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Hospitalising preterm infants in single family rooms versus open bay units: A systematic review and meta-analysis of impact on parents

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ABSTRACT

Background: Many parents develop stress-related symptoms and depression when their preterm infant is hospitalised in the neonatal intensive care unit (NICU) after birth. We reviewed the evidence of parent well-being with preterm infants hospitalised in single family rooms (SFRs) or in open bay neonatal units (OBUs).
Methods: For this systematic review and meta-analysis, we searched MEDLINE, EMBASE, PsycINFO, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, Clinicaltrials.gov, and International Clinical Trials Registry Platform (ICTRP) databases from inception through 22 November 2019 using controlled terms and text words related to prematurity and NICU-design. We included randomised and non-randomised studies comparing outcomes in parents with preterm infants admitted to SFRs or OBUs. Methodological quality was assessed using Cochrane Collaboration's Risk of Bias Tool for randomised controlled trials and the Risk of Bias Tool for Non-Randomised Studies of Interventions (ROBINS-I). Outcomes included: parental stress, satisfaction, participation (presence/involvement/skin-to-skin care), self-efficacy, parent-infant-bonding, depression, anxiety, post-traumatic stress, empowerment, and degree of family-centred care. Summary estimates were calculated using random effects models with standardised mean differences (SMDs). PROSPERO registration: CRD42016050643.
Findings: We identified 614 unique publications. Eleven study populations (1, 850 preterm infants, 1, 549 mothers and 379 fathers) were included. All but one study were at serious to critical risk of bias. SFRs were associated with higher levels of parental presence, involvement, and skin-to-skin care. Upon discharge, SFRs were associated with lower stress levels (n = 828 parents, SMD-0·30,95%CI -0·50;-0·09, p<0·004, I^2=46%), specifically NICU-related stress (n = 573, SMD-0·42,95%CI -0·61;-0·23, p<0·0001, I^2=0%). In majority of studies higher levels of empowerment, family-centred care, and satisfaction was present with SFRs. No differences were found for anxiety, parent-infant bonding, or self-efficacy. Depression was high (up to 29%) but not different between settings. No studies described post-traumatic stress.
Interpretation: Single family rooms seem to facilitate parental presence, involvement, skin-to-skin care, and reduce NICU-related parental stress.

Abbreviations: AA, at admission; BA, before-after study; BDI, Beck Depression Inventory; CI, confidence interval; EPDS, Edinburgh Postnatal Depression Scale; FCC, Family-Centred Care; FCCS, Family-Centred Care Survey; Mo, months; MPAS, Maternal Postnatal Attachment Scale; NA, not applicable; NICU, Neonatal Intensive Care Unit; NR, not reported; NRPI, non-randomised prospective intervention study; NRRI, non-randomised retrospective intervention study; OBU, Open Bay Unit; PES, Parent Expectations Scale; PG, Press Ganey NICU Survey; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analysis; PROSPERO, International Prospective Register of Systematic Reviews; PSI, Parental Stress Index; PSS-NICU, Parental Stressor Scale – NICU; RCT, Randomised Controlled Trial; RoB, Risk of Bias; ROBINS-I, Risk of Bias in Non-randomised Studies of Interventions; SMD, standardised mean difference; SD, standard deviation; SFR, Single Family Room; SPSQ, Swedish Parental Stress Index; STAI, State-Trait Anxiety Inventory; Wks, weeks

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1. Introduction

Every year, 14·9 million infants (approximately 11% of all live-births worldwide) are born preterm, and this number is rising [1]. After birth, preterm infants can spend a considerable amount of time in the neonatal intensive care unit (NICU) before discharge home. This period can be very stressful for parents [2]. Parental stress arising from the experience of the NICU is an important issue that potentially impacts parenting behaviour and long-term emotional and health problems in parents and their infants [3]. Currently, most preterm infants are hospitalised in open bay units (OBUs), with clusters of infants on the same ward and limited accommodations for parents to be present continuously with their infant. The physical setting of the OBU potentially limits the emotional and physical closeness between parents (or the actual caregivers) and their infant [4].

The recently published European Standards of Care for Newborn Health and the World Health Organisation Survive and Thrive report recommend to accommodate parents in skin-to-skin care (SSC), to actively welcome and engage parents in the care of their newborn, and to facilitate parental presence throughout the 24 h by an optimal design of the NICU [5–8].

More and more NICUs are building single family rooms (SFRs) to accommodate parents to be present continuously during the day and at night with their infant. A previous systematic review and meta-analysis showed lower incidences of sepsis and increased exclusive breastfeeding rates upon discharge and no difference in long-term neurodevelopment for preterm infants hospitalised in SFRs compared with OBUs [9]. Another systematic review showed parents to experience increased privacy and feeling like a family-unit in SFRs compared to OBUs [10]. However, the impact of SFRs on well-being of parents of preterm infants has not been assessed before.

In this systematic review and meta-analysis, we reviewed the evidence on whether the physical design of a NICU has an impact on the well-being of parents of preterm infants and their participation during infant hospital stay. We compared outcomes of parents of preterm infants hospitalised in either SFRs or OBUs.

2. Methods

2.1. Search strategy and selection criteria

This systematic review and meta-analysis used the same methods as our previous paper on infant outcomes [9]. A full protocol was published before conducting this research [11], and parental outcomes were prespecified to be secondary outcomes. We used the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA-)guidelines [12]. An information specialist (JL) performed a broad search (adapted from the initial search) [9] in MEDLINE, EMBASE, PsycINFO (all via the OVID interface), the Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, Clinicaltrials.gov, and the International Clinical Trials Registry Platform (ICTRP) databases from their inception through 22 November 2019 (Supplemental Table 1). There were no restrictions to language, date, study type, or publication status. We cross-checked reference lists and citing articles of identified relevant papers. We required studies to compare well-being of *parents* of preterm infants admitted to SFRs or to OBUs and to provide summary estimates of outcomes in parents [11]. We included randomised and non-randomised clinical trials. Two researchers (NRvV and SRDvdS) independently screened abstracts and assessed full-text articles for inclusion.

2.2. Data analysis

We calculated kappa and specific agreement for screening of studies. We collected the data as described in the protocol [11]. We contacted study authors up to twice to clarify (missing) data in included and potentially eligible studies (see acknowledgments). We defined a population as parents of infants from the same hospital during the same time-period of study. Two investigators (NRvV and SRDvdS) applied the Cochrane Collaboration's Risk of Bias Tool for randomised controlled trials and the Risk of Bias in Non-Randomised Studies of Interventions (ROBINS-I) tool to each study, at the study level, separately and independently [13]. Two investigators (NRvV and SRDvdS) independently examined the questionnaires and outcome measures used in the studies and grouped them into discrete conceptual categories (Supplemental Table 2). Discrepancies were resolved via discussion within the research team. The prespecified outcomes included parental stress, satisfaction, participation, self-efficacy, and parent-infant bonding. Parent participation was further defined as: *presence* (amount of time parents are physically present with the infant in the hospital during hospital stay of the infant), *involvement* (amount (of time) parents are taking part in the care of their infant), and *skin-to-skin care* (amount of time parents provide SSC to their infant). Outcomes of additional relevance included during the review process were depression, anxiety, post-traumatic stress, empowerment, and degree of family-centred care (FCC).

We used Review Manager (version 5.3; the Cochrane Collaboration) and the 'meta' and 'metafor' packages in R (version 3.6.1) to conduct meta-analyses, sensitivity and subgroup analyses [14, 15]. We assessed heterogeneity using the I^2 test for heterogeneity. We used a random-effects model for meta-analysis if heterogeneity was assessed to be acceptable ($I^2 \leq 50\%$) on crude estimates. In case of substantial or considerable heterogeneity ($I^2 > 50\%$) no pooled results were reported. Continuous data were analysed by computing the standardised mean difference (SMD) with 95% confidence intervals (CI) if studies assessed the same construct with different measurement instruments [16]. We calculated means and variances if they were not reported in the original publication as proposed previously [17]. We performed sensitivity analyses to estimate the effect of different assumptions on outcome variables (prespecified were risk of bias (RoB), gestational age (GA), and start of SFR care). Predefined subgroup analyses were performed for parent participation (analysing studies with higher levels of parent-involvement in SFR, significant more SSC in SFR, or >8 h per day difference in parental presence between SFR and OBU). We added subgroup analyses on different constructs of stress (biomarkers, NICU-related parental stress, and parenting stress; Supplemental Table 2). We prespecified to assess publication bias with funnel plots and to perform meta-regression analyses for outcomes assessed in more than 10 studies. This study was registered in PROSPERO (International Prospective Register of Systematic Reviews) on 2 November 2016 (registration number: CRD42016050643). Deviations from the protocol are described in the Supplement (p.2). This work was exempted from medical ethical approval as we used data from patients enroled in studies and trials already approved by relevant ethical committees.

2.3. Role of the funding source

There was no funding source for this study. NRvV, SRDvdS and AAMWvK had full access to all the data in the study and had the final responsibility for the decision to submit for publication.

3. Results

A total of 614 records were identified in our search. Eighty-six references were identified for full-text screening (Fig. 1). Thirty-one papers were reviewed in-depth. 24/27 (89%) of authors responded for additional information (see acknowledgments), and one full original dataset was provided [18].

Eleven study populations (1850 preterm infants, 1549 mothers and 379 fathers) were included in 17 papers (Table 1). Seven papers provided information about fathers [18–24]. Five study populations

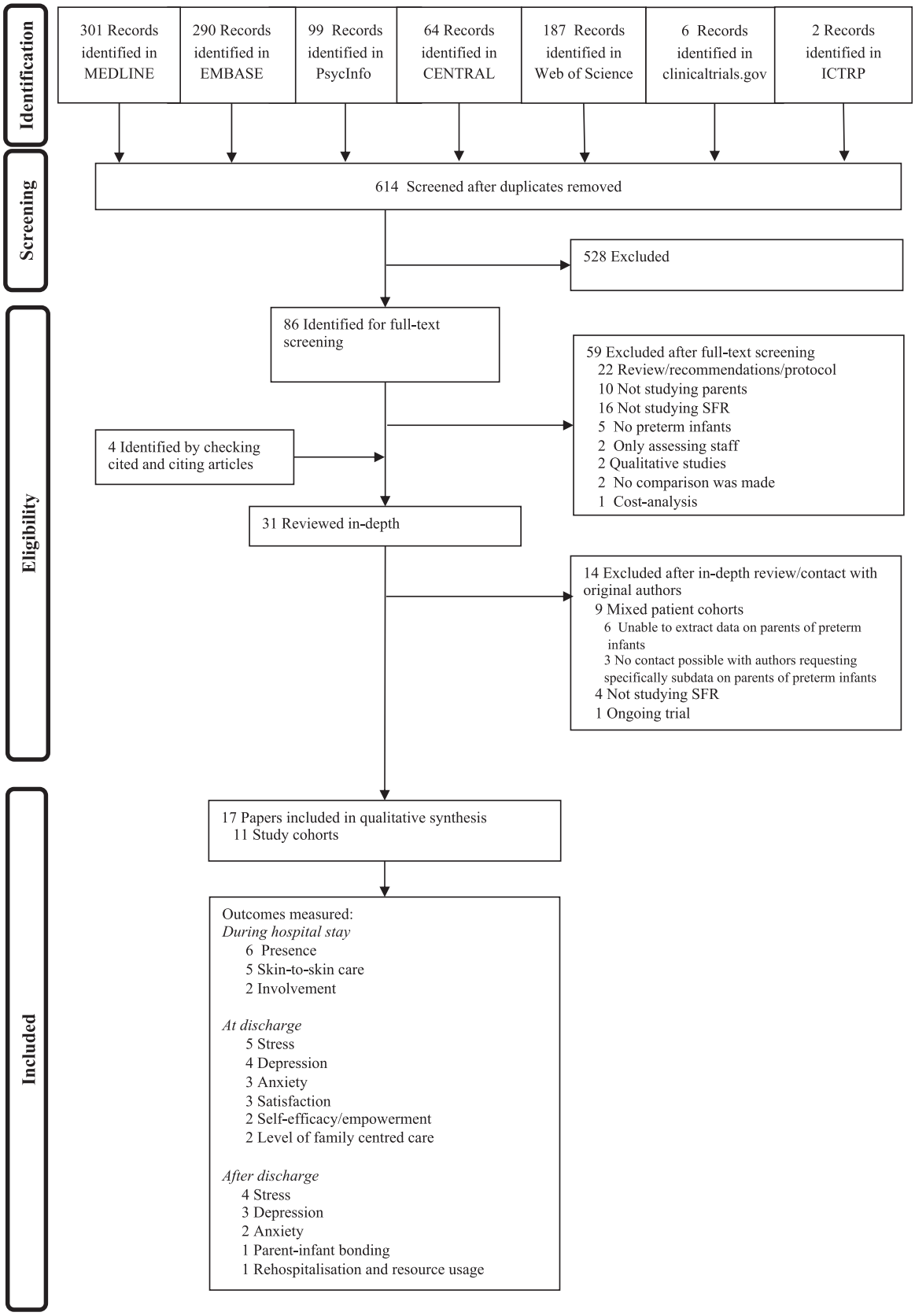

Fig. 1. Flow diagram Figure Legend: The inter-rater reliability for selection of titles and abstracts was good (Cohen's kappa: 0·72); positive specific agreement (73%) and negative specific agreement (99%) for the screening of studies for eligibility was high. Four additional papers were identified via cross-referencing. SFR: Single family rooms.

were described in multiple papers (Table 1, for a detailed description see Supplement p.13) [19–21, 24–29]. Care for mother and infant direct postnatally (couplet-care) was provided in 3 hospitals [24, 27, 30], and if mother was stable (usually 48 h after delivery) in 1 hospital [19–21]. Facilities for parents to be present in the NICU were as described in Supplemental Table 3. The papers were published

Table 1
Characteristics of studies, study populations and outcomes measured in parents of preterm infants.

First Author [reference]	Population	Country	Study type	Start of SFR care	Children in SFR	Mothers in SFR	Fathers in SFR	GA (wks (SD) or range) in SFR	Birthweight (grams (mean (SD) or range) in SFR	Children in OBU (n)	Mothers in OBU	Fathers in OBU	GA (wks (SD) or range) in OBU	Birthweight (grams (mean (SD) or range) in OBU	Presence (P), involvement (I) or SSC(S) *	Stress at discharge	Stress after discharge	Anxiety at discharge	Anxiety after discharge	Depression at discharge	Despression after discharge	Self-efficacy, empowerment and use of resources	Satisfaction	Family-centred care	Parent-infant bonding
Rosenblum [31]	1	USA	BA	AA	102	NR	NR	29·4 (0·3)	1505 (52)	106	NR	NR	29·5 (0·3)	1457 (48)	–	–	–	–	–	–	–	–	Y	–	–
Erdeve [25]	2	Turkey	NRPI	WS	31	26	0	30·8 (1·7)	1452 (82)	29	23	0	30·4 (2·1)	1413 (351)	Y (P)	–	–	–	–	–	–	Y	–	–	–
Erdeve [26]	2	Turkey	NRPI	WS	31	26	0	30·8 (1·7)	1452 (82)	29	23	0	30·4 (2·1)	1413 (351)	Y (P)	–	PSI-SF	–	–	–	EPDS	–	–	–	–
Mörelius [33]	3	Sweden	RCT	WS	152	135	0	33·2 (2·8)	NR	137	120	0	32·6 (2·9)	NR	Y (P/I)	Biomarker	–	–	–	–	–	–	–	–	–
Pineda [32]	4	USA	NRPI	AA	42	42	0	26·81 (0·82)	NR	39	39	0	26·31 (1·91)	NR	HR (P/I/S)	PSS-NICU†	–	STAI	–	EPDS	–	–	–	–	–
Wataker [34]	5	Norway	NRPI	AA	36	31	0	32·7 (4·0)	1900 (600)	30	30	0	34·7 (2·2)	2600 (838)	–	–	–	–	–	–	–	Y	–	–	–
Flacking [30]	6	Sweden	NRPI	AA	114	96	0	32·7 (2·9)	2046 (712)	186	170	0	32·1 (2·8)	1980 (657)	SR (S)	–	SPSQ	–	–	–	–	–	–	–	–
Lester [28]	7	USA	BA	AA	252	235	0	28·3 (2·4)	1050 (278)	151	147	0	28·2 (2·3)	1033 (261)	HR (P/I/S)	PSS-NICU	–	–	–	–	–	–	PG	FCCS	–
Lester [29]	7	USA	BA	AA	123	123	0	26·9 (1·7)	914 (220)	93	93	0	27·1 (1·7)	938 (248)	HR (P/I/S)	PSS-NICU	–	–	–	BDI	–	–	–	–	–
Blomqvist [22]	8	Sweden	NRPI	AA/WS	49	49	49	32·1 (28·7 – 33·7)	1760 (740– 2920)	55	55	55	32·1 (28·4 – 33·9)	1870 (930 – 2625)	SR /HR (S)	–	–	–	–	–	–	–	–	–	–
Baylis [23]	8	Sweden	NRPI	AA/WS	38	38	38	NR	NR	43	43	41	NR	NR	SR /HR (S)	–	–	–	–	–	–	–	–	–	–
Jones [18]	9	AUS	BA	AA	32	29	3	32·8 (2·7)	1939 (691)	49	46	3	32·5 (5·3)	1899 (495)	SR (P/S)	PSS-NICU, DASS-21	DASS-21	DASS-21	DASS-21	DASS-21	DASS-21	PES	–	–	–
Raiskila [27]	10	Europe	NRPI	AA/WS‡	108	108	107	NR	NR	103	102	96	NR	NR	SR (P/I/S)	–	–	–	–	–	–	–	–	–	–
Aija [24]	10	Europe	NRPI	AA/WS‡	100	88	76	NR	NR	72	68	54	NR	NR	SR (P/I/S)	–	–	–	–	–	–	–	Y	Y	–
Tandberg [20]	10	Norway	NRPI	AA	33	29	28	33 (1·7)	1889 (473)	31	29	29	31·1 (3·0)	1643 (679)	SR (P/I/S)	–	–	–	–	–	–	–	–	Y	–
Tandberg [19,21]	11	Norway	NRP	AA	35	30	30	30·5 (NR)	1452 (301)	42	36	36	30·1 (NR)	1382 (274)	SR (P/I/S)	PSS-NICU, PSI-SF	PSI-SF	STAI-SF	STAI-SF	EPDS	EPDS	–	–	–	MPAS
Total	**11**				**923**	**781**	**189**			**927**	**768**	**190**			**9**	**5**	**4**	**3**	**2**	**4**	**3**	**3**	**3**	**2**	**1**

* see Supplemental Table 5, †:Parental role alteration subscale, ‡: different in the participating units, AA: at admission, AUS: Australia BA: before-after study, BDI: Beck Depression Inventory, EPDS: Edinburgh Postnatal Depression Scale, FCCS: Family-Centred Care Survey, HR: healthcare-professional reported, I: Involvement, MPAS: Maternal Postnatal Attachment Scale, NA: not applicable, NR: not reported, NRPI: non-randomised prospective study, P: presence, PES: Parent Expectations Scale, PG: Press Ganey NICU Survey, PSI: Parenting Stress Index, RCT: randomised controlled trial, SPSQ: Swedish Parenting Stress Index, SR: self-report, S/SSC: skin-to-skin care, STAI: State-Trait Anxiety Inventory, USA: United States of America, WS: when stable, Y: yes.

Table 2
Risk of bias in included studies.

NSource	Bias due to confounding	Bias in selection of participants into the study	Bias in the classification of intervention	Bias due to deviations from intended interventions	Bias due to missing data	Bias in the measurement of outcomes	Bias in selection of reported result	Overall RoB
[31]	Moderate	No information	Low	Low	No information	No information	No information	No information
[25,26]	Serious	Serious	Low	Low	Moderate	Serious	Moderate	Serious
[34]	Serious	Serious	Low	Low	Serious	Serious	Moderate	Serious
[32]	Moderate	Serious	Low	Low	Low	Serious	Moderate	Serious
[30]	Serious	Serious	Low	Low	Moderate	Serious	Moderate	Serious
[22,23]	Serious	Serious	Moderate	Low	Low	Serious	Moderate	Serious
[18]	Low	Serious	Low	Low	Serious	Serious	Moderate	Serious
[28,29]	Low	Serious	Low	Low	Serious	Serious	Moderate	Serious
[27]	Critical	Critical	Moderate	Low	Serious	Serious	Moderate	Critical
[19–21]	Serious	Serious	Low	Low	Low	Serious	Moderate	Serious
Cochrane	**Bias arising from the randomization process**			**Bias due to deviations from intended interventions**	**Bias due to missing outcome data**	**Bias in the measurement of the outcome**	**Bias in selection of the reported result**	**Overall RoB**
[33]	Low			Low	Some concerns	Low	Low	Some concerns

RoB: risk of bias (see Supplement p. 16 for an elaborate discussion on RoB assessment).

between 2004 and 2019, and all were performed in middle- to high-income countries.

Data pertaining to RoB assessments are listed in Table 2. The randomised clinical trial (RCT) was considered to be at some concerns on RoB, the RoB of all of the other studies ranged from serious to critical. One study provided insufficient information to assess RoB across at least one domain (see Supplement p.16 for a detailed explanation) [31].

Including all studies that measured parental stress at discharge, statistical heterogeneity was high (I^2=79%, n = 909 parents, Table 3, Supplemental Figure 2) and no meta-analysis was performed [18, 21, 28, 29, 32, 33]. Heterogeneity decreased when accounting for RoB (including only studies with low risk of confounding, I^2=63%, Supplemental Table 4) [18, 28, 29, 33], but not for GA [21, 28, 32] or start of SFR care at admission [18, 21, 28, 32] (88% and 83%, respectively). One study specifically influenced heterogeneity, as it reported higher levels of stress on the parental role alteration *subscale* but not on all aspects of NICU-related parental stress [32]. Omitting this study decreased heterogeneity (I^2=46%) and SFRs were associated with lower parental stress (n = 828, SMD-0·30, 95%CI-0·50;−0·09, p<0·004, Fig. 2). Also subgroup analyses on constructs of stress decreased heterogeneity: non-significant lower levels of salivary cortisol [33] and specifically less NICU-related parental stress was present in SFRs (n = 595, SMD-0·41, 95%CI-0·58;−0·25, p<0·001, I^2=0%, Fig. 2). Two to four months after infant discharge, no differences in stress was found (Table 3, Supplemental Figure 5), all studies were at serious RoB and all infants were >32 weeks of GA [18, 26, 30]. No difference was noted analysing only infants admitted straight after birth to SFRs (Supplemental Table 4) [18, 21, 30].

Statistical heterogeneity was high for anxiety at discharge (I^2=81%, Supplemental Figure 3) and RoB serious in all but one study [18]. In this study significantly lower anxiety scores were found upon discharge (n = 81, SMD-0·55, 95%CI-1·00;−0·10, p = 0·02) [18]. Heterogeneity did not decrease when accounting for other aspects of RoB, GA or start of SFR care [18, 32]. In one study (assessing state and trait anxiety), mothers in SFRs had higher trait anxiety, but experienced lower state anxiety than mothers in OBUs [32]. After discharge, parent anxiety did not differ between admission to either of two environments (n = 136, SMD-0·17, 95%CI-0·51;0·17, p = 0·316, I^2=0%) [18, 21].

Table 3
Meta-analyses of single family rooms versus open bay units on outcomes in parents of preterm infants.

Outcome	Subgroup analyses	Study populations (n)	Total parents (n)	Parents in SFR (n)	Parents in OBU (n)	Heterogeneity (I^2,%)	SMD	95%CI	P-value
During hospital stay									
Participation	Presence	6 [18,19,25,27–29,32]	892	486	404	98%	–	–	–
	Involvement	2 [20,28]	497	292	205	78%	–	–	–
	SSC	5 [21,27–30,32]	993	551	542	96%	–	–	–
Upon discharge									
Stress*	*All*	5 [18,21,28,29,32,33]	909	496	413	79%	–	–	–
	Biomarker	1 [33]	255	135	120	NA	−0·07	−0·32; 0·01	0·56
	NICU- related~	3 [18,21,28]	573	319	254	0%	−0·41	−0·58; −0·24	<0·0001
	Parenting~	0	–	–	–	–	–	–	–
Depression	*All*	4 [18,21,29,32]	488	249	239	87%	–	–	–
Anxiety	*All*	3 [18,21,32]	272	126	146	81%	–	–	–
Follow-up (2 to 4 months after discharge)									
Stress	*All*	4 [18,21,26,30]	451	183	268	32%	−0·09	−0·35; 0·17	0·495
	Biomarker	NA	–	–	–	–	–	–	–
	NICU- related~	NA	–	–	–	–	–	–	–
	Parenting~	3 [21,26,30]	419	171	248	50%	−0·12	−0·43; 0·19	0·466
Depression	*All*	3 [18,21,26]	185	87	98	16%	−0·15	−0·48; 0·18	0·372
Anxiety	*All*	2 [18,21]	136	61	75	0%	−0·17	−0·51; 0·17	0·316

* see Supplemental Table 1 for the different stress constructs measured, †STAI-state anxiety, 95%CI: 95% confidence interval, NA: not applicable/available, OBU: open bay unit, OR: odds ratio, SFR: single family room, SMD: standardised mean difference. See Supplemental Table 4 for sensitivity analyses.

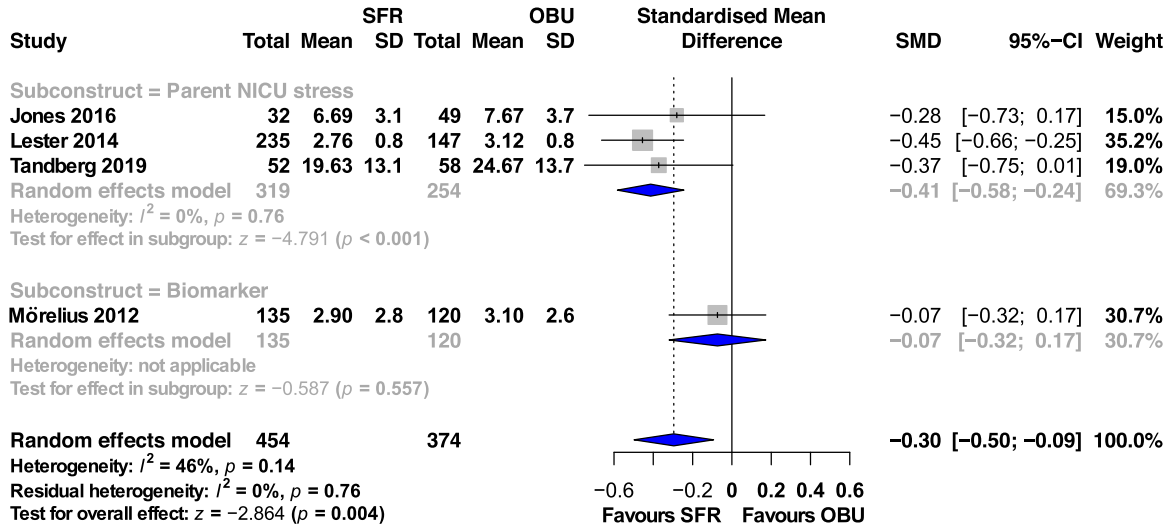

Fig. 2. Single family rooms versus open bay units association with parent stress upon discharge. OBU: open bay unit, Parent NICU stress was measured with the Parental Stressor Scale:NICU (PSS-NICU) or the biomarker (cortisol in saliva, see main text), SFR: single family room, SMD: Standardised mean difference.

Up to 29% of parents had depressive symptomatology upon discharge. Heterogeneity between studies was high (I^2=87%, Table 3, Supplemental Figure 4) [18, 21, 29, 32]. In sensitivity analyses of RoB, heterogeneity decreased (I^2=0%), and no statistically significant difference in parent depression upon discharge was noted (n = 297, SMD-0·10, 95%CI-0·33;0·14, p = 0·42, Supplemental Table 4) [18, 29]. Furthermore, no differences were found after infant discharge for parent depression (n = 185, SMD-0·15, 95%CI-0·48;0·18, p = 0·372, I^2=16%, Table 3, Supplemental Figure 6) [18, 26]. One study reported significantly lower depressive symptoms from admission up to 4 months for mothers with infants admitted to SFRs [21].

During hospital stay, higher levels of empowerment in SFRs and more confidence in taking care of an infant without an attending staff member one week prior to discharge were reported [34]. Parents in SFRs reported feeling heard and receiving greater guidance and (emotional) support from nurses [20], and they rated the degree of FCC and satisfaction higher compared with parents in OBUs [24, 28, 31]. No differences in self-efficacy upon discharge were found [18]. After discharge, mothers reported less need for information about understanding their infant's behaviour and about breastfeeding [34]. Mothers in SFRs had fewer acute care visits with their infant and fewer telephone consultations with a physician after discharge [25]. No differences in parent-infant bonding during hospital stay and after discharge was found as they scored high in both environments [21].

Parent participation was described in 15 studies (9 populations, Table 1, Supplemental Table 5) [18, 19, 29, 30, 32, 33, 20, 22–28] and measured in 8 populations [18, 19, 29, 30, 32, 20, 22–28]. It included reports on time of parental presence with the infant in the hospital [21, 27–30, 32], levels of parent-involvement in care [20, 24, 27–29] and amount of SSC [21, 27–30, 32]. No meta-analysis was performed, as statistical heterogeneity was high (I^2=98%, 78%, 96% respectively, Supplemental Figure 1, Supplemental Table 4).

Overall, in five out of six populations (n = 486 parents in SFRs, n = 404 parents in OBUs) increased parental presence was reported in SFRs [18, 19, 25, 27–29, 32]. In one study, lower presence in SFRs compared with OBUs was found if mother was not hospitalised [25, 26]. Overall, parental presence in SFRs (range:3·6 to 22·4 h per day) was higher than in OBUs (range:2·4 to 8·0 h per day). When accounting for RoB (specifically confounding), heterogeneity decreased and parents were significantly more present in SFRs (n = 417, SMD+0·59, 95%CI 0·36 to 0.83, p<0·0001, I^2=7%, Supplemental Table 4) [18, 28] Two studies in Sweden did not measure parental presence, but reported infants cared for with continuous SSC (24 h per day) for the first week of life in SFRs [22] or parents expected to be with the infant around the clock [22, 33]. If studies found >8 h difference per day in parental presence between SFR and OBU, SFRs were associated with lower levels of parental stress and depression upon discharge (Supplemental Table 6) [21].

The number of days per week that parents were involved was higher (4·5 days in SFRs versus 3·6 days in OBUs, without risk of confounding) [28, 29], and parents participated more in discussions during the doctor's round in SFRs [20].

Seeing or holding the infant skin-to-skin commenced earlier when infants were hospitalised in SFRs [23, 32]. The amount of SSC was higher in SFRs (range: 1·9 to 24 h per day) than in OBUs (range:0·5 to 2·5 h per day, Supplemental Table 5). Statistic heterogeneity was high (I^2=96%, Supplemental Table 4) [19, 20, 22, 27–30], and did not decrease with sensitivity analyses. In studies with significant higher levels of SSC [21, 28, 29] SFRs were associated with significantly lower stress levels (n = 492, SMD-0·44, 95%CI-0·62;−0·25, p<0·0001, I^2=0%, Supplemental Table 6) [21, 29].

In four study populations 379 fathers were present [18–24, 27], and 72 fathers were assessed on well-being (Supplement p.21) [18, 21]. In one study [18] one father in an OBU had extremely severe depression upon discharge; no fathers in SFRs had depression symptomatology. Three fathers in OBUs had anxiety and stress upon discharge compared with one father in SFRs. In the other study (n = 66), fathers had significantly lower stress levels in SFRs compared to OBUs, but no differences were noted on depression, anxiety, or parent-infant bonding [21].

As none of the outcomes were assessed in more than 10 studies, meta-regression analysis and publication bias was not assessed.

Discussion

This systematic review and meta-analysis suggests, that parents of preterm infants admitted to SFR NICUs experienced better outcomes compared with parents of infants admitted to OBU NICUs. We found lower NICU-related stress levels upon discharge, and more parental presence, involvement, skin-to-skin care, empowerment, degree of FCC, and satisfaction levels in parents of preterm infants admitted to SFRs. No differences were found in anxiety, parent-infant bonding, or depression upon or after discharge. No studies examined the association of different care environments with post-traumatic stress.

The findings of this review can only be generalised to mothers of preterm infants because only four studies included fathers [18–21], and only two studies examined well-being outcomes in fathers [18, 21]. Fathers can feel stressed, depressed, excluded, isolated, and

incompetent during and after hospitalisation of their infant in the NICU [35]. Additionally, the effect of infant hospitalisation on fathers might be different than on mothers [36]. More research that focuses on outcomes for fathers is necessary. Specifically, it is important to focus on the (different) role fathers play during hospitalisation of their infant supporting the infant and the mother, which might not be adequately captured when using questionnaires validated in mothers.

Almost all included studies showed that SFRs appear to facilitate parental presence, involvement, and SSC, supporting the WHO and EFCNI recommendations [6–8]. Engaging parents in their infants' care may lead to favourable long-term outcomes not only in infants [28, 29, 37, 38] but also in the parents themselves [37, 39]. We show this in subgroup analyses, focusing on studies with high parental presence and SSC levels in SFRs; in these studies, lower depression and stress levels were present in parents of preterm infants. This suggests a mediating effect of parental presence, SSC and involvement in the association between SFR and outcomes not only in infants but also in parents [28, 29].

Further research is required to understand the specific factors during hospitalisation of preterm infants that improve the outcomes for parents. This is especially important when hospital budgets are constrained, and priorities need to be established. We need to understand whether or not SFRs are required or if some of associated benefits can be achieved with other family-centred approaches such as family-centred rounds with supported parent participation and presence, increased support for parents to provide developmentally supportive care, better communication with parents, parent education, or family integrated care models [28, 37, 40, 41]. Also, caregiving practices for mothers, for instance couplet-care was heterogeneous in included studies, and should be studied more in depth. Other facilities might also be beneficial for parents, for instance a kitchen, lounge room, comfortable chair or other purpose-built family accommodations [42]. Teasing out specific factors and understanding their impact requires detailed data collection from individual families during a time in which they are already under stress. Mediation analyses or network meta-analyses [43] might be able to clarify the beneficial (associated) factors in SFRs.

By including not only RCTs, but all comparative study designs, we have created a complete overview of the existing literature that is highly generalisable to the neonatal field. However, only one randomised trial (with high internal validity) was found. Therefore, the overall quality of evidence on the effect of SFR on parental well-being is low. Many studies were considered to have serious RoB, specifically in the selection of participants, the measurement of outcomes, and confounding. This was mainly because the interventions studied were inevitably hospital-level interventions for which randomisation is difficult. Therefore, we cannot claim a causal relationship between SFRs and improved parent well-being. For instance implementing SSC might be easier in single family rooms, but could also be a result of care culture in the unit [44]. Also, statistical heterogeneity was high for many outcomes. Although this decreased in the sensitivity analyses if RoB was considered for stress, anxiety and depression, only a paucity of studies was available to explore this in-depth. More (robust) research is needed to provide more insight into the association between SFR and improved well-being in parents. In the future, (stepped wedge) cluster randomised trials should be considered to investigate hospital-level interventions, as these are less prone to bias than non-randomised trials [37, 45].

The data collection methods on parental presence, involvement, and SSC have not yet been validated and it presents an ongoing challenge to collect this information accurately without being subjective. Almost all outcomes were by necessity self-reported outcomes, which in an unblinded study are more prone to measurement bias. Biomarkers for outcomes could be a potential solution, but was only used in one study to measure for stress in parents [33, 46]. Whenever using biomarkers and specifically cortisol, several confounding factors should be considered, which potentially influence the outcome. For cortisol levels in saliva, the sampling time should be taken in consideration [47]. As we used summary measures as provided by the paper, we did not know how sampling times influenced the levels of stress in the baseline measures, as this study was designed to compare stress reactivity and co-regulation between groups.

Parental stress in the NICU has been described in multiple studies and is associated with longterm health of parents and their offspring [48]. However, none of the included studies assessed parent well-being beyond four months after discharge. As the risk of psychological distress is known to persist into early childhood, longer follow-up studies are needed [49]. In addition, important contextual factors such as personality traits, pregnancy and birth experiences, and family factors should be included in future studies [36]. Although post-traumatic stress symptomatology is common in parents of preterm infants [50] it was not measured in any of the studies in this review and should be addressed in future research.

This systematic review suggests that single family rooms facilitate parental presence, involvement and skin-to-skin care, and are associated with improved outcomes in parents during preterm infant hospitalisation. Most studies were characterised by serious risk of bias. Therefore, more robust research is needed as single family rooms seem to be a promising hospital level intervention for this vulnerable patient population and their families.

Contributors

NRvV, SRDvdS, JL, AAMWvK and JBvG developed the protocol for this systematic review [11]. JL developed and performed the search strategy for this review. NRvV and SRDvdS screened abstracts and read full texts. NRvV contacted authors to elucidate data in original papers. AAMWvK review the included and excluded papers of the screening and eligibility phase, assessing if any important papers were missing. NRvV and SRDvdS rated questionnaires and constructs that were measured in the studies. LSF and KOB provided background insights and contributed to the interpretation of studies and outcomes. NRvV and SRDvdS assessed the RoB in all studies. JHvdL provided background insight in the use of the ROBINS-tool. NRvV performed the meta-analysis in collaboration with JHvdL. NRvV SRDvdS, LSF, KOB, JL, JHvdL, AAMWvK and JBvG all contributed to writing, reading and approving this paper. NRvV, SRDvdS and AAMWvK are the guarantors of this review; they accept full responsibility for the work and the conduct of the study, had full access to the data and controlled the decision to publish. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Supplementary materials

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