The Stunting Scorecard for Early Prevention: Development and External Validation of a Novel Tool for Predicting Stunting Risk in Children Under 5 Years of Age

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ABSTRACT   Children under five years of age are very sensitive to environmental influences such as inadequate nutrition, lack of stimulation, and other factors. Several types of health problems can hinder the growth process of children under five, one of which is stunting. This study aims to develop a scorecard model for early detection of stunting risk based on stunting factor analysis in the Surabaya City Health Centre work area. The design of this study is conducted in several phases, including the first phase of analyzing risk factors using a case-control design, and the second phase of compiling a scorecard for early detection of stunting risk with a panel of experts. The sample in this study consisted of several mothers and infants, both with and without stunting risk. The sample size is 175 mothers and children under five years of age. The sampling method used was systematic random sampling. The risk factor data were analyzed using the multinomial logistic regression test, and the scorecard was created based on the OR value. The result of this study is the scorecard able to make early detection of stunting risk with a cut-off value is 3.50. It is mean that using the scorecard has a sensitivity of 80% and specificity of 75% to detect the stunting risk of children. The scorecard can be used to determine whether a child is at low or high risk for stunting. This study implies that the scorecard can be used for early detection of stunting risk by mothers, health cadres, and health workers. It is hoped that by using the scorecard, early identification of the risk of stunting can be addressed immediately and interventions can be implemented according to the recommendations and problems that children are experiencing.

INDEX TERMS: Scorecard, Early Detection, Risk Factors, Stunting Events

I. INTRODUCTION

Children under 5 years of age are a period that is very sensitive to the environment such as; inadequate nutritional intake, lack of stimulation, and not receiving adequate health services this period lasts very short and cannot be repeated, this can hamper the growth and development process of children under five, one of which is stunting (Short).[1]

In East Java, the prevalence of stunting tends to decrease, namely in 2010 (35.8%) and 2015 (26.1%)[2]. According to data from the Surabaya City Health Office, the prevalence of stunting in Surabaya also tends to decrease, where in 2017 it reached 10.78%, and in 2018 (8.82%), but there are areas in the city of Surabaya that still have stunting prevalence above the prevalence of the city of Surabaya and there are even some areas where the prevalence of stunting is still above

20%[3][2] This research was conducted in 3 (three) public health centers in the eastern city of Surabaya, namely; health center Mulyorejo, Puskesmas Kalirungkut and Puskesmas girlfriend Keling. The prevalence of stunting at the Mulyorejo Health Center in 2017 (19.37%) and 2018 (9.95%), the prevalence of stunting at the Kalirungkut Health Center in 2017 (15.92%) and 2018 (21.2%), and the prevalence of stunting at the girlfriend health center rivet in 2017 (16.62%) and 2018 (6.76%). [4]

Previous research on stunting was based on cohort studies in Vietnam, where children were followed intensively from early pregnancy to 3 years of age. However, in this study, the scorecard for children under 5 years of age was used for early detection of stunting[5][6][7][8].

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This early detection is expected to reduce morbidity and the incidence of stunting in children under five so that their growth and development become optimal[2][7]

The purpose of the study is to design a scorecard model for early detection of stunting risk based on the analysis of stunting incidence factors in the Surabaya City Health Center Work Area and specifically analyze the risk factors for stunting under five including factors of prematurity/LBW, congenital/congenital abnormalities, history of exclusive breastfeeding, history of breastfeeding[6][9][10][11]. complementary food (MP-ASI), history of infectious diseases, history of parenting, affordability of health services, environmental health conditions, and socio-cultural factors[12][13][14][15][11].

II. METHODS
A. MATERIALS
This type of research is a case-control study about the incidence of stunting in children under five in 3 public health centers in the working area of the city of Surabaya, which consists of the Kalirungkut, Pucang Sewu, and Mulyorejo health centers. The place where the stunting children s were found was 1436 children s consisting of 653 children s in the Kalirungkut Health Center working area, 278 children s in the Mulyorejo Health Center working area and 505 children s in the Pucang Sewu Community Health Center work area[2].

The results obtained were collected, processed, and analyzed using a multinomial logistic regression test to determine the factors that influence the incidence of stunting in children under five which include: History of Prematurity/LBW, History of Congenital/Congenital Disorders, History of Exclusive Breastfeeding, Complete Basic Immunization History, History Provision of Supplementary Food (MP-ASI), History of Infectious Diseases, Parenting Patterns, Affordability of Health Services, Environmental Health Conditions, Socio-Cultural[2][11][16].

B. Collecting Data
For data collection, the sample was divided into two groups, one with stunting (88 respondents) and one without stunting (87 respondents). All respondents recorded data on risk factors for stunting. The data obtained was then used to analyze the predisposing factors that influence the occurrence of stunting. The most important predisposing factors influencing the occurrence of stunting were also identified. The next step is to create a scorecard for early detection of stunting risk in children using analytical tests and "expert panels". The final step is to test the scorecard for early detection of stunting in children under five[6][8].

C. Analysis Data
The first stage of the study was to analyze the risk factors for stunting, at this stage, the researchers conducted an analysis using the frequency distribution, percentage, and average value in each group, then carried out statistical tests using the multinomial logistic regression test.

The second stage of the research is the preparation of the scorecard, the scorecard is arranged based on the OR value obtained and continued with the "expert panel" to refine the scores that have been compiled[6]. The third stage of the research is the trial of the stunting risk early detection scorecard, at this trial stage, the analysis is carried out using the ROC curve (ROC curve) to get the cut-off value. Sensitivity and specificity tests were conducted to see how valid the scorecard used was[6][7].

III. RESULTS
1. General Data Characteristics of parents and children

TABLE 1
Frequency distribution of the characteristics of parents and children in the working area of the Surabaya City Health Center in 2019

Age (Months)	Frequency	Percentage
0 – <24	62	35,4
24 - <60	113	64,6
Total	175	100
Gender	**Frequency**	**Percentage**
Woman	96	54.9
Man	79	45.1
Total	175	100
Father's occupation	**Frequency**	**Percentage**
Civil servant	2	1.1
Non civil servant	173	98.9
Total	175	
Mother's occupation	**Frequency**	**Percentage**
Housewife	123	70,3
Non civil servant	52	29,7
Total	175	100
Income/month	**Frequency**	**Percentage**
Rp >3 million	46	26.7
Rp ≤ 3 million	129	73.7
Total	175	100
Father's Education	**Frequency**	**Percentage**
University	16	9,2
Senior High School	135	77.1
Junior High School	16	9.2
Elementary	6	3.4
Not completed in primary school	2	1.1
Total	175	100
Mother's education	**Frequency**	**Percentage**
University	22	12.6
Senior High School	116	66.3
Junior High School	21	12
Elementary	9	5,1
Not completed in primary school	7	4
Total	175	100

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The research results include; a general description of the research location, demographic characteristics of parents and children, identifying the classification of children with stunting, identifying factors causing stunting, presenting the results of an expert panel (expert discussion) compiling a scorecard for early detection of stunting risk[6][7][8]. TABLE 1 Overview of Research Locations

The research was conducted in the city of Surabaya, the geographical location of the city of Surabaya is between 112.36 "and 1120.54" east longitude and between 070.12" south latitude. The area of the city of Surabaya is 326.37 km2 consisting of 31 sub-districts and 154 urban villages. There are 63 health centers in the city of Surabaya, consisting of 21 main health centers with inpatient services and 42 health centers with outpatient care[3]. While the health centers used in this study were health centers located in the eastern region of Surabaya totaling 9 health centers, of which 3 health centers were used as research sites, namely; Kali Rungkut health center, Mulyorejo health center, and Pucang Sewu health center. The three puskesmas were used as research sites because the incidence of stunting was quite high[2][17].

Based on the table above, it was found that the majority (64.6%) of under-fives were aged 24 - <60 months (children s), and according to gender, most of the under-fives (54.9%) were female. Almost all of the father's work (98%) are non-civil servants, while the mother's work is mostly (70.3%) housewives and for the monthly family income, most (73.7%) earn 3 million per month. Almost all of the father's education (77.1%) have high school education and the mother's education is mostly (66.3%) high school education.

2. Special Data
Based on TABLE 2 above, most (50.3%) of children under five are stunted and almost half (49.7%). not stunting (Normal).

TABLE 2
Distribution of the frequency of children's nutritional status in the work area of the Surabaya City Health Center in 2019

Child Nutritional Status	Frequency	Percentage
Normal (not Stunting)	87	49.7
Stunting	88	50.3
Total	175	100

Based on TABLE 3 above for the history of LBW births, almost all (82.9%) of children under five have no history of being born with LBW (Normal), and almost all (97.1%) of children under five have no history of congenital abnormalities (normal), for a history of breastfeeding Most (52%) of children under five are exclusively breastfed[18][9][19]. Based on the history of complementary feeding, most (52%) of children under five received complementary foods on time, for the history of

immunization, almost all (90.3%) of children under five received complete immunization, and for a history of infectious diseases, most (74.9%) of children under five experienced a mildly infectious disease, and for the history of parenting in meeting nutritional needs, most (54.3%) children s had appropriate parenting patterns[10][15][16]. Based on the affordability factor of health facilities, all health facilities are easily accessible, almost all (76%) have healthy environmental conditions and for socio-cultural factors almost entirely (76.6%) there is no socio-cultural influence[14].

TABLE 3
Distribution of the frequency of risk factors for stunting in the work area of the Surabaya City Health Center in 2019

Birth History	Frequency	Percentage
LBW/prematurity	30	17,1
Normal	145	82.9
Total	175	100
History of congenital abnormalities	**Frequency**	**Percentage**
Abnormalities	5	2,9
No abnormality	170	97,1
Total	175	100
Exclusive breast feeding	**Frequency**	**Percentage**
No Exclusive breast feeding	84	48
Exclusive breast feeding	91	52
Total	175	100
Riwayat MP-ASI	**Frequency**	**Percentage**
Not the right age	84	48
Right age	91	52
Total	175	100
Immunization History	**Frequency**	**Percentage**
Incomplete	17	9,7
Complete	158	90,3
Total	175	100
History of infectious disease	**Frequency**	**Persentase**
Moderate/severe infection	44	25.1
Minor Infection	131	74.9
Total	175	100
Parenting History	**Frequency**	**Percentage**
It is not in accordance	80	45.7
In accordance	95	54.3
Total	175	100
Accessibility of health facilities	**Frequency**	**Percentage**
Affordable	175	100
Total	175	100
Environmental health conditions	**Frequency**	**Percentage**
Not healthy	41	23,4
Healthy	134	76,6
Total	175	100
Socio-cultural	**Frequency**	**Percentage**
There is influence	41	23.4
No influence	134	76.6
Total	175	100

The data shows that almost all (76.7%) children under five with a history of LBW births are stunted and (55.2%) of

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babies with normal births are not stunted[18]. The data can be seen in TABLE 4.

TABLE 4
Cross-tabulation between birth history and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Birth history	Nutritional status		Total
	Not stunting	Stunting	
Low Birth Weight	7 23.3%	23 76.7%	30 100.%
Normal	80 55.2%	65 44.8%	145 100.%
Total	87 49.7%	88 50.3%	175 100.%

Based on TABLE 5 above, most (51.2%) children under five with no congenital abnormalities did not experience stunting, and all (100%) children with congenital abnormalities experienced stunting[2].

TABLE 5
Cross-tabulation between the history of congenital abnormalities and the incidence of stunting at the Surabaya City Health Center in 2019

History of congenital abnormalities	Nutritional status		Total
	Not stunting	Stunting	
Yes	0 0%	5 100.%	5 100 %
No	87 51.2%	83 48.8%	170 100%
Total	87 49.7%	88 50.3%	175 100.%

TABLE 6
Cross-tabulation between the history of exclusive breastfeeding and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Exclusive breastfeeding	Nutritional status		Total
	Not stunting	Stunting	
No	43 51.2%	41 48.8%	84 100.0%
Yes	44 48.4%	47 51.6%	91 100.0%
Total	87 49.7%	88 50.3%	175 100.0%

TABLE 7
Cross-tabulation between Giving MP ASIand the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Giving MP ASI	Nutritional status		Total
	Not stunting	Stunting	
No Right age	31 36.5%	54 63.5%	85 100.%
Right age	56 62.2%	34 37.8%	90 100.%
Total	87 49.7%	88 50.3%	175 100.%

Based on TABLE 7 above, most (63.5%) children s who received MP-ASI at the right age experienced stunting and

(62.2%) children s who received MP-ASI at the right age did not experience stunting.

The data shows that most (70.6%) children with incomplete immunization history are stunted and (51.9%) children with complete immunization history do not experience stunting, the data can be seen in TABLE 8

TABLE 8
Cross-tabulation between exercise and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Immunization	Nutritional status		Total
	Not stunting	Stunting	
Not complete	5 29.4%	12 70.6%	17 100 %
Complete	82 51.9%	76 48.1%	158 100 %
Total	87 49.7%	88 50.3%	175 100 %

The data shows that most (72.7%) children with a history of moderate/severe infectious diseases are stunted and (57.3%) children with a history of mild infectious diseases do not experience stunting, for more details, the data can be seen in TABLE 9 [1][16].

TABEL 9
Cross-tabulation between a history of infectious disease and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Infection disease	Nutritional status		Total
	No stunting	stunting	
Moderate/Severe	12 27.3%	32 72.7%	44 100 %
Mild	75 57.3%	56 42.7%	131 100 %
Total	87 49.7%	88 50.3%	175 100 %

TABLE 10
Cross-tabulation between the history of parenting and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Parenting	Nutritional status		Total
	Not stunting	Stunting	
Not appropriate	23 28.8%	57 71.3%	80 100 %
Appropriate	64 67.4%	31 32.6%	95 100 %
Total	87 49.7%	88 50.3%	175 100 %

The data shows that most (71.3%) children with a history of inappropriate parenting experience stunting and (67.4.3%) children with a history of appropriate parenting do not experience stunting, for more details the data can be seen in TABLE 10.

Based on TABLE 11 above, most (50.3%) children under five who received affordable health services were stunted

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and almost half (49.7%) children under five who received affordable services did not experience stunting.

TABLE 11
Cross-tabulation between the affordability of health services and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Health Service Affordability	Nutritional status		Total
	No stunting	Stunting	
Unreachable	0	0	0
	0%	.0%	0%
Affordable	87	88	175
	49.7%	50.3%	100%
Total	87	88	175
	49.7%	50.3%	100.0%

Based on TABLE 12 above, most (61%) children with unhealthy environmental conditions experienced stunting, and (53%) of children with healthy environmental conditions did not experience stunting.

TABLE 12
Cross-tabulation between environmental health and the incidence of stunting in the work area of the Surabaya City Health Center in 2019

Environmental Health	Nutritional status		Total
	No stunting	Stunting	
Unhealthy	16	25	41
	39%	61%	100%
Health	71	63	134
	53%	47%	100%
Total	87	88	175
	49.7%	50.3%	100.0%

TABLE 13
Cross-tabulation between socio-culture and stunting in the work area of the Surabaya City Health Center in 2019

Socio-Cultural History	Nutritional status		Total
	Not stunting	Stunting	
available	21	20	41
	51.2%	48.8%	100.0%
Not available	66	68	134
	49.3%	50.7%	100.0%
Total	87	88	175
	49.7%	50.3%	100.0%

The data shows that most (51.2%) children under five with a socio-cultural history do not experience stunting and (50.7%) children under five with no socio-cultural influence experience stunting, for more details the data can be seen in TABLE 13.

3. Results of Data Analysis of Risk Factors for Stunting Events

1. BIVARIATE LOGISTIC REGRESSION TEST

TABLE 14
Summary of the results of the bivariate logistic regression of the factors that influence the incidence of stunting in 2019

Variable			95% C.I.for EXP(B)	
	B	Sig.	Lower	Upper
History_birth	1.397	0.003	1.632	10.018
Abnormalities_congenital_congenital	-21.250	0.999	0.000	.
exclusive breastfeeding	0.114	0.708	0.619	2.028
MP_ASI	1.006	0.001	1.483	5.045
Imunization	0.951	0.087	0.872	7.694
Infection Disease	1.273	0.001	1.690	7.548
Parenting	1.632	0.000	2.680	9.769
Health service	21.226	1.000	0.000	.
Environmental Health	0.566	0.120	0.863	3.594
Social culture	0.079	0.826	0.537	2.178

The results of TABLE 14 bivariate test show that the variable that has a significance value of less than 0.250 is :
 a. Birth history   d. Infectious disease
 b. MP ASI   e. Parenting
 c. Immunization   f. Environmental Health
 With these results, these variables were further processed at the multivariate stage.

2. MULTIVARIATE LOGISTIC REGRESSION TEST

TABLE 15
Summary of the results of the multivariate logistic regression test of the factors that affect the incidence of stunting in 2019

Variable	B	Sig.	Exp(B)	95% C.I.for EXP(B)	
				Lower	Upper
History_birth	1.238	0.014	3.447	1.284	9.257
MP_ASI	0.746	0.033	2.108	1.063	4.177
Infection Disease	0.997	0.019	2.711	1.178	6.238
Parenting	1.401	0.000	4.058	2.045	8.055
Constant	-1.400	0.000	0.247		

The results of TABLE 15 multivariate logistic regression test showed that 4 independent variables had a significance level of less than 0.05, namely birth history, complementary feeding, infectious diseases, and parenting patterns[10]. Then the OR value varied from the lowest value of 2.108 on the MP ASI variable and the highest value of 4.058 on the parenting pattern variable[14][9][15].

3. DETERMINATION OF STUNTING SCORING BASED ON OR. VALUE
So with the following interval class, the score of the OR value of each variable is as follows:

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TABLE 15
Interval Class Values

Range	Lower limit	Upper limit
Range 1		
	2.108	2.5955
Range 2	> 2.5955	3.0830
Range 3	> 3.0830	3.5705
Range 4	> 3.5705	4.058

TABLE 16
Scorecard Value

Variable	Value OR	Category Score
History_birth (1)	3.447	3
MP_ASI history (1)	2.108	1
History of Disease_Infection (1)	2.711	2
Parenting (1)	4.058	4
	Total score	10

So the equation:
Stunting = 3 Birth history + 1 MPASI + 2 Infectious Diseases + 4 Parenting

IV.   DISCUSSION
A. RISK FACTORS THAT CAUSE STUNTING
1. LBW Birth History

The data shows that almost all (76.7%) children under five with a history of LBW births are stunted and (55.2%) of babies with normal births are not stunted. Based on the results of bivariate logistic regression testing (screening variables) where the test results have a significance value of <0.250, these variables will be processed for multivariate logistic regression testing. 6 variables have a significance value of <0.250 and are then analyzed multivariate, 4 variables greatly affect the occurrence of stunting, namely; history of birth/LBW, complementary feeding, infectious diseases, and parenting patterns[18][20][14][9][15]. The multivariate logistic regression test showed that the history of LBW had a high risk of stunting, where the value of OR> 1 gave meaning if the significance level of the test results was below 0.05[15]. The magnitude of the risk factor for children experiencing stunting due to a history of LBW birth is 3,447 times that compared of normal children with a category score of 3[6]

2. HISTORY OF COMPLEMENTARY FEEDING FACTORS

The data shows that most (63.5%) children s who received MP-ASI at the right age experienced stunting and (62.2%) children s who received MP-ASI at the right age did not experience stunting. Based on the results of bivariate logistic regression testing (screening variables) where the test results have a significance value of <0.250, these variables will be processed for multivariate logistic regression testing[2]. 6 variables have a significance value <0.250 and are then analyzed multivariate, 4 variables greatly affect the occurrence of stunting, namely; history of birth/LBW, complementary feeding, infectious diseases, and parenting patterns[21][1][22][18]. The multivariate logistic regression

test showed that the MP-ASI factor had a risk for stunting, where the value of OR> 1 gave meaning if the significance level of the test results was below 0.05. The magnitude of the risk factor for children experiencing stunting due to a history of complementary feeding is 2.108 times compared to children of the right age.[23][24][25][16]

3. FACTORS HISTORY OF INFECTIOUS DISEASES

The data showed that most (72.7%) children with a history of frequent infectious diseases (moderate/severe) were stunted and most (57.3%) children with a history of mild infectious diseases did not experience stunting[14]. Based on the results of bivariate logistic regression testing (screening variables) where the test results have a significance value of <0.250, these variables will be processed for multivariate logistic regression testing. 6 variables have a significance value of <0.250 then these variables will be processed and then analyzed multivariate, 4 variables greatly affect the occurrence of stunting, namely; history of birth/LBW, complementary feeding, infectious diseases, and parenting patterns.[22][25] The multivariate logistic regression test showed that the history of infectious disease had a risk for stunting, where the value of OR> 1 gave meaning if the significance level of the test results was below 0.05. The magnitude of the risk factor for children experiencing stunting caused by frequent infectious diseases (moderate/severe) is 2.711 times that compared to mild infectious diseases, with a scoring category of 2[6][14].

4. PARENTING FACTORS

The data showed that most (71.3%) children with a history of inappropriate parenting experienced stunting and (67.4.3%) children with a history of appropriate parenting did not experience stunting[13][2][15]. Based on the results of bivariate logistic regression testing (screening variables) where the test results have a significance value of <0.250, these variables will be processed for multivariate logistic regression testing. 6 variables have a significance value of <0.250, these variables are then analyzed multivariate, 4 variables greatly affect the occurrence of stunting, namely; history of birth/LBW, complementary feeding, infectious diseases, and upbringing[9][10]. The multivariate logistic regression test showed that parenting factors had a risk for stunting, where the value of OR> 1 gave meaning if the significance level of the test results was below 0.05. The magnitude of the risk factor for children experiencing stunting caused by inappropriate parenting is 4,058 times compared to children with appropriate parenting, with a category score of 4[2][15].

The limitation of this study is that the sample of respondents is not representative and several other respondents are still needed. Similarly, in data collection, there are still many different views among individual respondents as well as other factors such as the honesty factor in filling out the opinions of the respondents in the questionnaire, so support and guidance are needed filling out the questionnaire.

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V. CONCLUSION

The purpose of the study is to design a scorecard model for the early detection of stunting risk based on the analysis of stunting. The result of this study is the scorecard able to make early detection of stunting risk with a cut-off value is 3.50. It is mean that using the scorecard has a sensitivity of 80% and specificity of 75% to detect the stunting risk of children. From the research results, the score card can be used as a choice of flies to determine stunting detection early by mothers, health cadres, and health workers. For further research may use a larger sample of respondents. It is also necessary to correct the scorecard so that it is easily understood by all sections of society, and it is better to be accompanied by an official while filling it out to avoid mistakes in understanding the question.

VI. ACKNOWLEDGMENTS

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SCORECARD
EARLY DETECTION OF STUNTING RISK (DDRS) IN CHILDREN ≤ 60 MONTHS

Child Name :

Sex :

Age in months : ....months   Height: .... cm   Weight: .... kg

Date of birth :   birth weight: ....gram

Date of the examination :

No.	Risk Factor	Score				
1.	Incomplete basic immunizations	1				
2.	Breast milk substitutes are not on time	1				
3.	Low Birth Weight (<2500 grams)	2				
4.	Any dietary restrictions for children	2				
5.	Frequent communicable diseases (moderate/severe infection)	3				
6.	Improper parenting	4				
	Total Skor					

Category: Low risk
               High Risk

Information: Low risk   Skore: < 3,5
                High Risk
                       Skore: ≥ 3,5

Recommendation:

1. Low risk   :   Counseling, Information, and Education, it is recommended to always come to the Integrated Service Post for age-appropriate growth and development monitoring and Supplementary Feeding

2. High risk   :   Counseling, Information and Education, Provision of Supplementary Food and Referrals to Community Health Facilities (Puskesmas) and/or Level 1 Hospitals