Jabatan Radiologi
Hospital Melaka

IMPROVING THE IMAGE QUALITY OF CERVICAL SPINE RADIOGRAPHS IN THE RADIOLOGY DEPARTMENT, HOSPITAL MELAKA

Group: Armstrong

Dr. Nyin Li Yuen (Radiologist)
Dr. Siti Nurhamimah Yaacob (Medical Officer)
Dr. Nurul Amani Noordin (Medical Officer)
En. Goh Joon Hin (Radiographer)
Pn. Nur Samila Sajali (Radiographer)
Pn. Nur Aziera Abdul Aziz (Radiographer)

PROBLEM IDENTIFICATION

No.	PROBLEMS
1.	Suboptimal image quality of extremities radiograph in Paediatric patients
2.	Increased number of unnecessary computed tomography pulmonary artery (CTPA) request with negative CT findings of thromboembolism
3.	Suboptimal image quality of cervical spine (C-Spine) radiographs
4.	Increased turn around appointment date for Paediatric ultrasound appointments
5.	Increased incidence of reprinting radiological reports and films

PROBLEM PRIORITIZATION

PROBLEM	S	M	A	R	T	TOTAL
1. Suboptimal image quality of extremities radiograph in Paediatric patients	11	10	8	10	10	49
2. Increased number of unnecessary computed tomography pulmonary artery (CTPA) request with negative CT findings of thromboembolism	9	9	9	9	7	43
3. Suboptimal image quality of C-Spine radiographs	9	9	11	11	10	50
4. Increased turn around appointment date for Paediatric ultrasound appointments	8	8	8	8	8	40
5. Increased incidence of reprinting radiological reports and films	6	9	9	8	8	40

Scoring scale: 1- low, 2- medium, 3- high
Voting group members: 4

PROBLEM ANALYSIS

SERIOUSNESS	Suboptimal study of C-Spine radiographs may lead to missed findings and the need of performing CT C-Spine which may increase radiation exposure to the patients and increase the cost of imaging.
MEASUREABILITY	The acceptability of the C-Spine radiograph can be evaluated through the criteria in each views of the C-Spine radiographs.
APPROPRIATENESS	C-Spine radiograph is the baseline imaging in patients with C-Spine problems. With increasing requests from the clinicians, it is appropriate to improve the quality of the study to provide the optimal information to the clinicians.
REMEDIABLE	The quality of C-Spine radiograph can be improved by implementing measures and proper techniques to the radiographers.
TIMELINESS	Pre- and post remedial parameters can be completed and analyzed. This problem can be improved in a period of time.

PROBLEM ANALYSIS

SERIOUSNESS	Suboptimal study of C-Spine radiographs may lead to missed findings and the need of performing CT C-Spine which may increase radiation exposure to the patients and increase the cost of imaging.
MEASUREABILITY	The acceptability of the C-Spine radiograph can be evaluated through the criteria in each views of the C-Spine radiographs.
A	ACCEPTABILITY CRITERIA: CERVICAL SPINE RADIOGRAPH AP VIEW Visualization of C3-T2 vertebral bodies, intervertebral discs, space between the pedicles and intervertebral discs Spinous process and sternoclavicular joint is equidistant from the spinal column lateral borders Intervertebral discs spaces should be open Good soft tissues and bones delineation  Frank E, Long B, Smith B, Merrill V. Merrill's atlas of radiographic positioning & procedures. 12th ed. Jeanne Olson ACCEPTABILITY CRITERIA: CERVICAL SPINE RADIOGRAPH LAT VIEW Visualization of C1-C7 vertebral bodies, intervertebral discs, articular pillars and spinous process C1 to C2 is clear from rami of mandible Superimposition of both rami of mandible, both sides of apophyseal joints and posterior borders of vertebral bodies Good soft tissues and bones delineation  Frank E, Long B, Smith B, Merrill V. Merrill's atlas of radiographic positioning & procedures. 12th ed. Jeanne Olson
R	
T	

PROBLEM STATEMENT

- We found only 31.0% of our C-spine radiographs were optimal in our department as compared to 23.4% in a study done by Shrestha et al. (2016).
- Unnessary CT C-spine may encounter, which can lead to additional radiation dose to the patients. We found that there were two CT C-spine performed from the suboptimal radiographs in our study, which costed about extra RM 1490 in addition to a 4-fold increase in radiation dose to the patients.

Verification study from 1st Mar 2020 to 14th Mar 2020

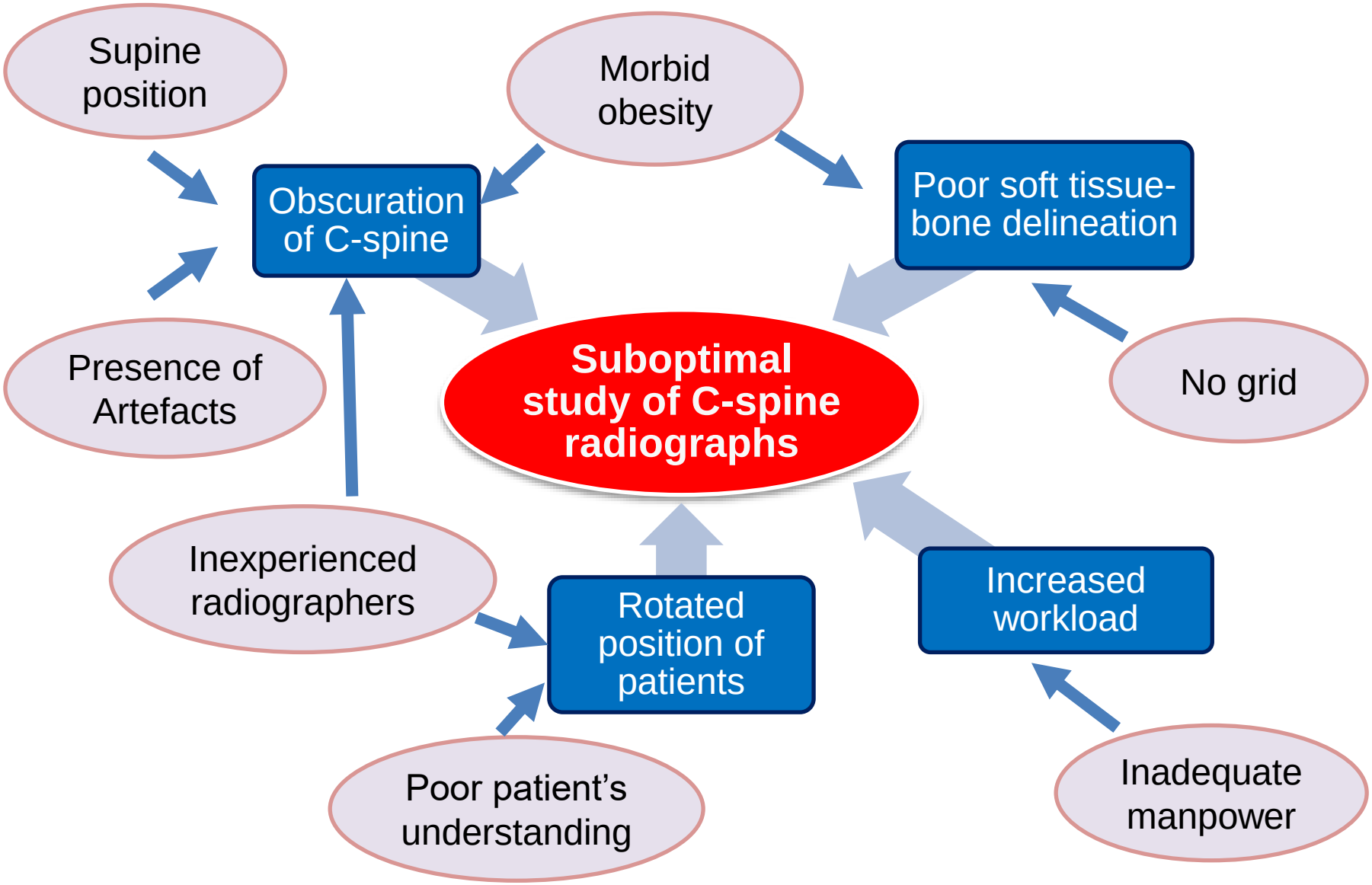
S Shrestha et al. Evaluation Of Image Quality In Cervical Spine Lateral Radiographs. Journal of Chitwan Medical College 2016; 6(15): 30-33

Paula J. Richards et al.Major Trauma & Cervical Clearance Radiation Doses & Cancer Induction. Injury, Int J.Care Injured (2008) 39, 347-356

PROBLEM STATEMENT

- The possible causes can be poor technique of the radiographers, inadequate manpower, artefacts, insufficient usage of grid, and poor patient's cooperation.
- This can be improved by implementing certain measures in the department. In this study, we hope to identify contributing factors and to propose remedial actions.

CAUSE EFFECT ANALYSIS



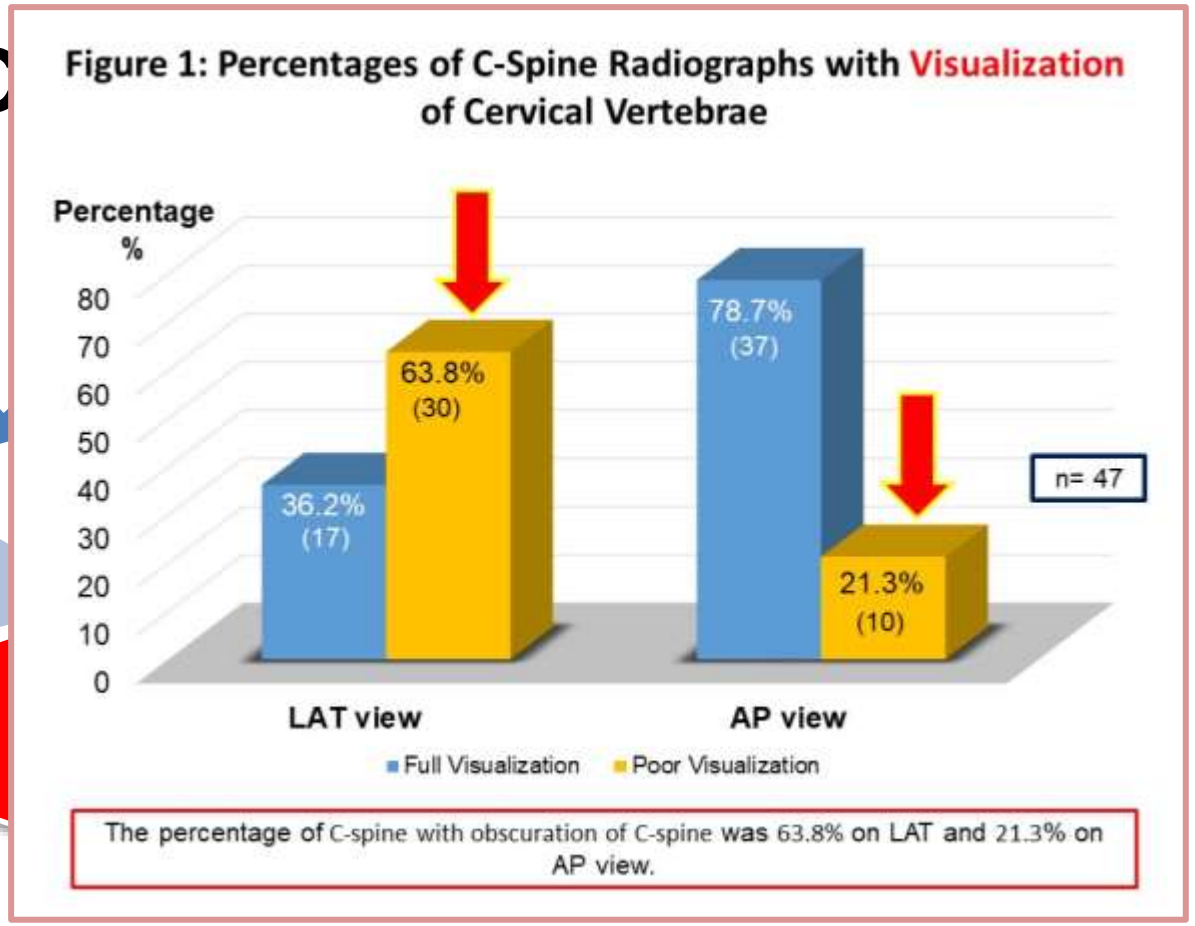
C

Supine position

Presence of Artefacts

Obscuration of C-spine

Inexperienced radiographers



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Supine position

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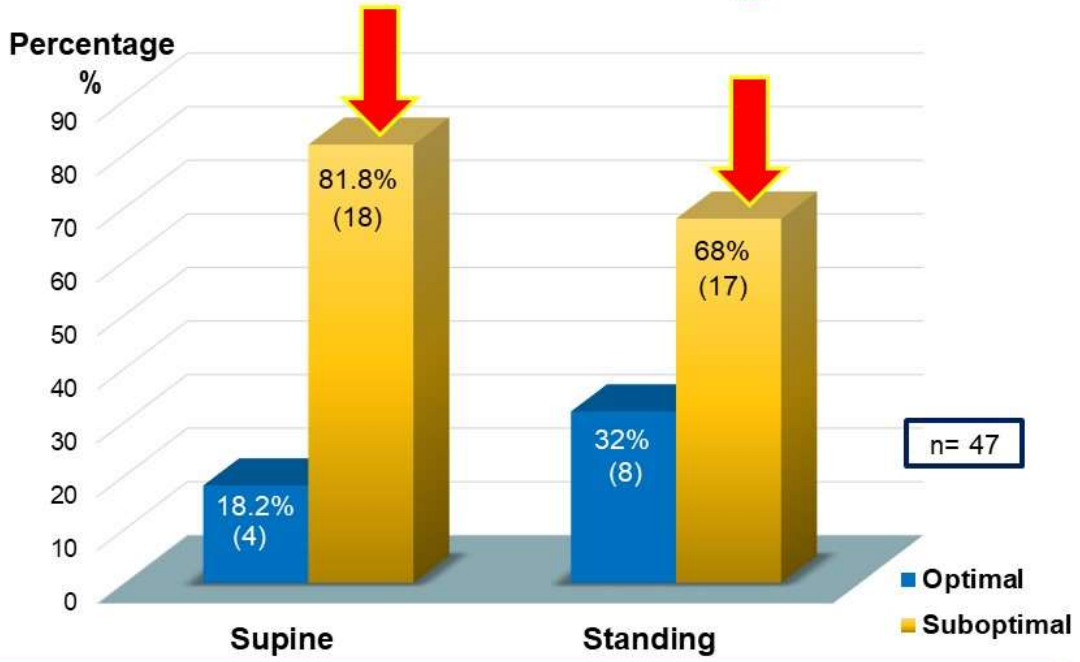
Figure 2: Percentages of C-Spine Radiographs Based on Positioning



Supine C-spine radiographs has high percentage of suboptimal study (81.8%) as compared to standing C-spine radiographs.

CAUSE EFFECT ANALYSIS

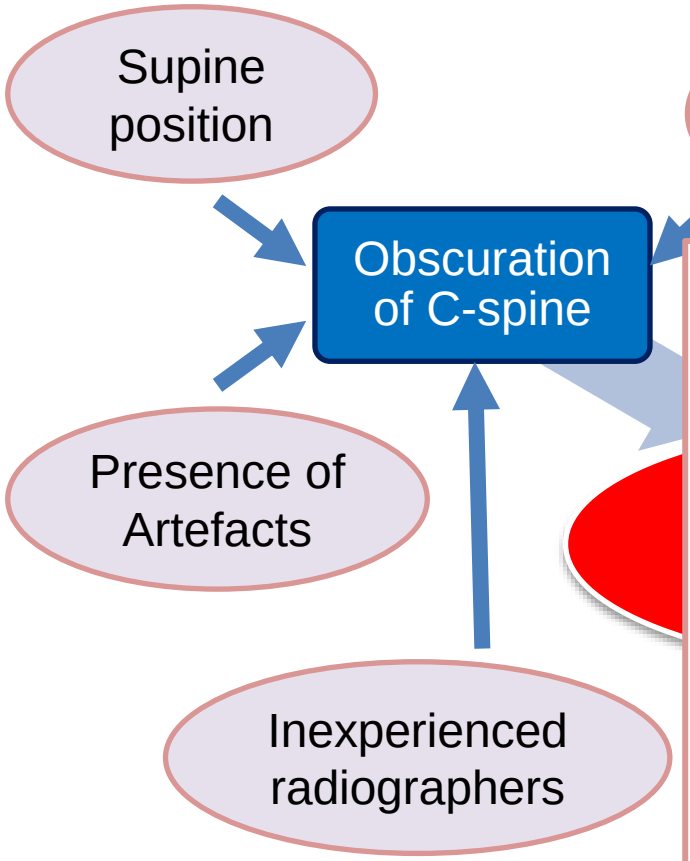


Table 1: The Acceptability of C-Spine Radiograph According to Body Weight

Body Weight Category (kg)	Optimal		Suboptimal	
	Number	%	Number	%
Below 60 (n=29)	10	34.5	19	65.5
61 to 80 (n=15)	1	6.7	14	93.3
Above 80 (n=3)	0	0	3	100

n= 47

CAUSE EFFECT ANALYSIS

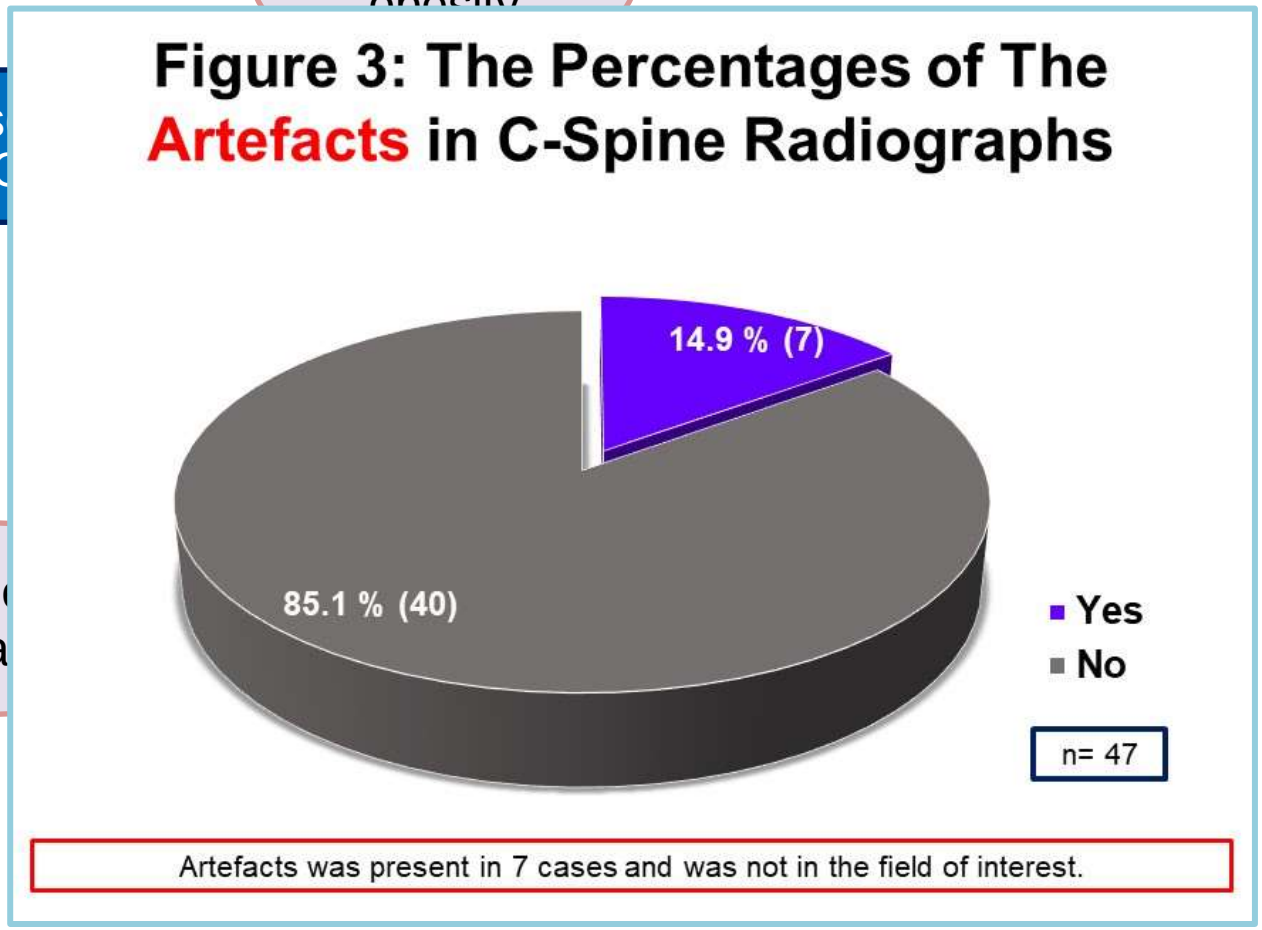
Supine position

Morbid obesity

Obs of C

Presence of Artefacts

Inexperi radiogra



CAUSE EFFECT ANALYSIS

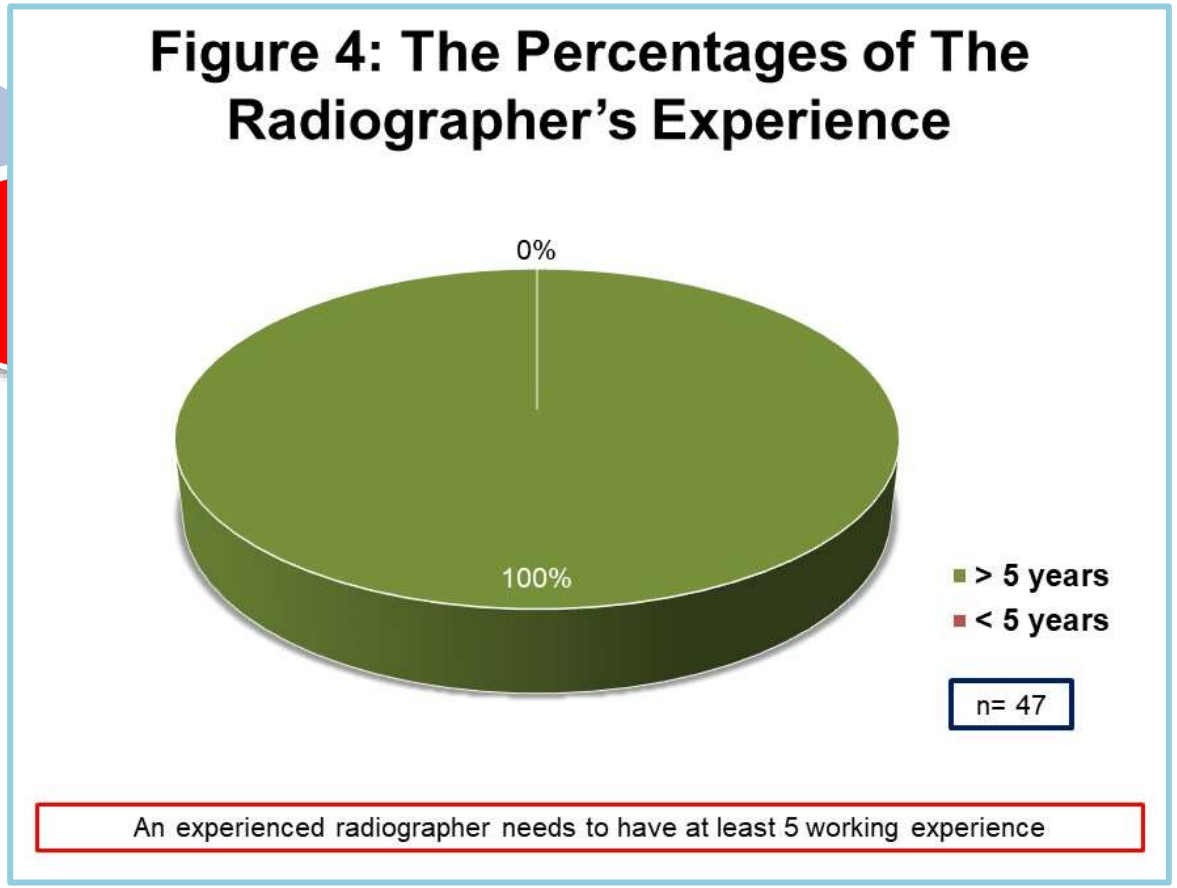
Supine position

Morbid obesity

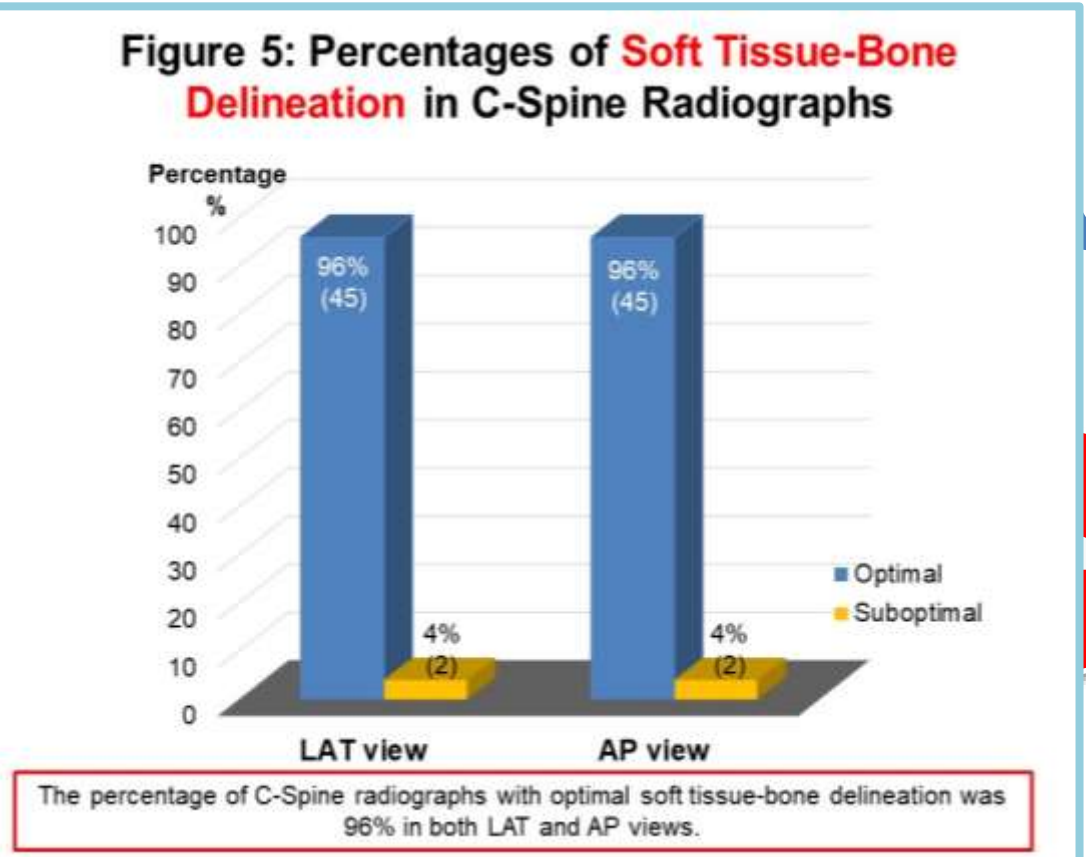
Obscuration of C-spine

Presence of Artefacts

Inexperienced radiographers



CAUSE EFFECT ANALYSIS



Poor soft tissue-bone delineation

No grid

CAUSE EFFECT ANALYSIS

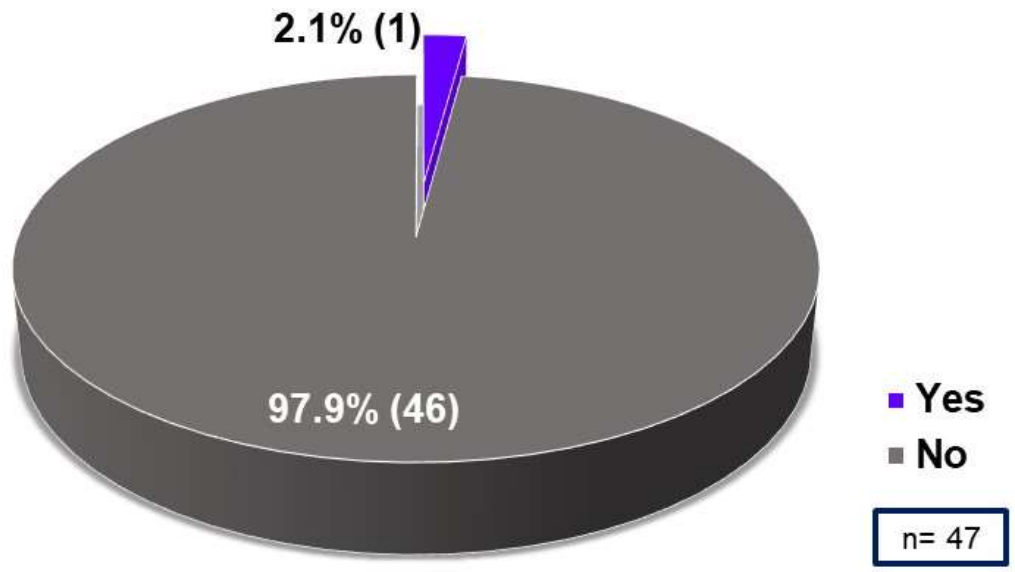
Supine position

Morbid obesity

ue-
ion

No grid

Figure 6: The Percentages of The Usage of Grid in C-Spine Radiographs



The grid was used in one of the cases to improve the contrast of the image. However, it was suboptimal due to other factors.

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Hospital Melaka

CAUSE EFFECT ANALYSIS

Supine position

Morbid obesity

Obscuration

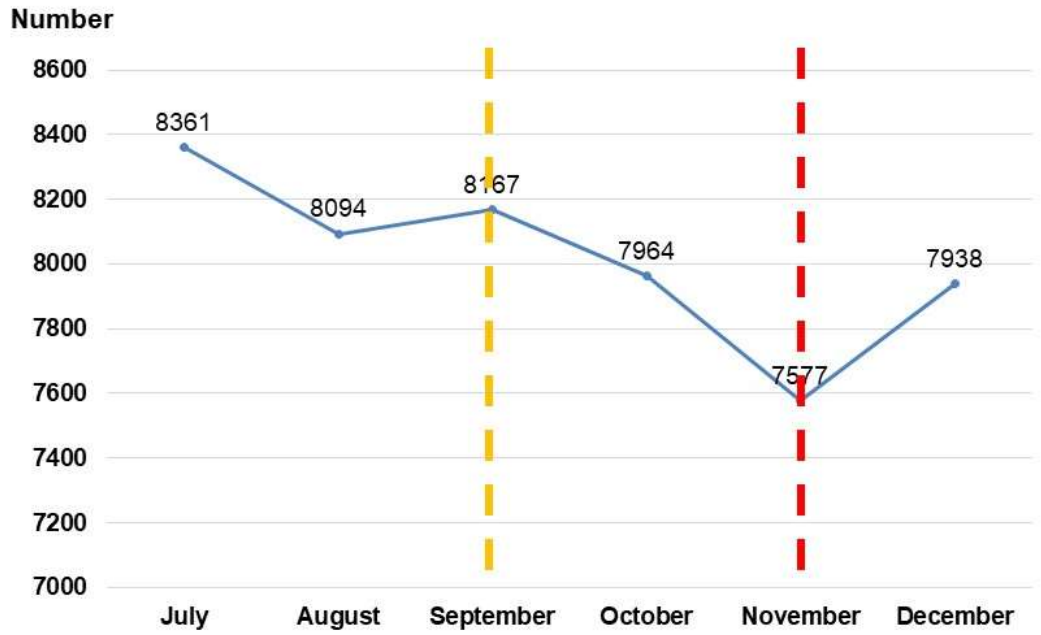
Poor soft tissue-bone delineation

No grid

Increased workload

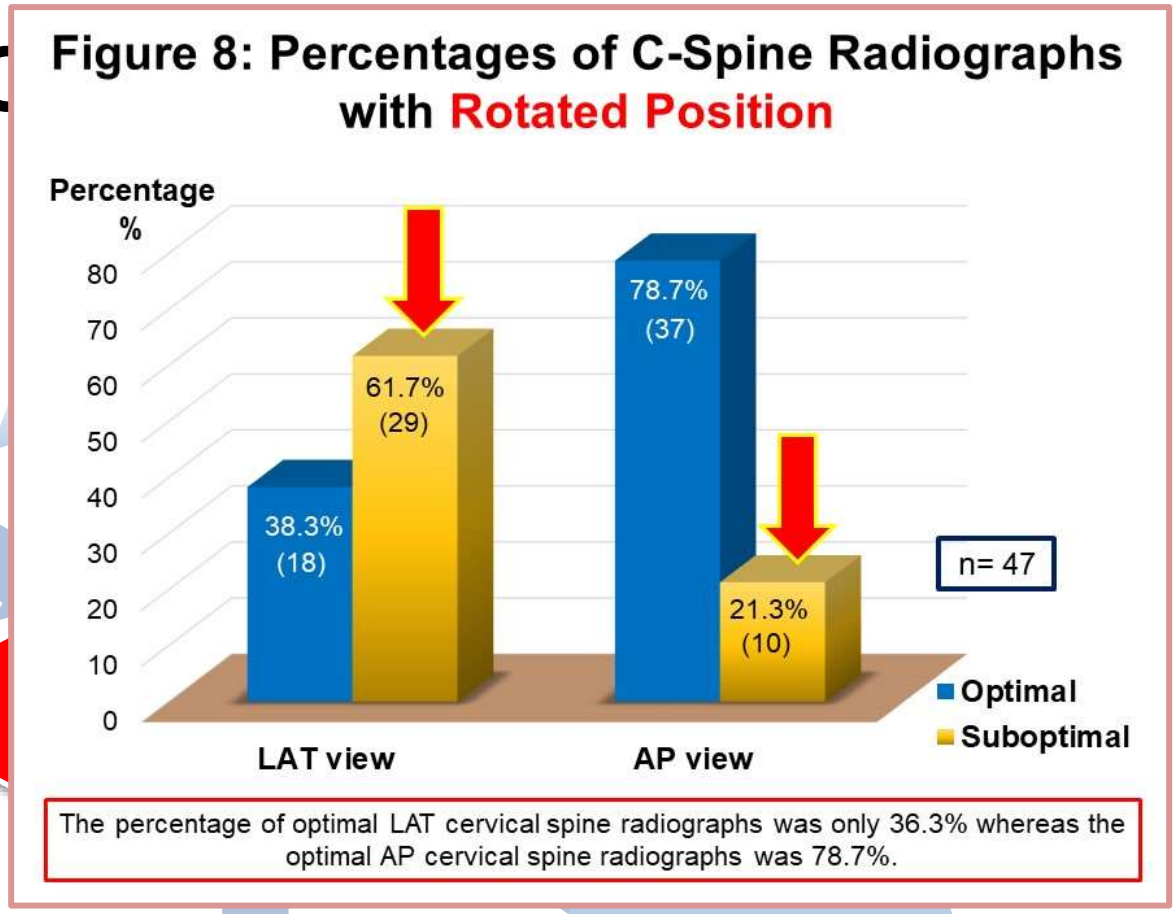
Inadequate manpower

Figure 7: The Total Number of The General X-Ray From July 2020 to December 2020



There was a reduction of the total number of general X-Ray cases from September to November which showed there was no increase in workload in the study period.

C



Supine position

Obscuration of C-spine

Presence of Artefacts

Inexperienced radiographers

Rotated position of patients

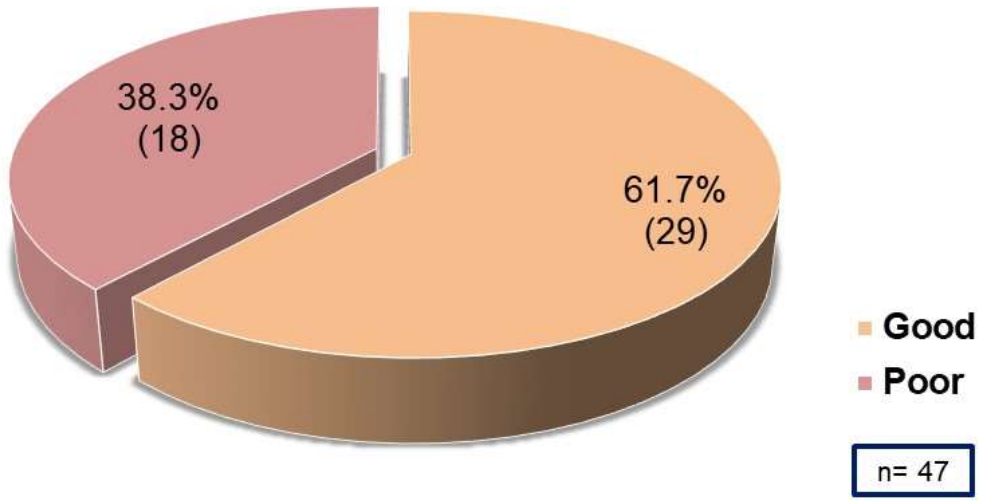
Poor patient's understanding

Increased workload

Inadequate manpower

ECT ANALYSIS

Figure 9: The Percentages of The Level of Patient's Understanding



Good understanding: A patient could follow > 50% the instructions during the procedure
Poor understanding: A patient could follow < 50% of the instructions during the procedure

Poor soft tissue-bone delineation

No grid

Increased workload

Inadequate manpower

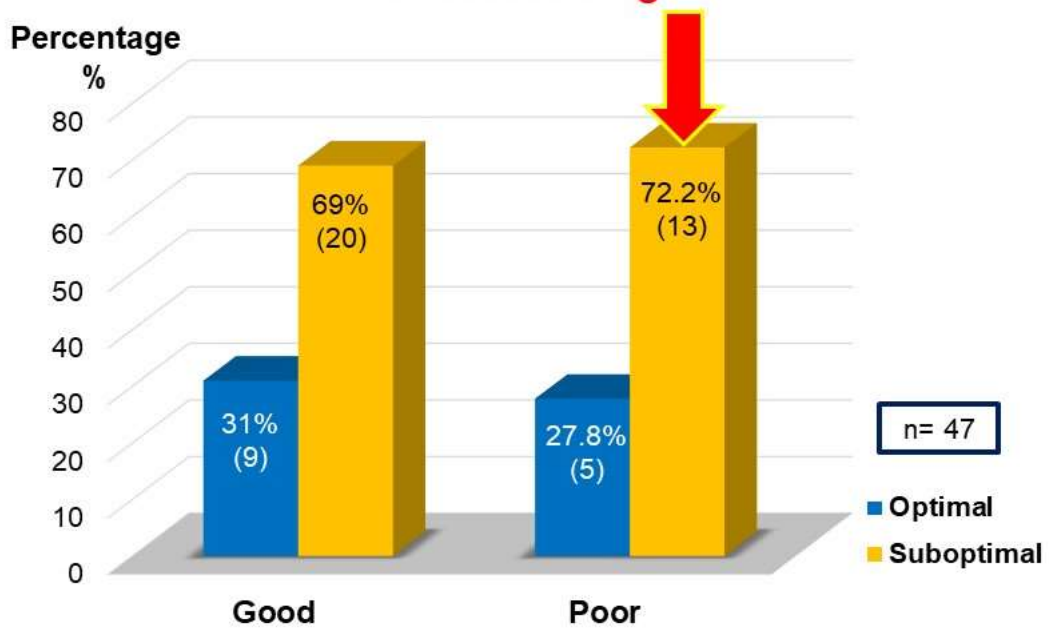
radiographers

Rotated position of patients

Poor patient's understanding

CAUSE EFFECT ANALYSIS

Figure 10: Percentages of The Acceptability of Cervical Spine Radiographs According to the Level of Patient's Understanding



Higher suboptimal cervical spine radiographs was observed in patients with poor understanding (72.2%)

Poor patient's understanding

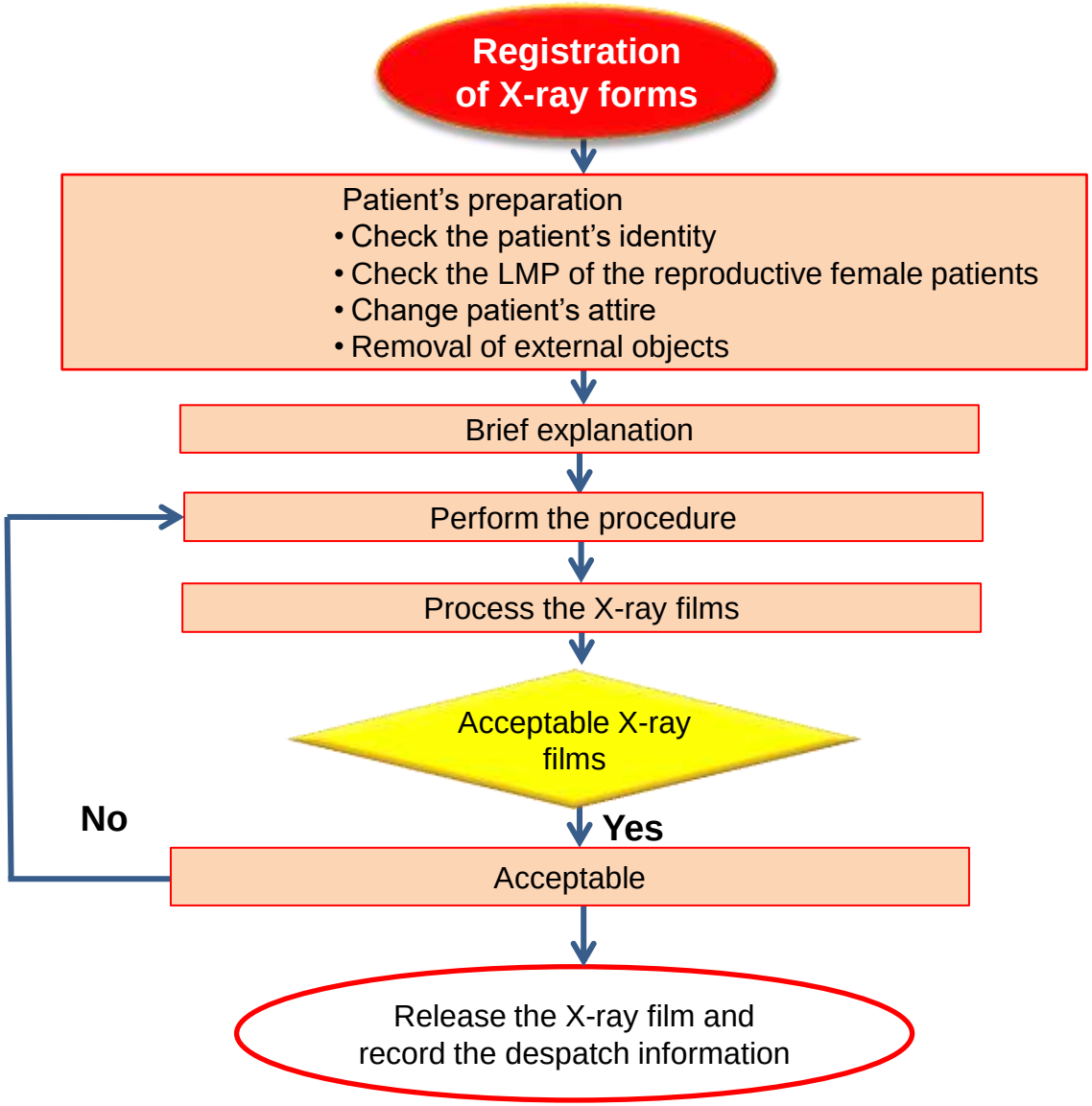
soft tissue-
delineation

No grid

Increased workload

Inadequate manpower

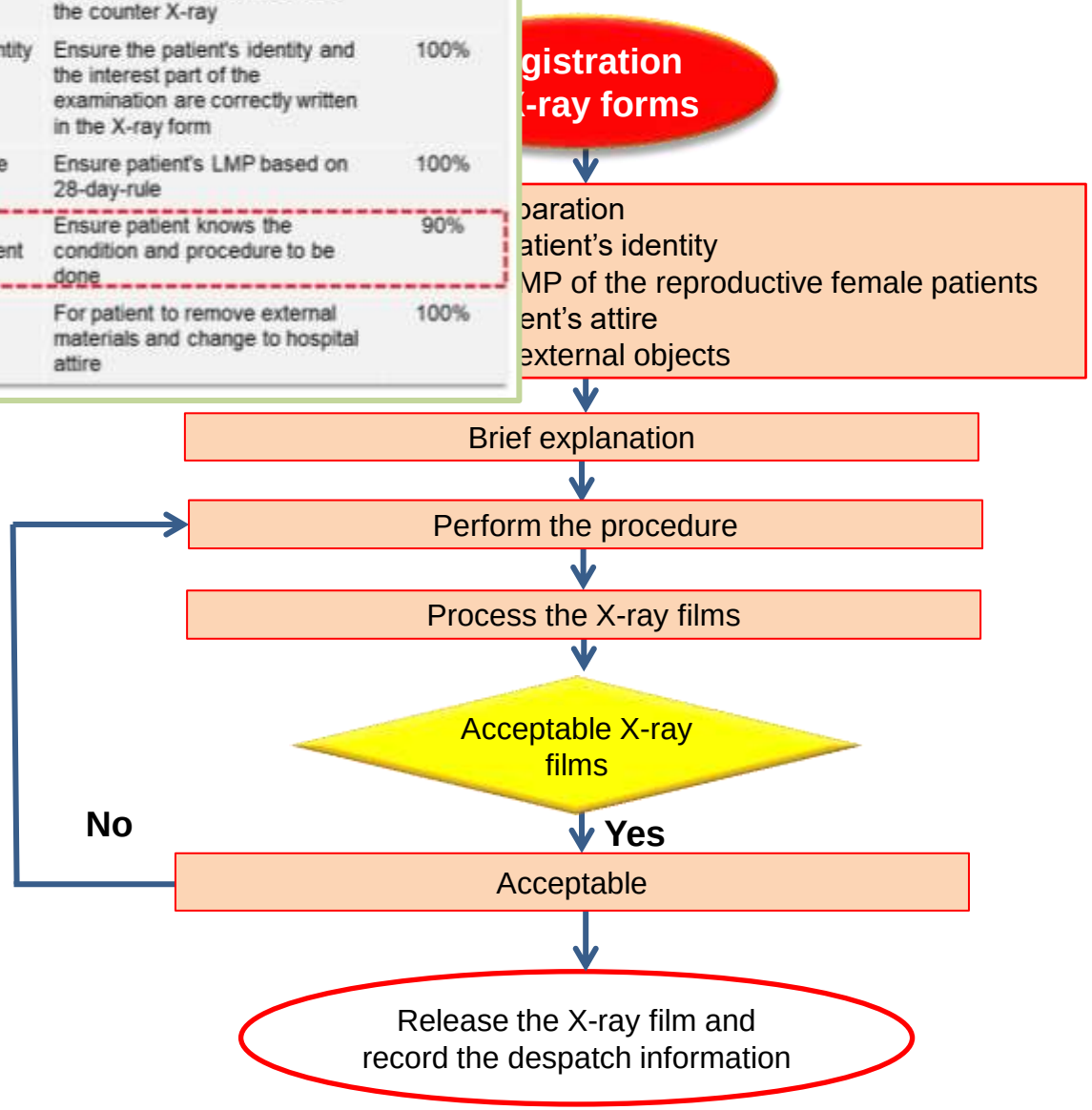
PROCESS OF CARE:
C-SPINE RADIOGRAPH



PROCESS OF CARE:
C-SPINE RADIOGRAPH

MODEL OF GOOD CARE

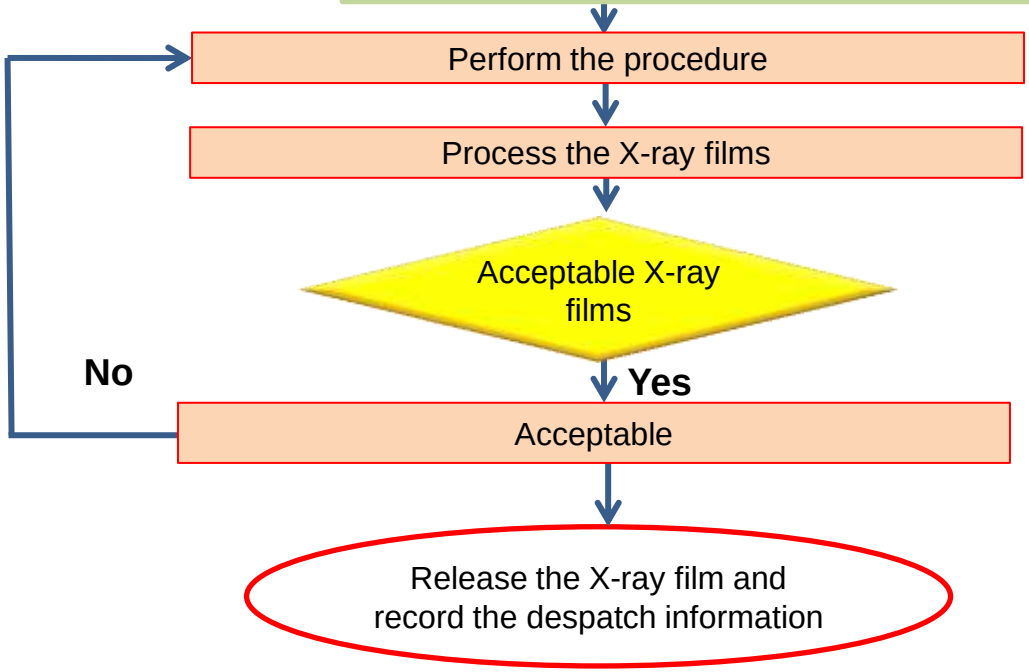
No.	Process	Criteria	Standard
1	Patient's registration	Ensure the X-ray form is registered in the general plain radiograph registration book at the counter X-ray	100%
2	Check the patient's identity before procedure	Ensure the patient's identity and the interest part of the examination are correctly written in the X-ray form	100%
3	Identify the reproductive female patient	Ensure patient's LMP based on 28-day-rule	100%
4	Brief explanation on examination to the patient	Ensure patient knows the condition and procedure to be done	90%
5	Patient's preparation	For patient to remove external materials and change to hospital attire	100%



PROCESS OF CARE:

MODEL OF GOOD CARE

No.	Process	Criteria	Standard
6	Performing the procedure	Proper positioning is applied accordingly with suitable protective lead shield and acceptable exposure factors	90%
7	X-ray film's acceptability	The image quality of the X-ray films are assessed by the radiographers	90%
8	Films despatchment	Depending on in- or outpatient basis	100%



QA STUDY:
METHODOLOGY

GENERAL OBJECTIVE	To improve image quality of C-spine radiographs
SPECIFIC OBJECTIVES	1. To **determine** the magnitude of the problem 2. To **find out** the contributing factors which can lead to reduce the quality of C-spine radiograph 3. To **establish** appropriate remedial measures to improve the quality of C-spine radiograph 4. To **evaluate** the remedial action and effectiveness of the remedial action

METHODOLOGY:
To Measure the Magnitude of the Problem

1	TYPE OF STUDY	Cross sectional
2	SAMPLING METHOD	All the C-spine radiographs performed during the study period
3	SAMPLE SIZE	All the C-spine radiographs
4	TOOLS	✓ All the C-spine radiographs traced from the general plain radiograph registration book ✓ All the X-ray images from CR viewer was retrieved and assessed for acceptability using **checklist (filled by the radiologist and MO)** for both AP and LAT C-spine radiographs respectively ✓ Data was collected and analyzed using Microsoft Excel Worksheet
5	STUDY PERIOD	2 weeks

METHODOLOGY:

To Find Out the Contributing Factors

1	TYPE OF STUDY	Cross sectional
2	SAMPLING METHOD	All the C-spine radiographs performed during the study period
3	SAMPLE SIZE	All the C-spine radiographs
4	TOOLS	✓ A **checklist (filled by the radiographers)** for both AP and LAT C-spine radiographs respectively ✓ Data was collected and analyzed using Microsoft Excel Worksheet
5	STUDY PERIOD	2 weeks

METHODOLOGY:
Criteria

INCLUSION CRITERIA	All the C-spine radiographs performed in the general x-ray rooms in the main X-ray department
EXCLUSION CRITERIA	✓ All the C-spine radiographs with **single view** alone (either AP or LAT) ✓ Paediatric patients (< 12 years old) ✓ Intubated or confused patients

METHODOLOGY:
Key Word Definition

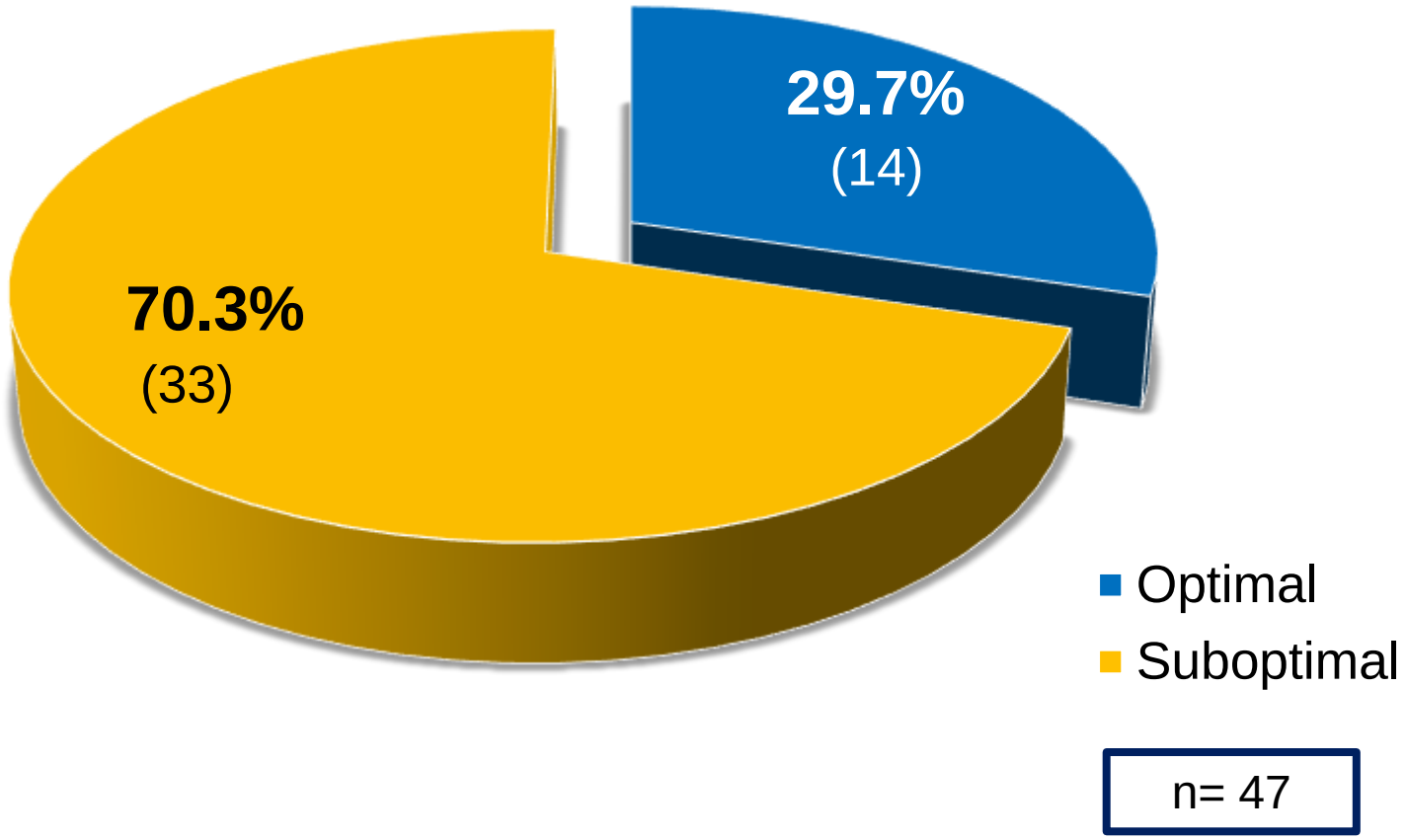
Key word	Definition
Cervical spine radiograph	It is a non-invasive X-ray examination that uses small amount of radiation to take a picture of bones in the neck
Optimal cervical spine radiograph	**All** acceptability criteria of AP and LAT C-spine radiographs

METHODOLOGY:
Proposed Indicator & Standard

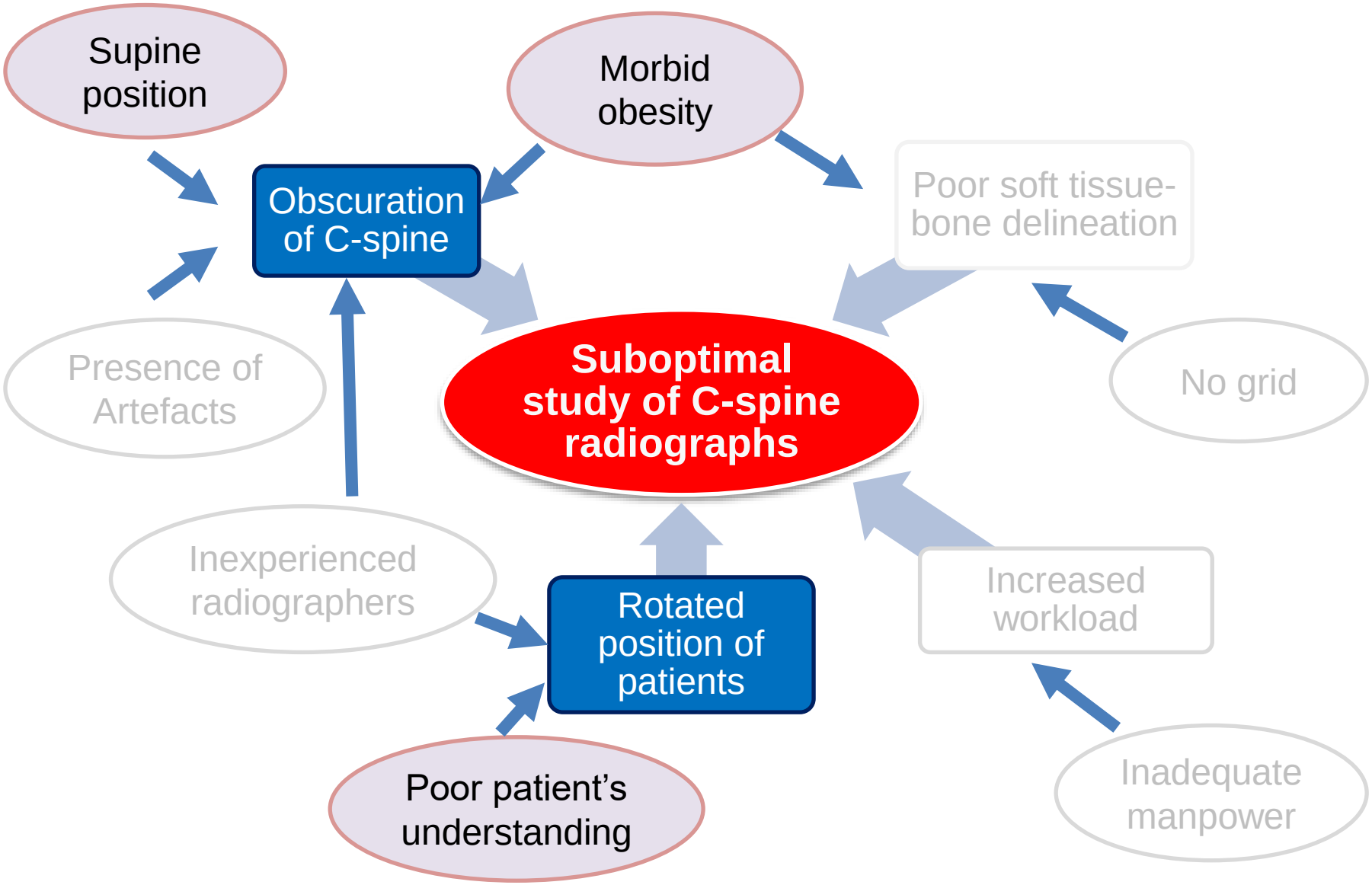
INDICATOR	FORMULA	PROPOSED STANDARD
Percentage of Optimal C-Spine Radiographs	$\frac{\text{Total number of the optimal C-spine radiographs}}{\text{Total number of C-spine radiographs}} \times 100$	**70%**

The proposed standard is based on the availability and appropriateness of the facilities and manpower in our current workflow

Figure 11: Percentages of Acceptability of C-Spine Radiographs



CAUSE EFFECT ANALYSIS



CAUSE EFFECT ANALYSIS

Table 2: Contributing Factors

Factors	Optimal	Suboptimal	Comments
Rotated position			
➢ LAT	38.3	**61.7**	★
➢ AP	78.7	21.7	
Positioning			
➢ Supine	18.2	**81.8**	★
➢ Standing	32.0	68.0	
Body weight			
➢ < 60 kg	34.5	65.5	
➢ 61 – 80 kg	6.7	**93.3**	★
➢ > 80 kg	0	**100**	★
Patient's understanding			
➢ Good	31.0	69.0	
➢ Poor	27.8	**72.2**	★

Pre-remedial study 1st Sep 2020 to 2nd Oct 2020 (n = 47)

AIMS

1. To reduce the rotated position in LAT C-spine radiographs
2. To improve the techniques on supine
3. To improve the techniques in patients > 60 kg
4. To increase the patient's understanding on C-spine radiographs to improve patient's cooperation

STEP 1

- ✓ **To straighten the C-spine on standing**
- ✓ **To reduce obscuration of lower C-Spine in patients >60kg on standing**

BEFORE

- ✓ Patient's arms are put by the body's sides freely with various degree of shoulder elevation
- ✓ The neck is easily flexed

Use **POWER TANK 5KG** for all the cases if possible. However, if the patient is weak and unable to carry the Power Tank 5kg, a **POWER TANK 3KG** can be used instead.

To improve the visualization of C7-T1 level by drawing down the shoulders.

REMEDIAL

Power Tank

STEP 2

- ✓ **To prevent rotation and to straighten the C-spine on supine**
- ✓ **To reduce obscuration of lower C-Spine in patients >60kg on supine**

Put the neck board behind the patient's neck.

Apply the flexible **STRAP** onto the forehead.

BEFORE

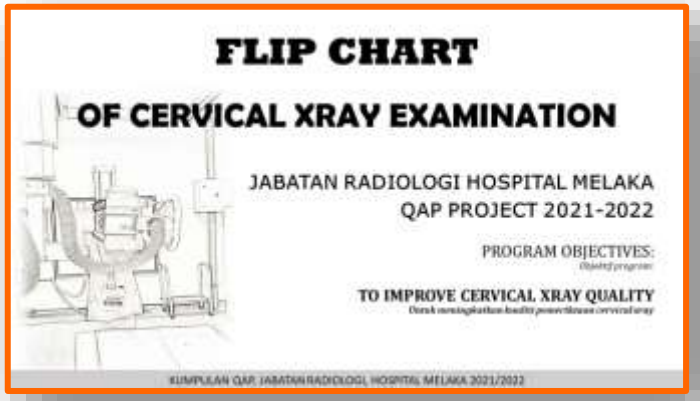
- ✓ Patient's arms are put by the body's sides freely with elevated shoulder
- ✓ No support around the head to prevent rotation
- ✓ The neck is easily flexed

REMEDIAL

Neck Board with Flexible Strap

STEP 3

- ✓ **To improve patient's understanding to facilitate cooperation**



BEFORE

- ✓ No systematic explanation to the patients especially in patients with inadequate understanding
- ✓ Patients tend to rotate and move during the procedure

REMEDIAL

- ✓ **Flip Chart**
- ✓ **Explanatory video**

EXECUTION

Explanatory chart
The usage of Power Tank and Neck Board

Presentation
Department Motivation Meeting

Introduction of QR Code
Registration counter in Radiology Department

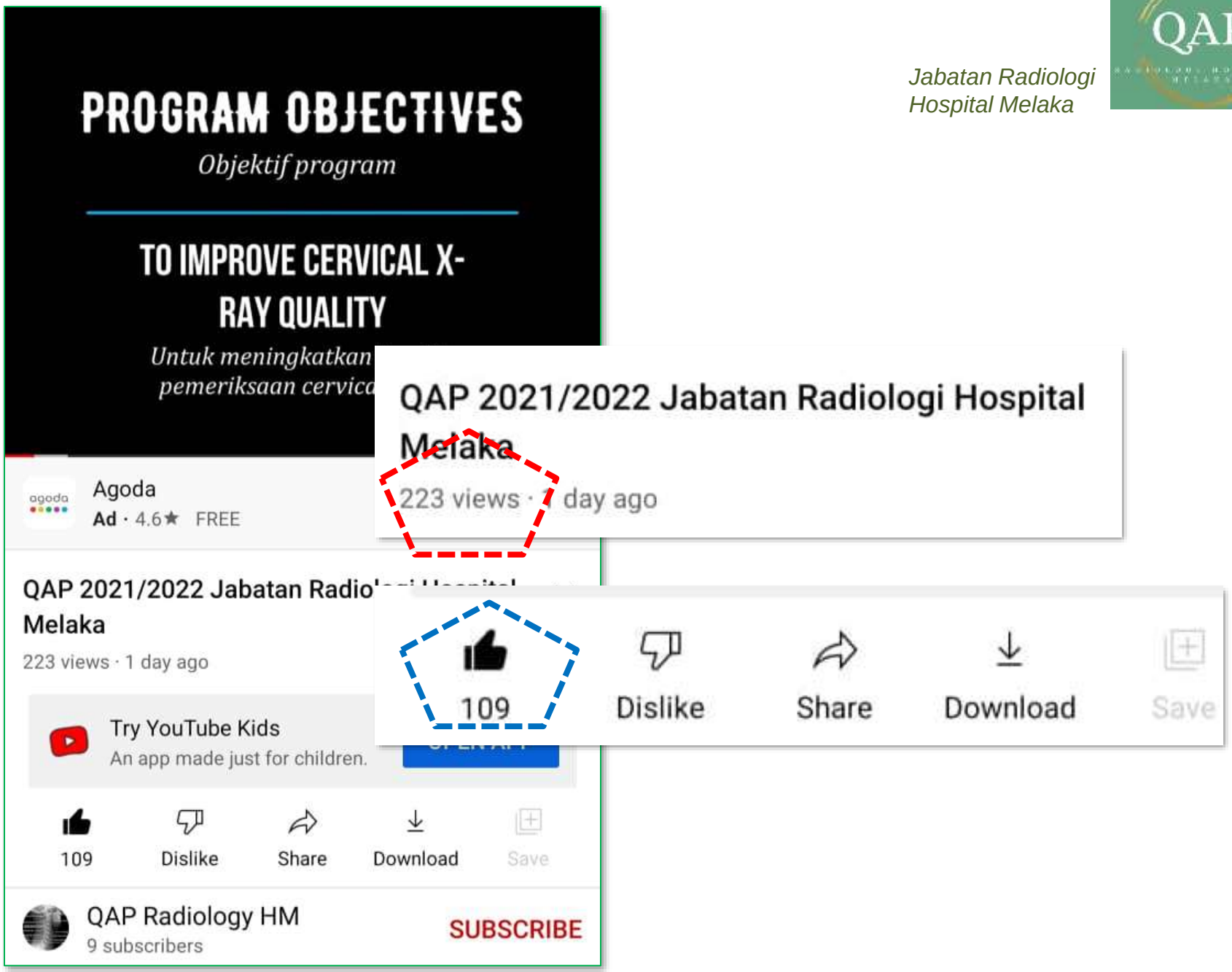
Live QA Help
Trained QA radiographers to help others

Available at all General X-Ray Rooms

Presented on 1/4/2022 19/8/2022

Explained by the radiographers

At General X-Ray Rooms and counter


PROGRAM OBJECTIVES
Objektif program
TO IMPROVE CERVICAL X-RAY QUALITY
Untuk meningkatkan
pemeriksaan cervica
Agoda
Ad · 4.6★ FREE
QAP 2021/2022 Jabatan Radiologi Hospital Melaka
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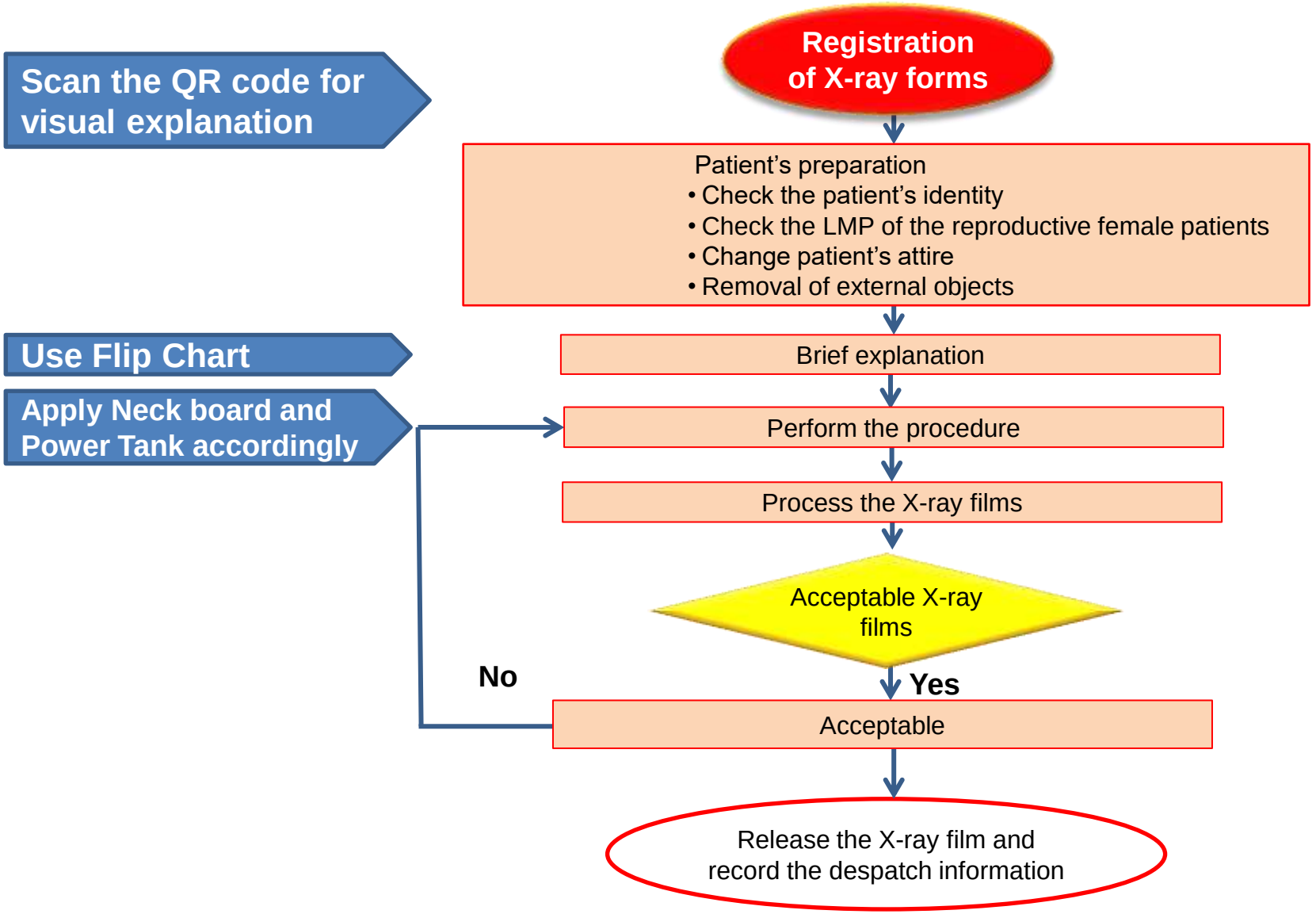
REVISED PROCESS OF CARE:
C-SPINE RADIOGRAPH



ONLINE CME TO CLUSTER HOSPITALS

Jabatan Radiologi
Hospital Melaka

HOSPITAL MELAKA
JALAN MUFTI HAJI KHALIL
75400 MELAKA

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No. Faks Pej. Pengarah : 06-284 1590
No. Faks Bhg. Pengurusan : 06-281 3240
Portal Rasmi : http://melaka.moh.gov.my

Ruj Kami: HM/JR/ 106 /22
Tarikh : Oktober 2022

Pengarah
Hospital Alor Gajah
Alor Gajah
78000 MELAKA

YBrs. Dr,

JEMPUTAN KE SESI PERBINCANGAN USAHA PENINGKATAN KUALITI RADIOGRAF *CERVICAL SPINE* DI HOSPITAL KLUSTER NEGERI MELAKA

Dengan segala hormatnya saya merujuk kepada perkara di atas.

2. Sukacitanya dimaklumkan bahawa kumpulan QA (*Quality Assurance*) Jabatan Radiologi Hospital Melaka tahun 2021 / 2022 telah menjalankan satu projek bertujuan untuk meningkatkan kualiti radiograf bagi *Cervical Spine*. Projek ini telah menunjukan hasil yang memberangsangkan. Sehubungan itu, pihak kami ingin meneruskan projek ini dengan mengaplikasikan penambahbaikan ini di Jabatan Radiologi Hospital Kluster iaitu Hospital Alor Gajah dan Hospital Jasin.

3. Untuk maklumat pihak YBrs Dr, penambahbaikan yang dimaksudkan adalah dengan menggunakan *Power Tank* dan *Neck Board* semasa melakukan pemeriksaan radiograf *Cervical Spine*. Penggunaan kedua-dua peralatan ini telah terbukti dapat meningkatkan kualiti radiograf *Cervical Spine* dengan membolehkan visualisasi tulang belakang sehingga C7 dan juga T1.

4. Sehubungan dengan usaha ini, kami akan menganjurkan satu sesi perbincangan di atas talian menggunakan platform *Google Meet* bersama Jabatan Radiologi Hospital Alor Gajah dan Hospital Jasin pada 21 September 2022 bermula jam 01:00 petang sehingga 02:00 petang. Selain itu, kami merancang untuk mengadakan lawatan bagi sesi praktikal pada keesokan harinya, 22 September 2022 dan pihak kami berharap agar YBrs Dr dapat memberi kebenaran untuk sesi lawatan ini.

"Sila nyatakan bilangan rujukan apabila menjawab"

Hospital Alor Gajah

HOSPITAL MELAKA
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Tarikh : Oktober 2022

Pengarah
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Jasin
77000 MELAKA

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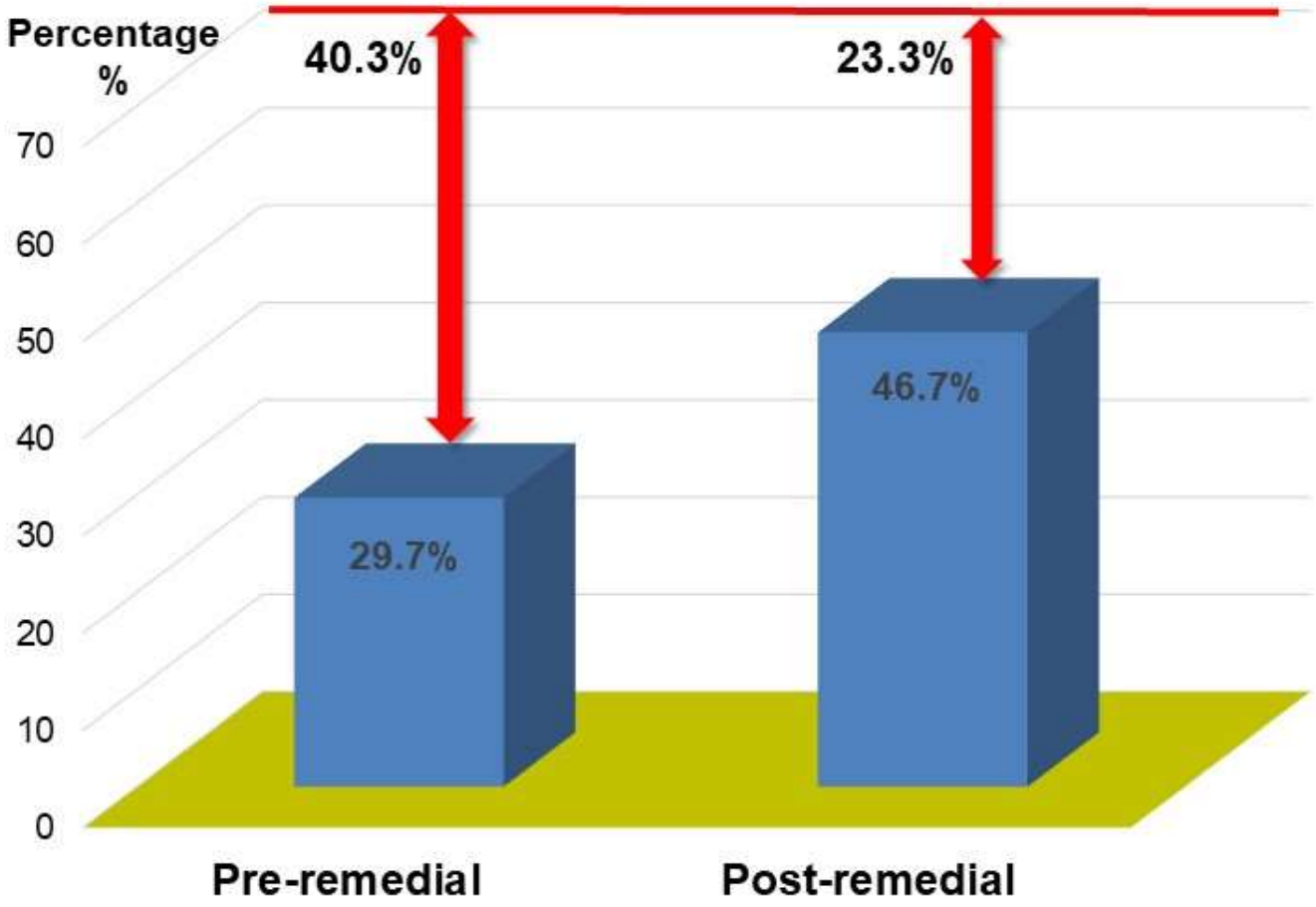
"Sila nyatakan bilangan rujukan apabila menjawab"

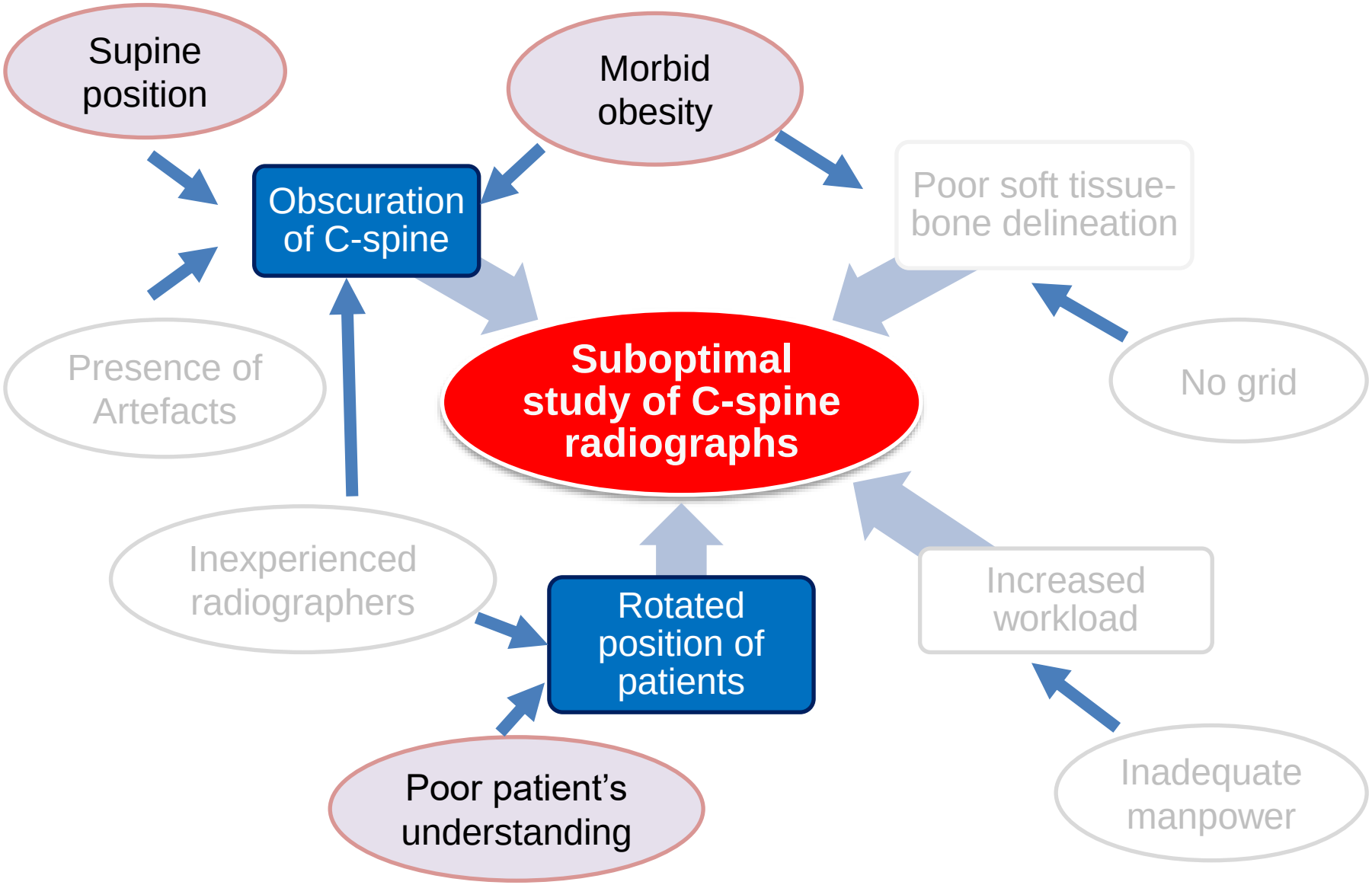
Hospital Jasin

Figure 12: Pre- and Post-remedial Percentages of Optimal C-Spine Radiographs



We still have not achieved our 70% standard
The difference of ABNA was **reduced** from 40.3% to 23.3%

CAUSE EFFECT ANALYSIS



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CAUSE EFFECT ANALYSIS

Supine position

Obscuration of C-spine

Presence of Artefacts

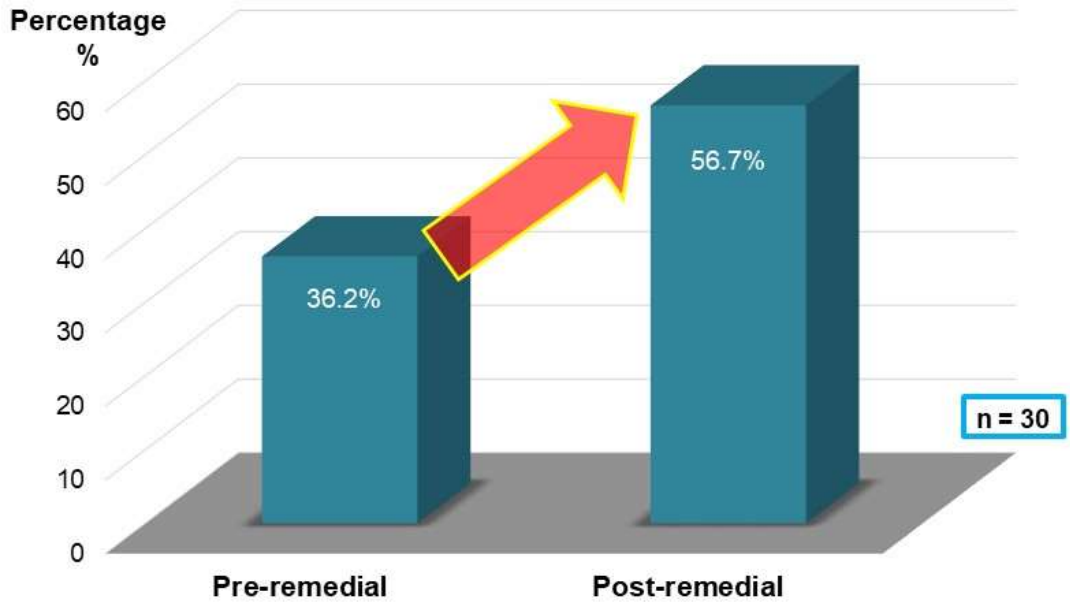
Inexperienced radiographers

patients

Poor patient's understanding

Inadequate manpower

Figure 13: Pre- and Post-remedial Percentages of LAT C-Spine Radiographs with Full Visualization of Cervical Vertebrae



The percentage of full visualization of LAT radiographs was improved from 36.2% to 56.7%

CAUSE EFFECT ANALYSIS

Supine position

Morbid obesity

Obscuration of C-spine

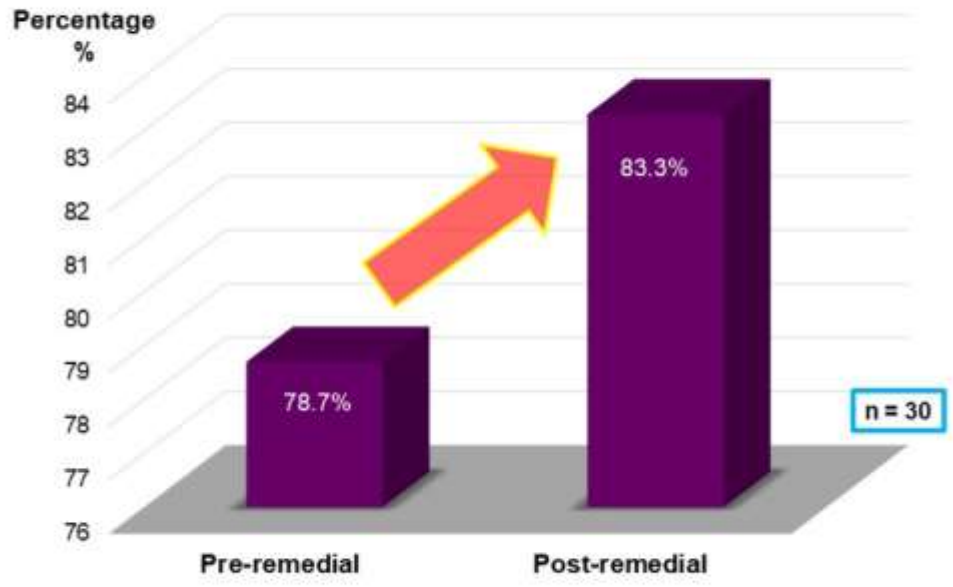
Poor soft tissue-

Presence of Artefacts

Inexperienced radiographers

Poor p
understanding

Figure 14: Pre- and Post-remedial Percentages of AP C-Spine Radiographs with Full Visualization of Cervical Vertebrae



The percentage of full visualization of AP radiographs was improved from 78.7% to 83.3%

CAUSE EFFECT ANALYSIS

Supine position

Presence of Artefacts

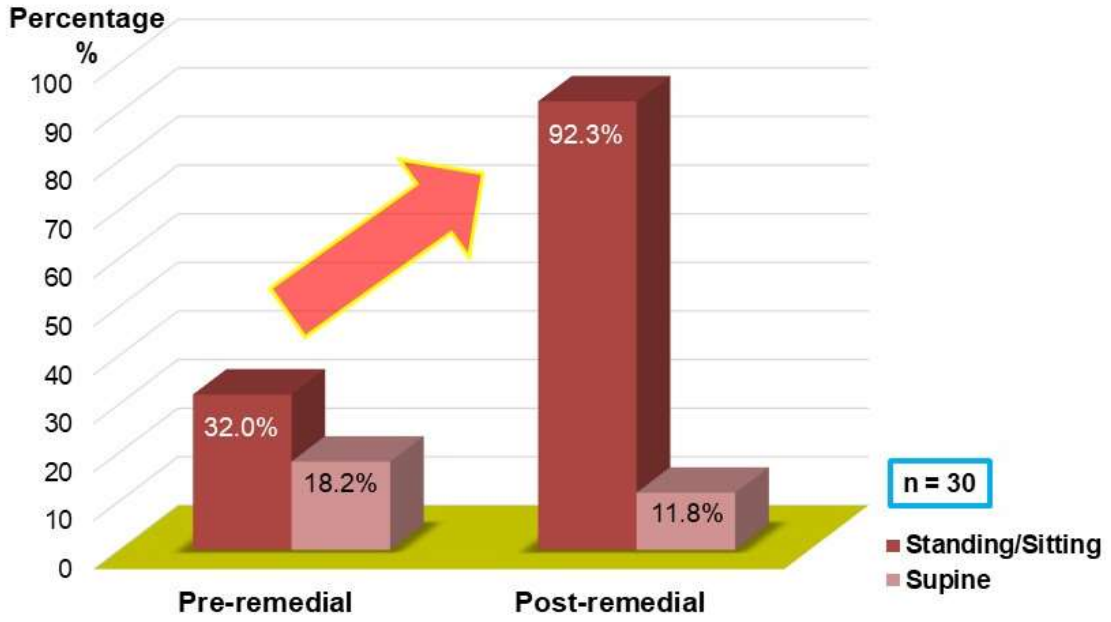
Inexpe
radiogr

grid

Poor patient's understanding

Inadequate manpower

Figure 15: Pre- and Post-remedial Percentages of Optimal C-Spine Radiographs Based on Positioning



The percentage of optimal standing/sitting radiographs was improved from 32.0% to 92.3% whereas optimal supine radiographs was reduced from 18.2% to 11.8%

CAUSE EFFECT ANALYSIS

Supine position

Morbid obesity

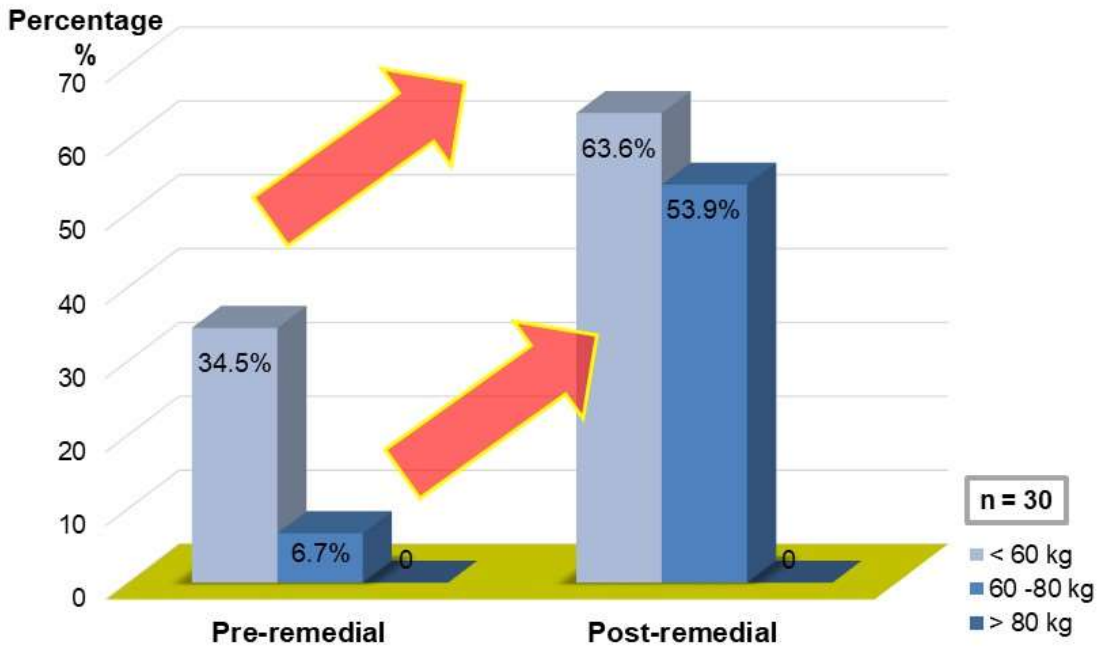
Presence of Artefacts

Inexp radio

grid

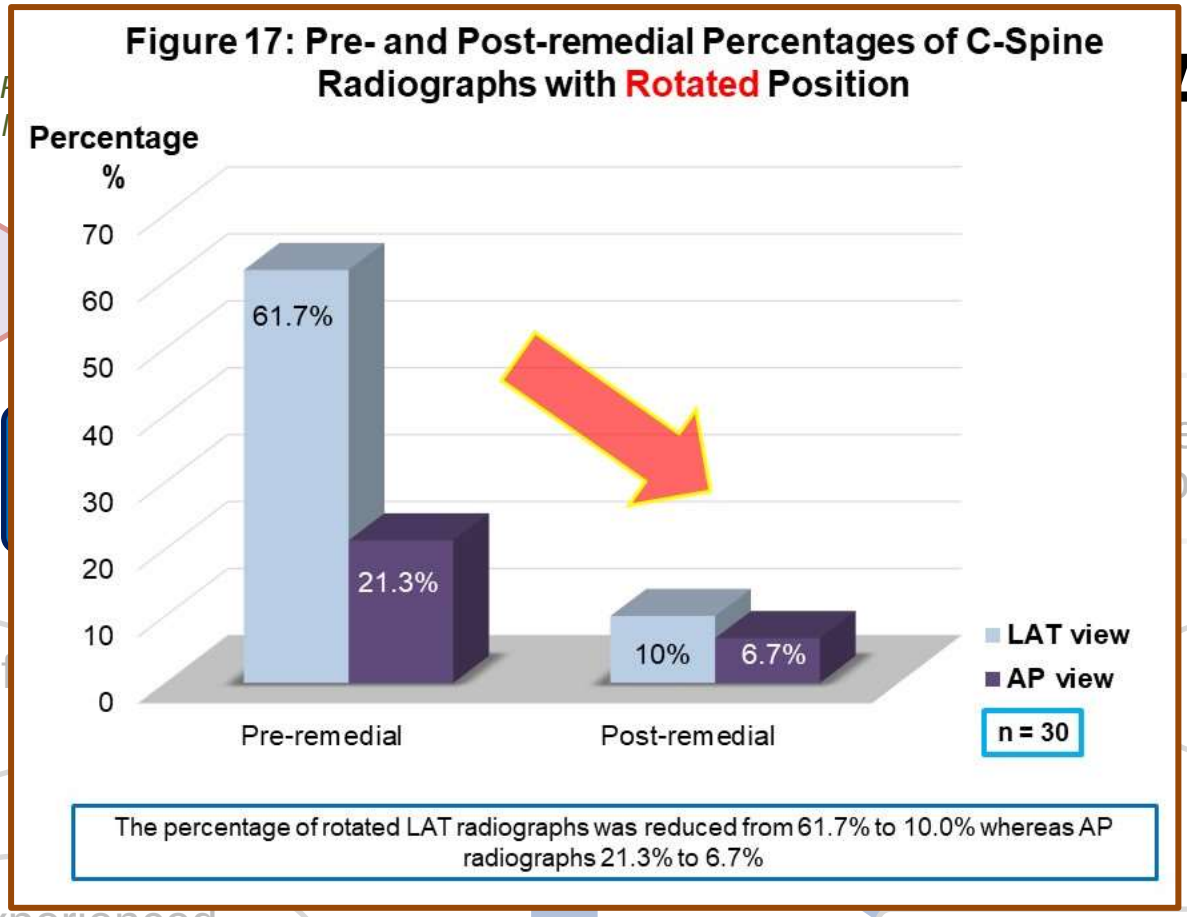
quate ower

Figure 16: Pre- and Post-remedial Percentages of Optimal C-Spine Radiographs According to Body Weight



The percentage of optimal of radiographs was improved in patients < 60 kg (34.5% to 63.6%) and 60-80 kg (6.7% to 53.9%)

ALYSIS



Supine position

Presence of Artefacts

No grid

Inexperienced radiographers

Increased workload

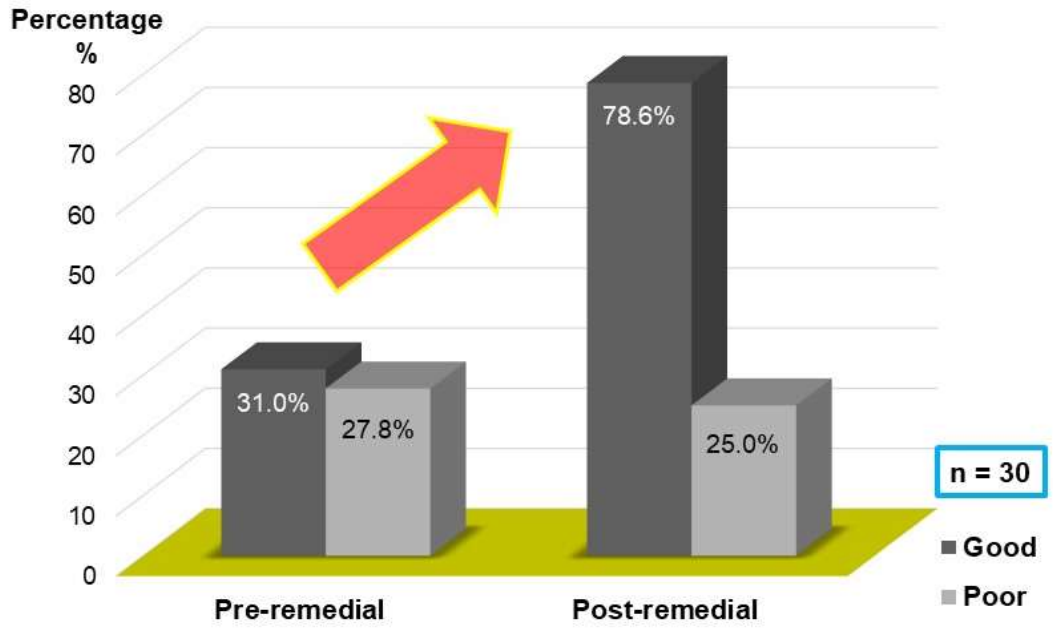
Rotated position of patients

Poor patient's understanding

Inadequate manpower

CAUSE EFFECT ANALYSIS

Figure 18: Pre- and Post-remedial Percentages of Optimal C-Spine Radiographs According to Patient's Understanding



The percentage of optimal radiographs was improved in patients with good understanding (31.0% to 78.6%) but it was not improved in patients with poor understanding (27.8% to 25.0%)

Poor patient's understanding

soft tissue-
delineation

No grid

Increased workload

Inadequate manpower

CONCLUSIONS

- In pre-remedial data, the percentage of optimal C-spine radiographs was only 29.7%.
- The main contributing factors were rotated position on LAT C-spine radiographs, positioning on supine, patient's body weight > 60kg and poor patient's understanding.
- Our innovations (Neck Board with a Flexible Strap and Power Tank) to improve the techniques of performing radiographs were used. Explanatory videos/flip charts were introduced to the patients to improve understanding.

CONCLUSIONS

- In post-remedial measures, we have **improved** the optimal C-spine radiographs from 29.7% to 46.7%.
- Although we have not achieved 70%, we are still continuing to reinforce the remedial measures in order to improve further the quality of C-spine radiographs in delivering the best patient's care in our hospital.

THE NEXT STEP

- We hope the new interventions in the process of care can be applied in the rest of the government hospitals and district clinics in other states.

THANK YOU

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4. Frank E, Long B, Smith B, Merrill V. Merrill's atlas of radiographic positioning & procedures. 12th ed. Jeanne Olson

- **Appendix A** - Pre-ren (Radiographers)
- **Appendix B** - Pre-ren
- **Appendix C** - Post-re (Radiographers)
- **Appendix D** - Post-re
- **Appendix E** - QR coc programme
- **Appendix F** - Flyer of Teknik untuk Cervical Sp