Yokoyama, 2014 Yang, 2016 Tanaka, 2012 Reddy, 2007 Rayes, 2007 Rayes, 2005 Rayes, 2002a Rayes, 2002 Rayes, 2012 Rammohan, 2015 Zhang, 2013 Sugawara, 2006 Yokoyama, 2016	Q=15.7 p=0.789 (df=21) I ² =0	$\tau^2=0$ $\tau=0$	-0.47 (-1.49, 0.56) p=0.355	Dose: 0.08 (p=0.665) Intervention (Synbiotic vs. Probiotic): 0.31 (p=0.422) Operation (Hepatobiliary vs. Gut): -0.19 (p=0.687), (Mixed vs. Gut): 0.84 (p=0.285) ROB (Low vs. High): -0.16 (p=0.687) Duration: 0.01 (p=0.775) Timing (Post vs. Peri): -0.14 (p=0.834), (Pre vs. Peri): -0.45 (p=0.583)
Reoperation	0.43 (0.14, 1.29)	-1.51 p=0.132	Komatsu, 2016 Mangell, 2012 Grat, 2017	Q=1.22 p=0.545 (df=2) I ² =0	$\tau^2=0$ $\tau=0$	0.57 (-28.5, 29.6) p=0.845	NOT ESTIMABLE

Sepsis	0.69 (0.58, 0.81)	-4.56 p=0.00001	Eguchi, 2011 Liu, 2013 Liu, 2015 Zhang, 2012 Rayes, 2007 Rayes, 2002 Rammohan, 2015	Q=5.43 p=0.491 (df=6) I ² =0	$\tau^2=0$ $\tau=0$	-0.97 (-1.67, -0.26) p=0.017	Dose: 0.55 (p=0.062) Intervention (Synbiotic vs. Probiotic): -1.12 (p=0.154) Operation (Hepatobiliary vs. Gut): -1.23 (p=0.168), (Mixed vs. Gut): -0.73 (p=0.650) ROB (Low vs. High): -1.12 (p=0.154) Duration: 0.12 (p=0.065) Timing (Post vs. Peri): -0.73 (p=0.650), (Pre vs. Peri): -1.71 (p=0.097)
SSI	0.55 (0.39, 0.78)	-3.36 p=0.001	Flesh, 2017 Kanazawa, 2005 Komatsu, 2016 Kotzampassi, 2015 Okazaki, 2013 Zhang, 2012 Zhang, 2013 Sugawara, 2006 Yokoyama, 2016 Mizuta, 2016	Q=9.77 p=0.369 (df=9) I ² =7.89	$\tau^2=0.027$ $\tau=0.163$	-1.24 (-2.37, -0.11) p=0.035	Dose: 0.40 (p=0.136) Intervention (Synbiotic vs. Probiotic): 0.22 (p=0.592) Operation (Hepatobiliary vs. Gut): 0.0001 (p=1.0), (Mixed vs. Gut): -1.09 (p=0.326) ROB (Low vs. High): -0.21 (p=0.582) Duration: -0.03 (p=0.403) Timing (Post vs. Peri): -0.06 (p=0.913), (Pre vs. Peri): -0.71 (p=0.537)
Superficial incisional	0.53 (0.38, 0.74)	-3.77 p=0.0002	Aisu, 2015 Komatsu, 2016 Liu, 2010 Liu, 2015 Okazaki, 2013 Yokoyama, 2014 Yang, 2016 Usami, 2011 Tanaka, 2012 Sadahiro, 2014 Reddy, 2007 Rayes, 2007 Rayes, 2005 Rammohan, 2015 Mizuta, 2016	Q=6.65 p=0.947 (df=14) I ² =0	$\tau^2=0$ $\tau=0$	-0.17 (-1.08, 0.75) p=0.703	Dose: 0.28 (p=0.240) Intervention (Synbiotic vs. Probiotic): 0.14 (p=0.670) Operation (Hepatobiliary vs. Gut): -0.19 (p=0.674), (Mixed vs. Gut): -1.44 (p=0.335) ROB (Low vs. High): -0.2603 (p=0.441) Duration: -0.03 (p=0.338) Timing (Post vs. Peri): -0.46 (p=0.778), (Pre vs. Peri): 0.33 (p=0.706)
UTI	0.32 (0.18, 0.57)	-3.89 p=0.0001	Aisu, 2015 Eguchi, 2011 Kotzampassi, 2015 Liu, 2010 Liu, 2013 Liu, 2015 Okazaki, 2013 Yang, 2016 Rayes, 2007 Rayes, 2005 Rayes, 2002a Rayes, 2002 Rammohan, 2015 Zhang, 2013	Q=9.51 p=0.734 (df=13) I ² =0	$\tau^2=0$ $\tau=0$	-0.17 (-1.84, 1.51) p=0.832	Dose: -0.53 (p=0.104) Intervention (Synbiotic vs. Probiotic): -0.22 (p=0.722) Operation (Hepatobiliary vs. Gut): -0.48 (p=0.454), (Mixed vs. Gut): 1.01 (p=0.399) ROB (Low vs. High): -0.19 (p=0.746) Duration: -0.17 (p=0.071) Timing (Post vs. Peri): -0.27 (p=0.700)

† Egger's regression intercept test for asymmetry of the funnel plots; Dose – dose of probiotic (log), ROB – risk of bias, Post – post operation, Pre – pre operation, Peri – peri operation, SSI- surgical site infection

Outcome	SMD (95%CI)	Z-value	References	Heterogeneity	Tau	Intercept (95%CI)†	Meta-regression coefficients
Blood loss	0.004 (-0.120, 0.128)	0.059 p=0.953	Komatsu, 2016 Liu, 2010 Liu, 2015 Yang, 2016 Sadahiro, 2014 Rammohan, 2015 Sugawara, 2006	Q=3.15 p=0.789 (df=6) I ² =0	$\tau^2=0$ $\tau=0$	-0.43 (-2.92, 2.06) p=0.675	Dose: -0.04 (p=0.642) Intervention (Synbiotic vs. Probiotic): -0.01 (p=0.922) Operation (Hepatobiliary vs. Gut): 0.16 (p=0.373) ROB (Low vs. High): -0.16 (p=0.373) Duration: -0.02 (p=0.135) Timing: NOT ESTIMABLE
Duration of antibiotic therapy	-0.60 (-1.09, -0.10)	-2.36 p=0.018	Kanazawa, 2005 Liu, 2010 Liu, 2013 Liu, 2015 Yang, 2016 Tanaka, 2012 Sommacal, 2015 Rayes, 2002a Zhang, 2013 Sugawara, 2006	Q=102 p<0.00001 (df=9) I ² =91	$\tau^2=0.575$ $\tau=0.758$	-4.91 (-15.57, 5.74) p=0.319	Dose: -0.16 (p=0.514) Intervention (Synbiotic vs. Probiotic) : -0.66 (p=0.212) Operation (Hepatobiliary vs. Gut): -0.86 (p=0.085) ROB (Low vs. High): -0.50 (p=0.342) Duration: 0.08 (p=0.085) Timing (Post vs. Peri): -0.95 (p=0.083)
Duration of postoperative pyrexia	-0.44 (-0.68, -0.192)	-3.50 p=0.0005	Liu, 2010 Liu, 2013 Liu, 2015 Yang, 2016	Q=4.85 p=0.183 (df=3) I ² =38.1	$\tau^2=0.024$ $\tau=0.154$	2.90 (-15.65, 21.46) p=0.570	Dose: -0.17 (p=0.072) Intervention: NOT ESTIMABLE Operation: NOT ESTIMABLE ROB: NOT ESTIMABLE Duration: -0.13 (p=0.072) Timing: NOT ESTIMABLE
Fluid diet	-0.35 (-0.58, -0.12)	-3.00 p=0.003	Liu, 2010 Liu, 2015 Yang, 2016	Q=1.31 p=0.520 (df=2) I ² =0	$\tau^2=0$ $\tau=0$	-0.06 (-52.91, 52.80) p=0.991	Dose: NOT ESTIMABLE Intervention: NOT ESTIMABLE Operation: NOT ESTIMABLE ROB: NOT ESTIMABLE Duration: NOT ESTIMABLE Timing: NOT ESTIMABLE
Hospital stay	-0.48 (-0.66, -0.30)	-5.17 p=0.0000002	Kanazawa, 2005 Kotzampassi, 2015 Liu, 2010 Liu, 2015 Zhang, 2012 Yang, 2016 Usami, 2011 Sommacal, 2015 Rayes, 2002a Zhang, 2013	Q=20.2 p=0.042 (df=11) I ² =45.7	$\tau^2=0.045$ $\tau=0.213$	0.60 (-3.87, 5.07) p=0.771	Dose: -0.03 (p=0.773) Intervention (Synbiotic vs. Probiotic): -0.25 (p=0.183) Operation (Hepatobiliary vs. Gut): -0.25 (p=0.183) ROB (Low vs. High): -0.002 (p=0.994) Duration: -0.005 (p=0.7434) Timing (Post vs. Peri): -0.10 (p=0.679), (Pre vs. Peri): -0.23 (p=0.551)

			Sugawara, 2006 Mizuta, 2016				
ICU stay	-0.10 (-0.36, 0.16)	-0.73 p=0.460	Kanazawa, 2005 Usami, 2011 Tanaka, 2012 Rayes, 2002a	Q=1.35 p=0.719 (df=3) I ² =0	$\tau^2=0$ $\tau=0$	3.23 (-19.10, 25.56) p=0.597	Dose: -0.05 (p=0.922) Intervention: NOT ESTIMABLE Operation (Hepatobiliary vs. Gut): 0.25 (p=0.406) ROB (Low vs. High): -0.28 (p=0.357) Duration: 0.009 (p=0.697) Timing (Post vs. Peri): -0.02 (p=0.944)
Operating time	0.02 (-0.14, 0.18)	0.26 p=0.797	Komatsu, 2016 Liu, 2010 Liu, 2013 Liu, 2015 Zhang, 2012 Yang, 2016 Sadahiro, 2014 Rayes, 2002a Zhang, 2013 Sugawara, 2006 Mizuta, 2016	Q=19.6 p=0.033 (df=10) I ² =49.0	$\tau^2=0.034$ $\tau=0.184$	0.20 (-3.07, 3.47) p=0.893	Dose: -0.06 (p=0.502) Intervention: -0.04 (p=0.820) Operation (Hepatobiliary vs. Gut): 0.06 (p=0.754) ROB (Low vs. High): 0.005 (p=0.979) Duration: -0.0006 (p=0.966) Timing (Post vs. Peri): 0.28 (p=0.248), (Pre vs. Peri): -0.15 (0.665)
Solid diet	-0.31 (-0.50, -0.12)	-3.26 p=0.001	Aisu, 2015 Liu, 2010 Liu, 2015 Yang, 2016	Q=1.97 p=0.578 (df=3) I ² =0	$\tau^2=0$ $\tau=0$	2.44 (-8.04, 12.93) p=0.422	Dose: NOT ESTIMABLE Intervention: NOT ESTIMABLE Operation: NOT ESTIMABLE ROB (Low vs. High): -0.26 (p=0.194) Duration: NOT ESTIMABLE Timing: NOT ESTIMABLE

† Egger's regression intercept test for asymmetry of the funnel plots; Dose – dose of probiotic (log), ROB – risk of bias, Post – post operation, Pre – pre operation, Peri – peri operation

Table S2. Risk of bias assesement.

Study reference	Publication year	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data addressed (attrition bias)	Selective reporting (reporting bias)	Other bias	No. of low assesments
Aisu	2015	H	H	H	H	L	L	?	2
Anderson	2003	L	L	L	L	L	?	?	5
Diepenhorst	2011	L	L	?	?	?	L	?	3
Eguchi	2011	?	?	?	?	L	?	?	1
Flesh	2017	L	H	L	H	?	H	?	2
Grą	2017	L	L	L	L	L	L	?	6
Horvat	2010	?	?	L	L	H	?	L	3
Kanazawa	2005	?	?	?	L	H	?	?	1
Komatsu	2016	L	L	H	H	L	L	L	5
kotzampassi	2015	?	L	L	L	L	L	H	5
Liu	2011	L	L	H	L	H	H	L	4
Liu	2013	L	L	L	L	H	?	L	5
Liu	2015	L	L	L	L	?	L	?	5
Mangell	2012	?	?	L	L	H	L	L	4
McNaught	2002	L	?	H	?	H	?	?	1
Mizuta	2016	L	H	?	?	L	?	?	2
Nomura	2007	?	?	?	?	L	?	?	1
Okazaki	2013	?	?	H	?	L	?	H	1
Rammohan	2015	L	H	H	H	L	L	?	3
Rayes	2007	?	?	L	L	H	H	?	2
Rayes	2005	?	?	L	L	L	H	?	3
Rayes	2002a	?	?	?	?	H	H	?	0
Rayes	2002	?	?	?	?	H	H	?	0
Rayes	2012	?	?	L	L	H	H	?	2

Reddy	2007	?	?	?	?	L	?	?	1
Sadahiro	2014	L	L	L	L	L	L	?	6
Sommacal	2015	L	L	L	L	L	L	L	7
Sugawara	2006	?	H	?	?	L	L	?	2
Tanaka	2012	L	H	H	H	L	L	?	3
Usami	2011	L	L	L	?	L	H	H	4
Yang	2016	L	L	L	L	H	L	?	5
Yokoyama	2014	L	L	H	L	L	L	H	5
Yokoyama	2016	L	H	H	H	L	?	?	2
Zhang	2012	?	L	L	L	L	?	L	5
Zhang	2013	H	H	H	H	L	L	?	2

L-low risk of bias, H-high risk of bias, ?-unclear risk of bias