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Maternal and infant characteristics associated with prone and lateral infant sleep positioning in Washington State, 1996-2002

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Abstract

Objective—To identify factors predictive of either lateral or prone infant sleep positioning.

Study design—We used data for 11,340 mother-infant pairs from the Pregnancy Risk Assessment Monitoring System for infants born in Washington State, 1996–2002. We employed predictive modeling to identify statistically significant ($p < 0.05$) predictors of lateral and prone sleep positioning.

Results—Factors associated with both high-risk sleep positions included infant's year-of-birth, maternal race and ethnicity, maternal county of residence, and maternal parity. Mother's being US-born (vs. foreign-born) and male infant sex were predictive only of prone sleep positioning. Having Medicaid as primary insurance, receipt of government benefits, low infant gestational age, and low birth weight were predictive only of lateral sleep positioning.

Conclusion—Factors predictive of either high-risk sleep position should be considered when devising public health intervention strategies for the prevention of SIDS.

Keywords

Sudden Infant Death Syndrome (SIDS); Pregnancy Risk Assessment Monitoring (PRAMS)

Since the early 1990s, prone (stomach) sleep positioning has been an accepted risk factor for Sudden Infant Death Syndrome (SIDS).^{1–3} In 1992, the American Academy of Pediatrics (AAP) Task Force recommended that infants be placed to sleep in either the supine (back) or lateral (side) position to minimize risk of SIDS.^{2,4} At that time, approximately 70% of infants in the United States (US) were placed prone to sleep.⁵ The “Back to Sleep” campaign begun

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Conflict of interest: None.

in June 1994 by the US Public Health Service, the AAP Task Force, and other organizations helped maximize the number of infants placed in a non-prone sleep position.⁴

In December 1996, however, new evidence suggested that, as compared with supine placement, lateral placement was also associated with an increased risk of SIDS.⁶ Thus, the AAP Task Force revised its recommendations, stating the supine position was preferred over the lateral sleep position.⁷ Subsequently, the supine position became the predominant infant sleep position in the US.⁵ This change is believed to be largely responsible for the 40% reduction in the national incidence of SIDS that occurred between 1992 and 1997.⁸ As the prevalence of prone sleeping declined, however, the proportion of SIDS deaths related to lateral sleep positioning has grown.⁹ As new studies bolstered previous findings regarding the lateral position,¹⁰ the AAP in 2005 recommended that the lateral sleep position be avoided altogether.⁹

In 2005, an estimated 13.8% of infants were positioned to sleep lateral and 12.8% prone in the US.⁵ Each year approximately one million infants in the US are placed to sleep laterally or prone; over half are placed laterally.¹¹ No population-based study has been conducted to evaluate factors related to lateral sleep positioning. We aimed to identify factors predictive of either infant prone or lateral sleep positioning.

Methods

Participant Identification

Study participants were mothers and their infants who took part in the Pregnancy Risk Assessment Monitoring System (PRAMS) statewide population-based survey between 1996 and 2002 in Washington State.¹² Annual overall response rates for PRAMS in Washington State during the study period ranged from 69% to 75%.¹³ PRAMS is an ongoing behavioral survey developed by the Centers for Disease Control and Prevention (CDC) administered to a sample of new mothers in 37 states when their infants are approximately two to five months of age, when the risk of SIDS is high.¹⁴ Since 1996, the PRAMS survey has included the question, "How do you most often lay your baby down to sleep now?"¹⁴ We abstracted all survey data for infants who slept supine, prone, or lateral, excluding infants with no typical, or more than one typical, sleep position (n=318). Other PRAMS questions pertained to behavioral characteristics such as well-child care and maternal smoking in pregnancy.¹⁴

Data Collection

PRAMS survey data were linked to infants' corresponding birth certificates at the Washington State Department of Health (DOH). Additionally, each infant's name, birth date, and sex were used to match study subjects' surveys to hospital discharge data. Hospital discharge information is routinely collected by the DOH during inpatient stays at non-federal hospitals in Washington State.¹⁵ From these linked data, we obtained birth and delivery characteristics, demographics, and all ICD-9 diagnosis and procedure codes for the birth hospitalization for mothers and infants.¹⁶

Variable inclusion and categorization

Based on previous reports, we anticipated that sleep positioning could be related to year-of-birth and socioeconomic factors such as education level, race, ethnicity, marital status, parity, and household income.^{17–23} Other social factors we hypothesized might be related to sleep positioning included mother's age, country of birth, location of residence, county of residence, source of payment for delivery, receipt of government benefits, and smoking.²⁴ Mother's county of residence was classified as Seattle-King; Pierce or Snohomish (both predominantly suburban areas adjacent to Seattle-King county); or other western Washington, or eastern

Washington counties (both predominantly composed of small towns and rural areas). Receipt of government benefits indicated assistance from programs such as Women, Infants and Children (WIC). Insurance was classified as health maintenance organization (HMO)/commercial, Medicaid (which typically covers poor and uninsured mothers), and others/self-pay. Smoking was measured from birth certificates and PRAMS responses; exposures were combined into a binary variable based on a positive response from either data source.

We also included perinatal care indicators such as numbers of prenatal and well-baby care visits.^{17, 24} Infant characteristics we examined included infant's sex, birth weight, gestational age at birth, and age at the time of the PRAMS survey.^{17, 20} We included infant birth hospitalization factors such as length-of-stay and whether the infant spent time in intensive care. We also considered maternal delivery characteristics such as the number of stressful life events during pregnancy (e.g. death of a family member) and whether the delivery was assisted or breech. All variables were categorized as in Table I (available at www.jpeds.com.) except when exploring potential effect modification with other variables, when infant's year-of-birth was categorized according to whether infants were born in 1996–1999 or in 2000–2002. Variables not predictive of either sleep position are those listed in Table I but not included in the final models.

Analysis

We used survey methods to account for the Washington State PRAMS survey's sampling, non-response and frame non-coverage weights; the clustering effect by year; and the stratified random sample design.¹² For each potential risk factor of interest, we obtained descriptive statistics by sleep positioning.

To identify predictors of prone and lateral sleep positioning we employed a standard predictive modeling approach. Separate predictive models comparing the prevalence of prone with supine and lateral with supine sleep positioning were developed by manually applying a backward logistic regression modeling procedure. All potentially predictive variables were included in the initial model. The variable with the highest p-value was removed and the remaining model rerun. This process was repeated until all variables in the model had p-values of <0.05 from a design-based Wald test. The number of observations in each model was allowed to vary because the difference in the number of observations between any two adjacent models was relatively small, generally less than 5%. Next, we examined potential interactions using a multiplicative interaction term between year-of-birth and potential predictors. A p-value of <0.05 for the interaction term(s) was used to determine the presence of interaction.

To evaluate the accuracy of prediction of the final models, we generated a probability of sleeping prone (or lateral) given individuals' covariate values. We used this probability to calculate the area under the ROC curve (AUC). AUC varies from zero to one, with zero representing poor accuracy of prediction and one representing perfect prediction of infant sleep positioning.²⁵

This research was approved by the Washington State Department of Social and Health Services Institutional Review Board and the Washington State PRAMS Coordinator.

Results

Descriptive statistics and univariate comparisons

We identified 11 340 Washington State PRAMS survey respondents from 1996 to 2002 who had answered the sleep position question as primarily supine (n=7,029), prone(n=1,188), or lateral (n=3,123) and whose records linked to birth certificate and hospital discharge data; 65% typically placed their infants to sleep in the supine position, 10.6% prone, and 24.1% lateral.

Dramatic changes in sleep positioning occurred in Washington State over this time period. The prevalence of supine positioning increased by more than 30%; concomitantly, prone, and lateral positioning declined substantially (Table I). In bivariate analyses, a greater proportion of women <18 years of age placed their infants to sleep in the lateral position as compared with women who were ≥ 35 years old. More African-American mothers placed their infants prone to sleep and fewer Hispanic mothers placed their infants prone as compared with white/other non-Hispanic mothers. Conversely, a greater proportion of Hispanic mother placed their infants to sleep in the lateral position than any other ethnic group. Mothers with <12 years of education more commonly placed their infants to sleep lateral than mothers with ≥ 15 years of education (Table I).

Predictors of prone sleep positioning

Maternal African-American race, being born in the US, primiparity, and earlier infant birth year were most predictive of prone sleep positioning. Maternal residence outside the Seattle area and infant male sex were also positively associated with prone sleep positioning (Table II; available at www.jpeds.com). There was evidence of an interaction between mother's education level and infant's year-of-birth ($p=0.03$). Because the models with and without the interaction had similar AUC (0.678 v. 0.673, respectively) the interaction did not improve prediction enough to justify the added complexity, so we proceeded with the model without the interaction.

Predictors of lateral sleep positioning

The factors most highly predictive of lateral sleep positioning were maternal non-white and non-Native American race, Medicaid payment for delivery, infant's earlier birth year, and mother's county of residence being other than the Seattle area. Other independent, positive predictors of being positioned to sleep laterally included mother's primiparity, mother's receipt of government benefits during pregnancy, infant prematurity, and infant of normal (vs. low) birth weight (Table II). There was evidence of an interaction between infant's year-of-birth and mother's race and ethnicity ($p=0.03$). The accuracy of prediction based on models with and without the interaction were similar (AUC = 0.685 v. 0.682, respectively) so we dropped the interaction term from the final model (data not shown).

Discussion

We found several infant and maternal characteristics that may help identify populations to be targeted for future sleep positioning interventions. Some characteristics, such as maternal primiparity, residence outside Seattle-King County, or African-American race, were associated with both prone and lateral positioning. However, prone sleep positioning was associated with characteristics that were unassociated with lateral positioning, such as mother's being US-born and infant of male sex. Similarly, lateral sleep positioning was associated with characteristics not related to prone sleep positioning, such as mother's receipt of government benefits, infant's prematurity, and infant's normal birth weight. Racial and ethnic sleep positioning patterns also differed.

Our observation that African-American mothers more commonly used the prone sleep position is consistent with previous studies,^{17, 18, 20, 22} but our data suggest they were also more likely to use the lateral position relative to Caucasian, non-Hispanic mothers. Thus, African-American mothers remain an important subgroup for targeted sleep positioning interventions. Also consistent with findings from an earlier study was that Hispanic mothers less frequently used the prone position but were more apt to use the lateral position relative to white non-Hispanic mothers.¹⁷ Future SIDS prevention efforts in this group should therefore focus on modification of lateral sleep positioning. Because Native American infants are known to have

a relatively high incidence of SIDS,²⁶ it is notable that Native American mothers used the prone and lateral positions less frequently than white, non-Hispanic mothers. This finding suggests factors other than sleep position may play a more important role in the etiology of SIDS in this population.

Lateral sleep positioning was significantly more common in rural counties outside the Seattle-King County metropolitan area, including Pierce county, a mix of rural and urban areas that includes a large military base. Both rural areas and military bases have been implicated as factors related to prone positioning.^{18, 24} It may be that these communities are not reached by current modes for conveying SIDS prevention messages. Perhaps efforts targeted at such communities could help increase the prevalence of supine sleep positioning. Lateral sleep positioning was more common among infants <37 weeks gestation as well as among low birth weight infants; after multivariable adjustment, lateral positioning was less common among low birth weight infants. The strong correlation between these two characteristics influences the strength of each as a sleep positioning predictor in models that include both. Evidence suggests that infants who spend time in the neonatal intensive care unit are most commonly placed in non-prone sleep positions^{27, 28} and that parents often adopt the sleep position used by health care providers²⁸; perhaps among infants of similar birth weight, prematurity is a marker of serious underlying conditions requiring hospitalization. It is also possible that the negative adjusted association between low birth weight and lateral positioning represents a chance finding.

Mothers who received government assistance such as WIC, and mothers whose delivery was paid by Medicaid more commonly placed their infants to sleep in the lateral position. Integrating targeted sleep positioning messages with other Medicaid services may be a cost-efficient way to improve the prevalence of supine positioning in this subgroup. Descriptively, other markers of low socioeconomic status were also common in infants placed lateral to sleep, including single marital status, low maternal education and being from a low-income household. That these markers of lower socioeconomic status were not independent predictors of lateral sleep position may reflect their relatively strong correlation with factors that were retained in the predictive models, such as maternal race and parity. These results imply there could be little additional gain in targeting interventions on the basis of education or marital status in addition to interventions targeted towards specific racial or ethno-cultural groups.

Among the potential socio-economically related factors that were not independent predictors of prone sleep positioning in this study, several have been observed to be predictive of prone positioning in previous studies. These include young maternal age,^{20, 29} low maternal education,^{18, 20, 24} and single marital status.³⁰ It may be that initial SIDS prevention efforts to encourage mothers to place their infants in a non-prone position have been effective in these subpopulations. Indeed, in Seattle-King County, Washington between 1992 and 1994, single and young mothers were more likely to place their infants prone than women who were married or older at the time of their infant's birth, factors not associated with sleep position in our later study.³⁰ We did not observe similar trends for lateral sleep positioning, which historically has not been the target of public health efforts.

The strong relation between year-of-birth and prone and lateral sleep positioning demonstrates that considerable shifts in sleep positioning were still occurring during the study period. The dramatic increase in the prevalence of supine positioning, concomitant with drops in both prone and lateral positioning also occurred nationally.⁵ However, associations between sleep positioning and many of the factors we examined were relatively invariant over the study period. Specifically, we observed similar associations for the predictors of interest across the year groupings except for maternal age, marital status, years of education and smoking as discussed above. Though these socioeconomic factors were predictors in the early years of the

study, they were not significant independent predictors in the final models. These analyses suggest that our findings are not driven by factors that were predictive of sleep positioning only in the early years of this study.

AUC analysis suggested that sleep positioning could be accurately predicted approximately 67% and 68% of the time for prone and lateral positioning respectively, which is relatively high but far from perfect. Even though the AUC can be reduced by data misclassification, there also may be unidentified factors that play a role in how an infant is positioned to sleep. Without data on factors such as advice from family members, recommendations of health care providers, the position in which health care providers place infants to sleep while hospitalized, or infant contentment^{20, 22, 27, 28} we are unable to discern whether these or other unmeasured factors are predictors of prone (or lateral) sleep positioning. Factors such as co-sleeping may alter SIDS risk even if the infant is normally placed supine. Other infants may have conditions such as Pierre Robin sequence for which supine sleep positioning is contraindicated. These factors may also influence sleep positioning and the risk of SIDS but they could not be assessed in our study. Furthermore, we are unable to evaluate whether mothers who place their infants prone are aware of recommendations to avoid this sleep position but do so for other reasons.

There are reported inadequacies in the quality and completeness of birth certificate data, the source of data for many of the factors used in the current study.^{31, 32} In Washington State, this limitation is minimized by linking birth certificate data to birth hospital discharge data for the mother-infant pair.¹⁵ Misclassification of the primarily demographic characteristics of interest is unlikely and is also unlikely to be strongly associated with how an infant was placed to sleep. However, any such misclassification may have decreased the study power for identifying other predictors of sleep positioning. In addition to misclassification, missing data is another problem commonly identified with birth certificate records.^{15, 32} There was little missing data for most variables. By allowing the number of observations to vary between models being tested, we considered all complete observations at each step of our modeling efforts. Furthermore, secondary analysis by using a dataset with observations that had complete data on all factors considered yielded similar predictors for both models. Consequently, incompleteness of individual records is unlikely to have biased the observed estimates. To evaluate potential selection bias, we compared PRAMS study participants with all live births in Washington State during the study period and found minimal differences by mother's age, ethnicity, education level, and marital status (data not shown).³³ Potential selection bias was minimized by adjusting survey weights for non-response on factors such as marital status or education level.¹⁴ Sleep positioning interventions may have differed in other states, which could limit generalizability of the findings if such interventions have altered factors predictive of prone or lateral sleep positioning. However, we are unaware of any other reason to expect that associations with possible predictors of prone or lateral sleep positioning would differ in magnitude in other parts of the US.

Lateral positioning was used by the majority of non-supine sleepers. Many of the same factors were predictive of both lateral and prone positioning, however, several factors were predictive of either prone or lateral sleep positioning only. SIDS prevention efforts may benefit from consideration of factors predicting either lateral or prone infant sleep positioning.

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Abbreviations

SIDS, Sudden Infant Death Syndrome; AAP, American Academy of Pediatrics; US, United States; PRAMS, Pregnancy Risk Assessment Monitoring System; CDC, Centers for Disease Control and Prevention; DOH, Department of Health.

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Table 1

Distribution of maternal demographic and medical characteristics and infant birth characteristics by predominant infant sleep position *,†

	Supine (n=7,029)		Prone (n=1,188)		Lateral (n=3,123)	
	%	n	%	n	%	n
<i>Infant's year of birth</i>						
1996	42.9	627	16.1	230	41.0	675
1997	53.2	1,019	10.5	237	36.3	834
1998	63.4	1,338	11.1	224	25.5	643
1999	65.4	798	11.6	140	23.0	293
2000	75.6	1,046	7	7	17.4	264
2001	75.6	1,120	9.2	127	15.2	226
2002	76.5	1,081	9.8	119	13.7	188
<i>Infant's sex</i>						
Female	66.1	3,548	9.1	525	24.8	1,572
Male	64.7	3,481	12	663	23.4	1,551
<i>Infant's birth weight (in grams)</i>						
<2500	66.0	365	8.2	62	25.8	181
≥2500	65.4	6,640	10.7	1,121	24.0	2,929
<i>Infant's gestational age at birth (in weeks)</i>						
<37	58.7	448	11.6	97	29.8	250
≥37	65.8	6,498	10.5	1,082	23.7	2,834
<i>Infant's age at the time of PRAMS survey (in months)</i>						
2	66.4	2,835	10.1	468	23.4	1,235
3	63.8	2,510	11.3	439	24.9	1,147
4	67.7	1,156	10.2	174	22.1	448
≥5	60.2	369	11.8	79	28.0	216
<i>Number of well-baby care visits at time of PRAMS survey</i>						
0/1	67.0	613	12.0	104	27.9	338
2	65.5	2,775	12.3	512	22.3	1,154
3	68.0	2,192	8.8	371	23.2	899
≥4	63.6	1,317	9.1	182	27.3	643
<i>Mother's age (in years)</i>						
<18	59.3	316	8.8	55	31.9	161
18–24	61.7	2,155	10.9	409	27.4	1,116
25–29	65.2	1,908	10.5	339	24.2	877
30–34	68.6	1,677	11.0	249	20.4	619
≥35	68.8	972	9.7	136	21.5	350
<i>Mother's race/ethnicity</i>						
White / Other, non-Hispanic	66.9	2,001	11.4	333	21.7	650
African American, non-Hispanic	53.2	906	19.5	346	27.4	507
Native American, non-Hispanic	69.6	1,354	8.4	178	22.0	514
Asian, non-Hispanic	66.8	1,385	8.6	187	24.6	563
Hispanic, any race	58.8	1,291	5.4	131	35.8	858
<i>Annual household income</i>						
<\$25,000	61.3	728	7.9	130	30.8	443
\$25–\$34,999	61.2	1,830	10.1	337	28.7	996
\$35–\$44,999	64.7	1,869	11.1	337	24.2	812
\$45–\$54,999	67.9	1,279	11.7	207	20.4	446
≥\$55,000	72.8	998	11.4	141	15.8	252
<i>Mother's marital status</i>						
Married	66.9	4,715	10.7	750	22.5	1,915
Unmarried	61.4	2,297	10.3	434	28.3	1,201
<i>Mother's education (in years)</i>						
<12	56.0	1,273	8.9	174	35.1	847

	<i>Supine</i> (n=7,029)		<i>Prone</i> (n=1,188)		<i>Lateral</i> (n=3,123)	
	%	n	%	n	%	n
12	65.0	1,889	11.6	375	23.5	884
13-14	64.8	1,355	11.9	277	23.3	529
≥15	73.2	1,881	9.7	255	17.1	504
<i>Mother's country of birth</i>						
Foreign	68.7	1,579	7.0	177	24.3	641
USA	65.0	5,450	11.0	1,011	24.0	2,482
<i>Mother's county of residence</i>						
Seattle-King	70.5	2,616	9.3	385	20.2	913
Snohomish	70.3	718	10.7	100	19.0	243
Pierce	58.2	788	14.3	234	27.5	470
Other western WA	66.0	1,450	11.6	252	22.4	611
Eastern WA	60.7	1,457	8.9	217	30.5	886
<i>Mother's parity (previous live births)</i>						
0	68.2	3,075	9.0	451	22.9	1,202
1	66.6	2,151	10.4	394	23.0	934
≥2	58.9	1,661	13.7	321	27.4	909
<i>Mother smoked near time of pregnancy</i>						
No	66.8	5,657	19.0	900	23.1	2,387
Yes	59.2	1,232	13.3	272	27.6	656
<i>Source of payment for delivery</i>						
HMO/Commercial insurance	68.5	3,224	10.9	499	20.6	1,062
Medicaid	59.9	2,508	8.3	404	31.9	1,480
Other and self-pay	66.9	847	14.7	208	18.4	341

Totals for each variable may not add up to 11,340 due to missing data

*Proportions may not equal row count divided by row total (n/N*100) due to survey weighting

Table II

Predictors* of the prone and lateral as compared with supine sleep positioning, and the magnitude of the associated odds ratios (OR)

	Prone vs. Supine OR (95% CI ^{**})	p-value	Lateral vs. Supine OR (95% CI ^{**})	p-value
<i>Infant's year of birth</i>				
1996	3.2 (2.2, 4.6)	<0.001	5.4 (4.0, 7.3)	<0.001
1997	1.5 (1.1, 2.2)		3.7 (2.8, 4.9)	
1998	1.4 (1.0, 2.0)		2.1 (1.6, 2.8)	
1999	1.5 (1.0, 2.1)		1.9 (1.4, 2.6)	
2000	0.8 (0.5, 1.1)		1.3 (0.9, 1.7)	
2001	0.9 (0.6, 1.4)		1.1 (0.8, 1.5)	
2002	1.0 (Ref)		1.0 (Ref)	
<i>Mother's race and ethnicity</i>				
White / Other, non-Hispanic	1.0 (Ref)	<0.001	1.0 (Ref)	<0.001
African American, non-Hispanic	2.4 (1.9, 2.9)		1.5 (1.3, 1.8)	
Native American, non-Hispanic	0.7 (0.5, 0.8)		0.7 (0.6, 0.8)	
Asian, non-Hispanic	1.3 (0.9, 1.7)		1.3 (1.1, 1.5)	
Hispanic, any race	0.6 (0.4, 0.7)		1.5 (1.2, 1.7)	
<i>Mother's country of birth</i>				
Foreign	1.0 (Ref)	0.001		
USA	1.8 (1.3, 2.5)			
<i>Mother's county of residence</i>				
King	1.0 (Ref)	0.004	1.0 (Ref)	<0.001
Snohomish	1.2 (0.8, 1.7)		1.0 (0.8, 1.3)	
Pierce	1.7 (1.2, 2.3)		1.6 (1.2, 2.0)	
Other western WA	1.4 (1.0, 1.8)		1.2 (1.0, 1.5)	
Eastern WA	1.2 (0.9, 1.6)		1.6 (1.3, 1.9)	
<i>Mother's parity (previous live births)</i>				
0	1.0 (Ref)	<0.001	1.0 (Ref)	0.02
1	1.1 (0.9, 1.4)		1.1 (0.9, 1.3)	
≥2	1.8 (1.4, 2.2)		1.3 (1.1, 1.6)	
<i>Infant's sex</i>				
Female	1.0 (Ref)	0.009		
Male	1.3 (1.1, 1.6)			
<i>Source of payment for delivery</i>				
<i>Source of payment for delivery</i>				
HMO [†] /Commercial insurance			1.0 (Ref)	<0.001
Medicaid			1.3 (1.1, 1.6)	
Other and self-pay			0.8 (0.6, 1.0)	
<i>Mother received government benefits in pregnancy</i>				
No			1.0 (Ref)	0.01
Yes			1.3 (1.1, 1.6)	
<i>Infant's gestational age at birth (in weeks)</i>				
≥37			1.0 (Ref)	<0.01
<37			1.7 (1.2, 2.5)	
<i>Infant's birth weight (in grams)</i>				
<2500			0.6 (0.4, 1.0)	0.04
≥2500			1.0 (Ref)	

* Some characteristics were predictive of only lateral or only prone positioning. Blank entries indicate that a characteristic was not predictive of the given sleep position.

** CI = confidence interval

[†] HMO = Health Maintenance Organization