

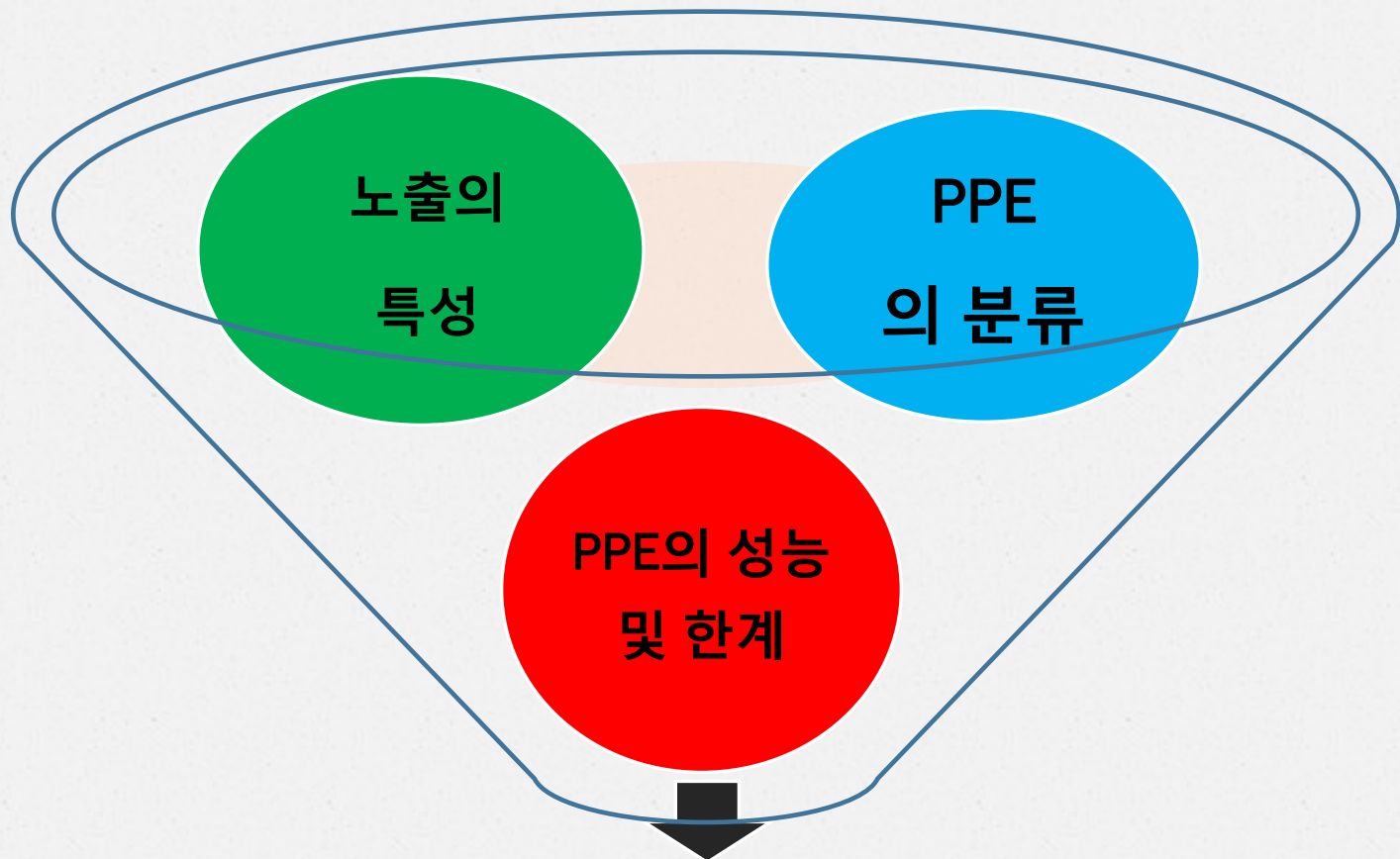


HANYANG UNIVERSITY  
MEDICAL CENTER

# **Personal Protective Equipment (PPE) in clinical practices of ED**

Hanyang University Medical Center  
Infection control and prevention department

# Core Contents of keynote



적합한 PPE의 선택 및 사용

# Core Contents of keynote

- PPE의 분류 체계 및 분류의 목적을 안다.
- 위험 물질의 노출 경로 및 특성을 안다.
- 각각의 PPE의 성능, 적응증 및 한계를 안다.
- 상황에 적합한 PPE를 선택할 수 있다.
- 선택된 PPE 를 올바르게 사용하고, 성능을 모니터링할 수 있다.



# **Core Contents (1)**

**Classification & purpose of  
Personal Protective Equipment**



<http://www.cdc.gov/niosh/about.html>

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Centers for Disease Control and Prevention

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## The National Institute for Occupational Safety and Health (NIOSH)



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### About NIOSH



The National Institute for Occupational Safety and Health (NIOSH) is the U.S. federal agency that conducts research and makes recommendations to prevent worker injury and illness.

NIOSH research is key to these efforts and provides practical solutions to identified problems. The Institute's work in this area protects the safety and health of the nation's 155 million

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Centers for Disease Control and Prevention

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New Hours of Operation  
8am-8pm ET/Monday-Friday  
Closed Holidays

[Contact CDC-INFO](#)

The National Institute for Occupational Safety and Health (NIOSH) is the U.S. federal agency that conducts research and makes recommendations to prevent worker injury and illness.



# Need for PPE

Personal protective equipment, or PPE, is designed to provide protection from serious injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other hazards. Careful selection and use of adequate PPE should protect individuals involved in chemical emergencies from hazards effecting the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods, including exposure control procedures and equipment.

# Levels of PPE



**FOUR LEVELS OF PPE**



# Check point of Classification of PPE







- The highest level of respiratory protection
- The highest level of skin and eye protection
- Hazards have not been fully characterized



- The highest level of respiratory protection
- lesser level of skin and eye protection
- Minimum level recommended on initial site entries





- The type of airborne is known
- Criteria for using air-purifying respirators met
- Skin and eye exposure is unlikely
- Periodic monitoring of the air must be performed

## Level-D



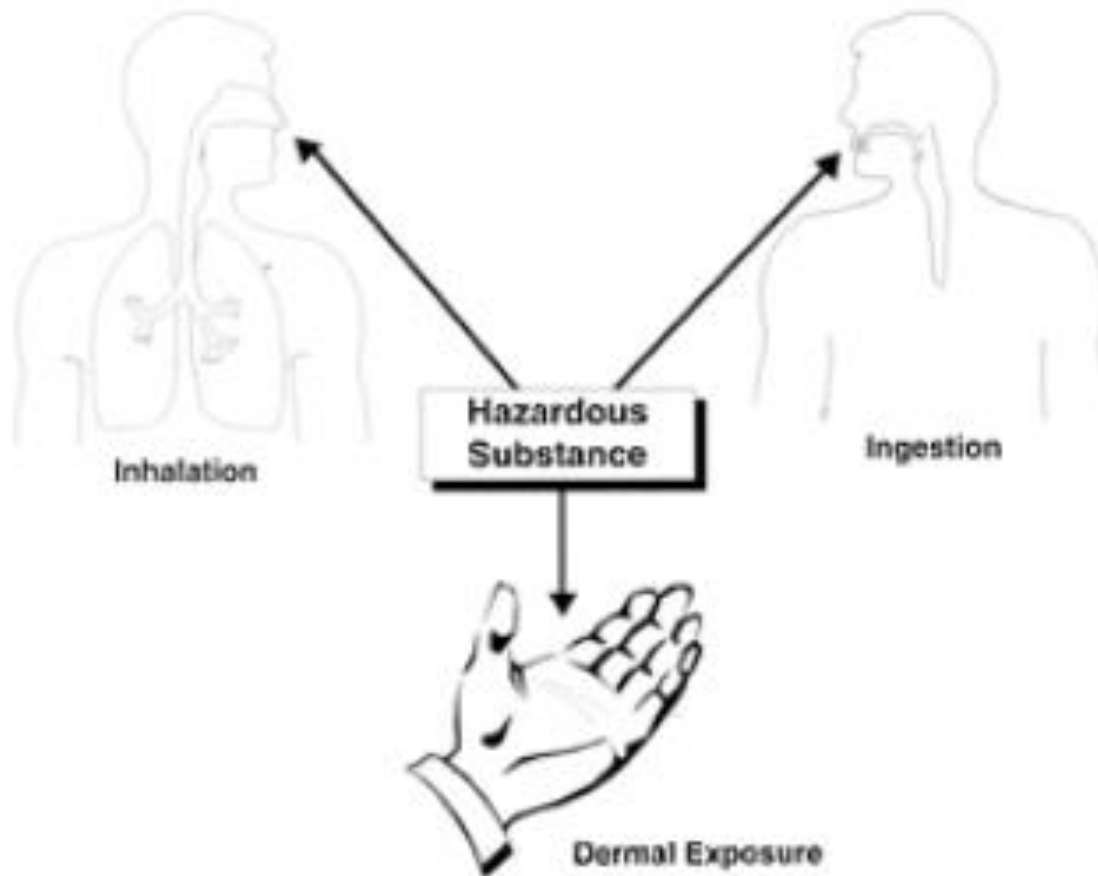
- Primarily a work uniform
- Only coveralls and safety shoes/boots
- It should not be worn on any site where respiratory or skin hazards exist.



# **Core Contents (2)**

**Characters & exposure routes  
of various hazards**

### Exposure Pathways



#### ➤ Inhalation

-mg/m<sup>3</sup>

#### ➤ Ingestion

-mg/day

#### ➤ Dermal exposure

-mg or mg/cm<sup>2</sup>



# Chemical Exposure Pathways

- **Inhalation** – Chemical vapors or dust
- **Ingestion** – Hand hygiene is important!
- **Injection** – Needlesticks or broken glass
- **Absorption** – Direct skin contact due to not wearing gloves, or wearing inappropriate gloves



**Inhalation and absorption are most common**

# Check point of Classification of PPE





## Particles

Tiny Piece of Matter

Dry = Dust

Liquid = Mist

Burning = Fume

## Gases

No form or shape, non visible, odor or odorless

Heated liquids = Vapors

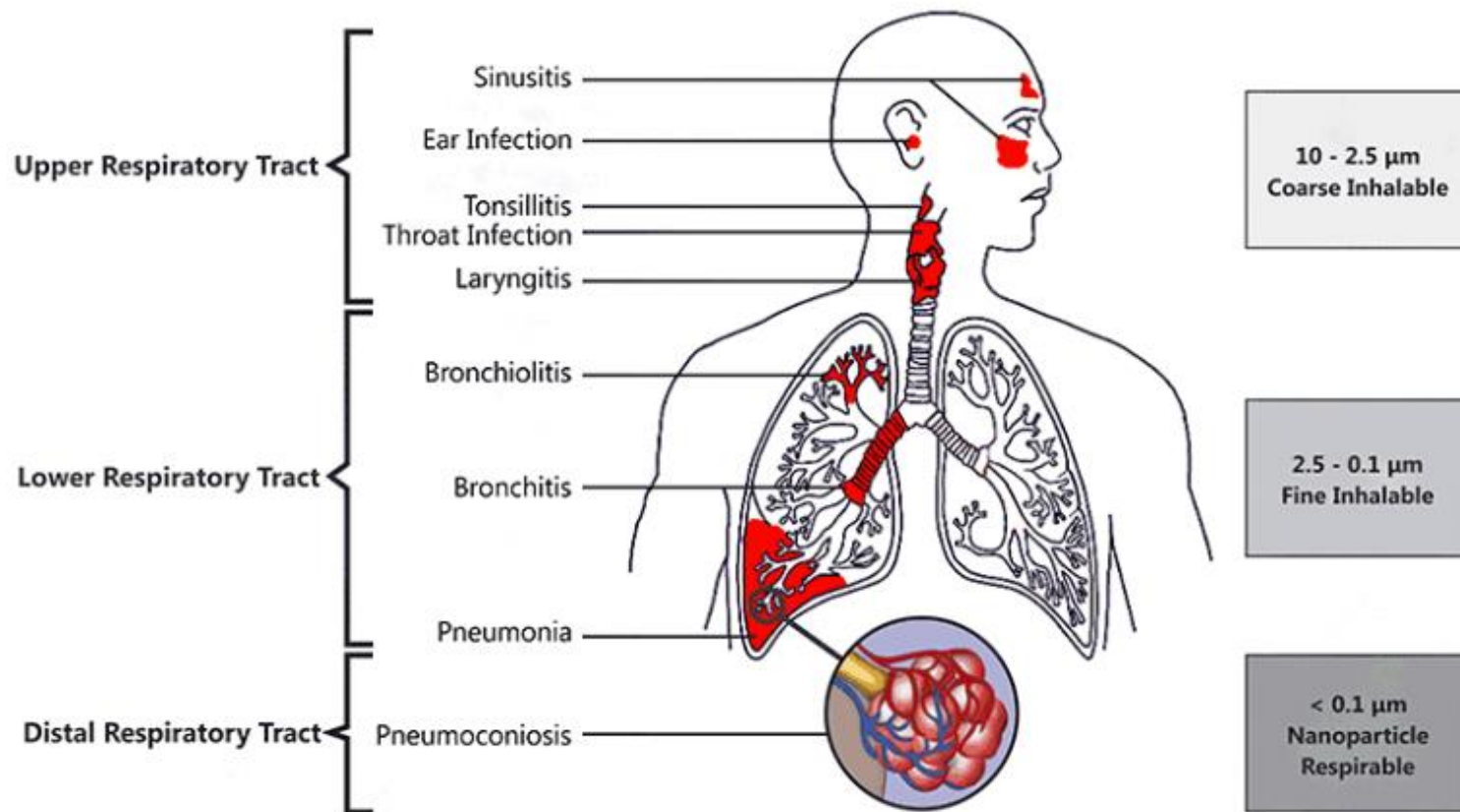
Common Gas; Carbon Monoxide (CO)

Heavier than air and sinks  
– bottom level testing

# Respiratory Hazards

CATEGORIES	SOURCES	ENVIRONMENTS	CONDITIONS
<b>Organic Dusts</b>	Grain, hay, endotoxin, silage, cotton, animal feed, animal by-products, microorganisms	Animal confinement operations, barns, silos, harvesting and processing operations	Asthma, asthma-like syndrome, OIDS chronic bronchitis hypersensitivity pneumonitis (FHP)
<b>Inorganic Dusts</b>	Silicates	Harvesting/tilling	Pulmonary fibrosis
<b>Gases</b>	Ammonia, H <sub>2</sub> S nitrogen oxides methane, CO	Animal confinement facilities, silos, fertilizers	Asthma-like syndrome, tracheobronchitis, silo-filler's disease, pulmonary edema
<b>Chemicals</b>			
Pesticides	Paraquat, organophosphates, fumigants	Applicators, field workers	Pulmonary fibrosis, pulmonary edema, bronchospasm
Fertilizers	Anhydrous ammonia	Application in fields, storage containers	Mucous membrane irritation, tracheobronchitis
Disinfectants	Chlorinated compounds	Dairy operations	Reactive airway dysfunction syndrome
<b>Others</b>			
Solvents	Diesel fuel, Pesticide solutions	Storage containers	Mucous membrane / respiratory irritation
Welding fumes	Nitrous oxides ozone, metals	Welding repairs	Bronchitis, metal-fume fever, emphysema
Zoonotic	Microorganisms	Animal husbandry, veterinary services	Anthrax, Q fever, ornithosis, swine flu





*Possible Health Issues Arising From Dust Inhalation.*



# 메르스 '공기 감염' 가능할까?

## 침에 의한 전파

(Droplet)

수분



## 침 속 바이러스에 의한 전파

의한 전파

(Droplet Nuclei)



- 크기가  $5\mu\text{m}$  보다 큼
- 낙하속도는 초당 30~80cm
- 비산거리가 약 1m 정도로 짧은 편

### 특징

- 크기가  $5\mu\text{m}$  보다 작음
- 낙하속도는 초당 0.06~1.5cm
- 비산거리가 공기의 흐름에 따라 좀 더 멀리 날아갈 수 있음

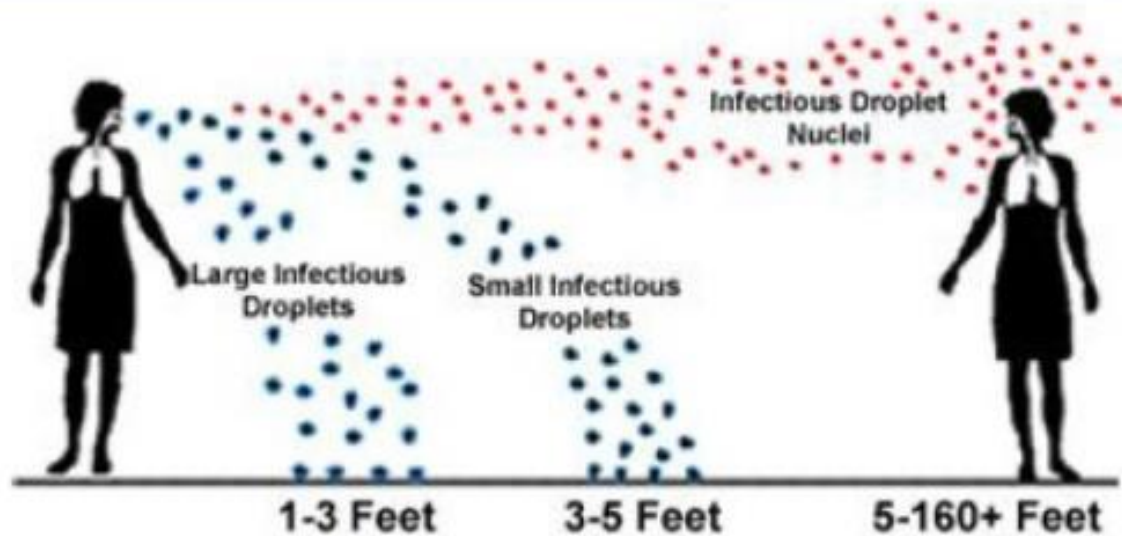
감기, 볼거리, 풍진 등

바이러스 유형

결핵, 수두, 홍역 등

메르스는 침에 의한 전파 가능성이 높으나 공기 감염 가능성도 완전 부인 못함

# 비말감염 vs 공기감염



비말(비말감염)의 이동거리 약 30cm~1 m 50cm

비말핵(공기감염)의 이동거리는 약 1 m 50cm~48 m 이상이라는 내용(1피트=약 30cm로 계산)



# **Core Contents (3)**

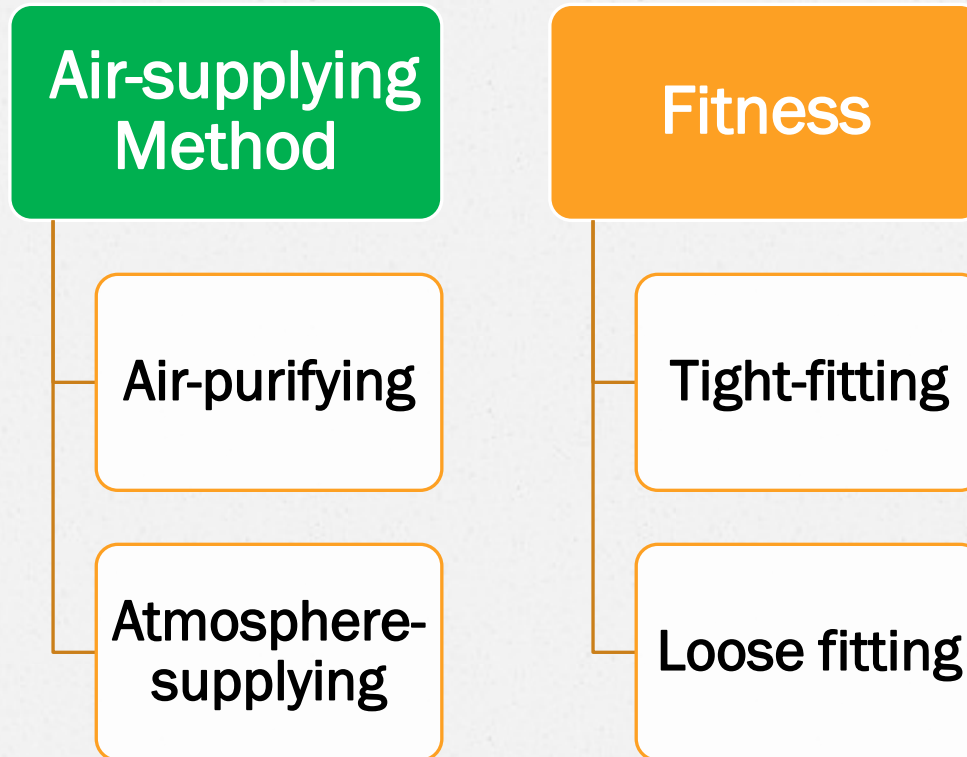
**The ability ,indication**

**& limitation of PPE**



OSHA/EPA Classification.	Level A.	Level B.	Level C.	Level D.
Protection provided.	Highest level of skin, eye, and respiratory protection.	Highest level of respiratory protection; lower level of skin protection.	Lower level of respiratory and skin protection. + Adequate for radiation event response where other hazards have been determined not to be present.	Lowest level of respiratory and skin protection.
Indications.	Identified or suspected hazards requiring maximal skin, eye, and respiratory protection. + Working in confined areas where hazards have not been fully characterized.	Identified or suspected hazards requiring maximal respiratory protection. + Working in atmospheres containing less than 19.5% oxygen. + Lower level skin hazard may be present.	Hazards have been identified. + Hazards will not be absorbed by or adversely affect exposed skin. + All criteria for using an <a href="#">air-purifying respirator</a> are met (i.e., concentrations of all airborne	Atmosphere contains no known hazards. + No or very low potential for unexpected respiratory or skin contact with environmental hazards.
			contaminants are known, appropriate filters are available, oxygen levels are sufficient).	
Who should wear.	<b>First responders</b> + When identified or potential risk of biological, liquid or vapor chemical hazard exposure exists.	First responders + When entering the most heavily contaminated radiation zones to rescue victims or protect valuable property necessary for public welfare.	First responders and <b>first receivers</b> + When caring for patients/victims likely to be contaminated with radiological material.	First receivers + When working in post-decontamination areas should wear <a href="#">Standard Precautions</a> PPE (per protocol) for infection control purposes.

# RESPIRATOR TYPES



# Atmosphere –supplying respirators



Self Contained Breathing Apparatus /SCBA/ Positive pressure air  
respirator/compressed air/carbon fibre cylinder/ 90min



# Two filtering device paths

Loose  
fitting



Tight  
fitting



3M™ Versaflo™ Easy Clean PAPR Respirator Kit

3M 9211 Respirator Mask N95 Mask

- Respirators

- Surgical mask – only when you want to protect the client from your illness
- N95 – to protect you from dust exposures especially when doing nails
  - Should be NIOSH approved
- Air purifying respirator – when working with chemicals such as formaldehyde
  - May need special cartridges based on exposure



Photos by National Jewish Health



# Types of Dust Masks

Some masks are more protective than others

**N95/R95/P95** masks filter out 95% of dust particles

**N99/R95/P99** masks filter out 99% of dust particles

**N100/R100/P100** masks filter out 99.7% of dust particles

N99 or N100 masks are recommended for very fine dust or dangerous dusts such as asbestos or silica.

# N95 filtering-facepiece vs N95 elastomeric

## Cone Type



SH-9550



SH-9550A



SH-9550C

## Flat-fold type



SH-2950



SH-2950A



SH-2950C



**3M 3200 N95 Respirator Gas Mask Dust**



## Guide to Respirators

The following chart will help you decide what kind of respirator you need:

Substance	Type of Respirator	Rating (if applicable)
Acid Gases	Chemical cartridge	
Allergens	Particulate filter	N95 or higher
Ammonia	Chemical cartridge	
Asbestos	Particulate filter	N100 or HE
Bacteria and Viruses	Particulate filter	N95 or higher
Bleach	Particulate filter	N95 or higher
Dust	Particulate filter	N95 or higher
Fibers (not asbestos)	Particulate filter	N95 or higher
Insulation	Particulate filter	N95 or higher
Lead	Particulate filter	N100 or HE
Mold	Particulate filter	N95 or higher
Organic vapor	Chemical cartridge	
Paint	Particulate filter	R95 or higher
Pesticides, Sprays	Particulate filter	R95 or higher
Pollen	Particulate filter	N95 or higher
Sanding	Particulate filter	N95 or higher
Welding	Particulate filter	N95 or higher

# Limitations of respirators

## N95 mask

- Facial Seal Leaks/Periodic fit testing
- Not effective to oil, chemical hazards
- Poor tolerance/Exposed face& neck

## PAPR

- Difficult communication
  - noisy & bulky
- Inability to use stethoscope
- Requirement for electricity

## Atmosphere supplying respirator

- Limited time to use
  - closed circuit  
4hours
  - open-circuit  
30-60minutes



# **Core Contents (4)**

**The selection of proper**

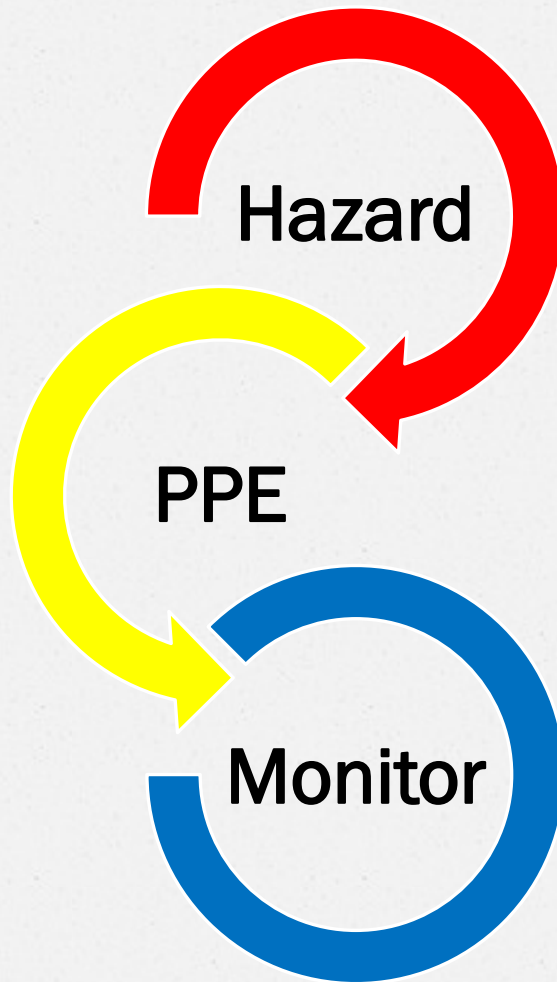
**PPE in clinical situations**

# No single combination PPE could protect all hazards

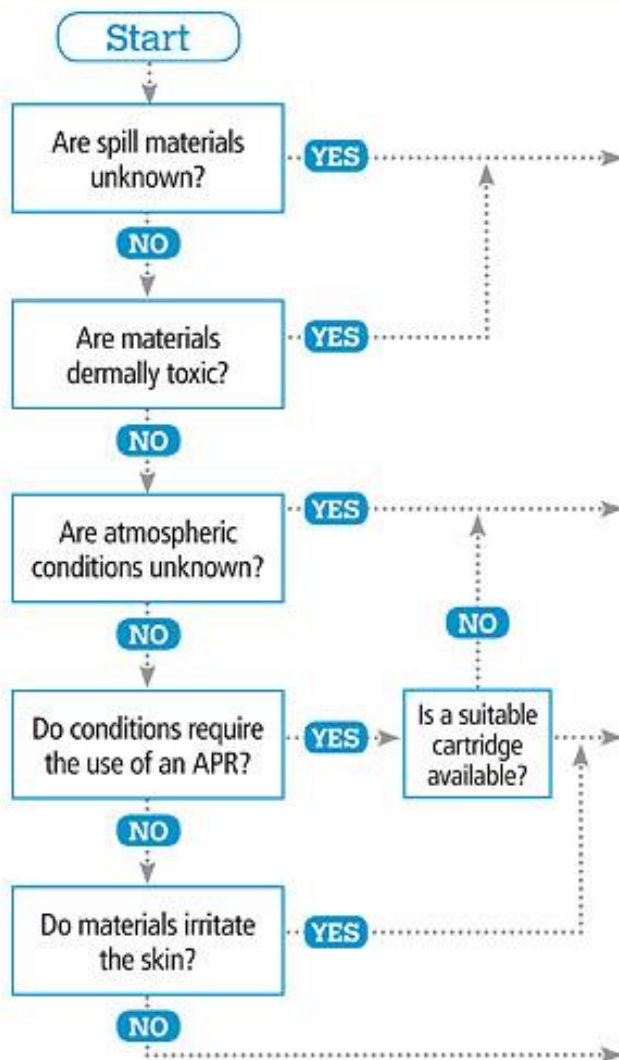




# Chains of PPE



Use this chart to determine the appropriate level of PPE for your spill requirements.



### Level A

Use when you need the highest level of skin, eye, respiratory and mucous membrane protection. Includes either a Self-Contained Breathing Apparatus (SCBA) or a Supplied Air Respirator (SAR) with egress bottle.



### Level B

Use when you need the highest level of respiratory protection, but a lower level of skin, eye and membrane protection. Includes either an SCBA or SAR with egress bottle.



### Level C

Select this suit when the type of airborne substance is known, its concentration is measured, the criteria for using Air-Purifying Respirators (APR) are met, and skin and eye exposure is unlikely.



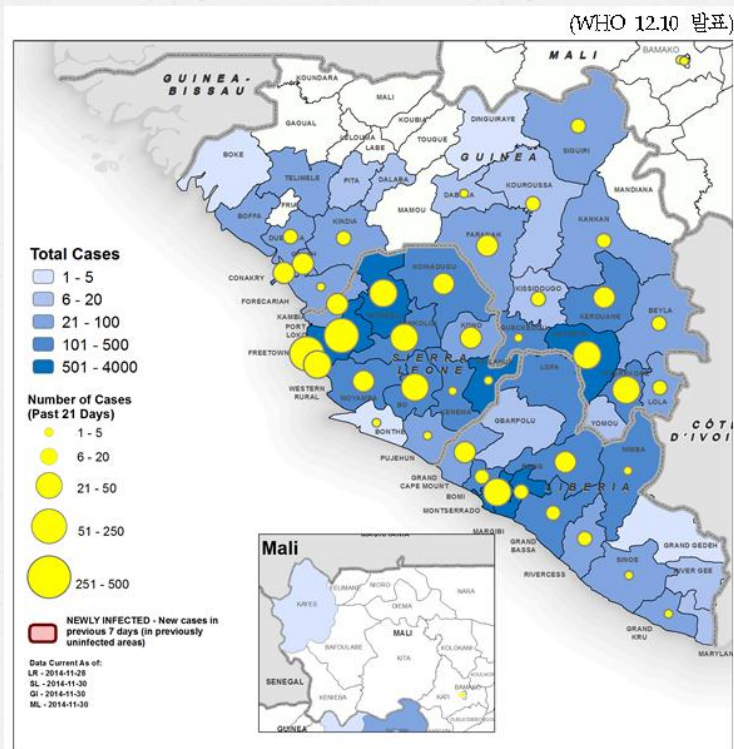
### Level D

Wear a work uniform where no eye, skin or respiratory hazards are present.

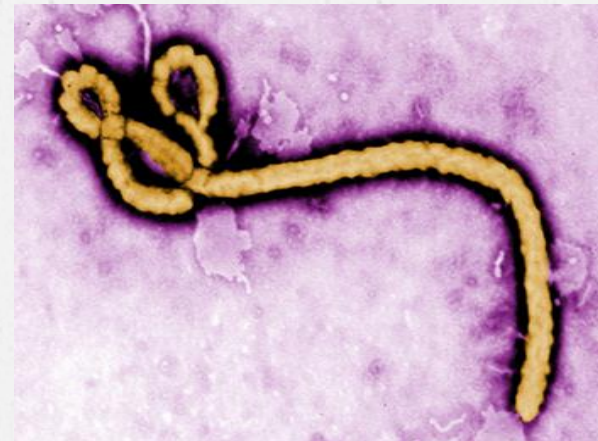




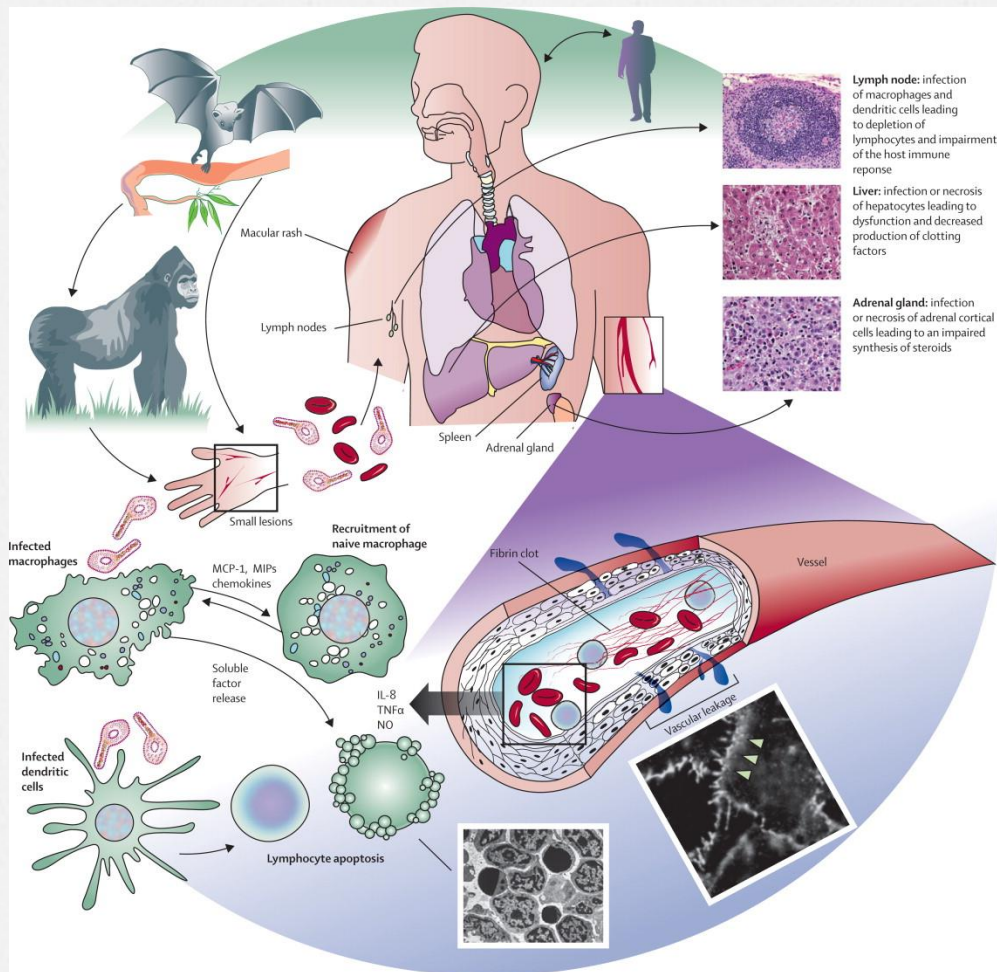
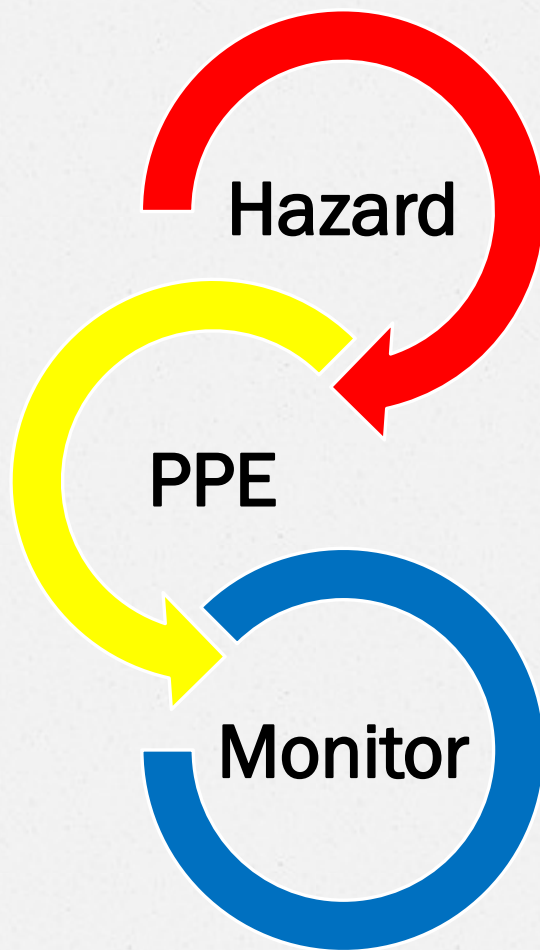
# Application of chains of PPE



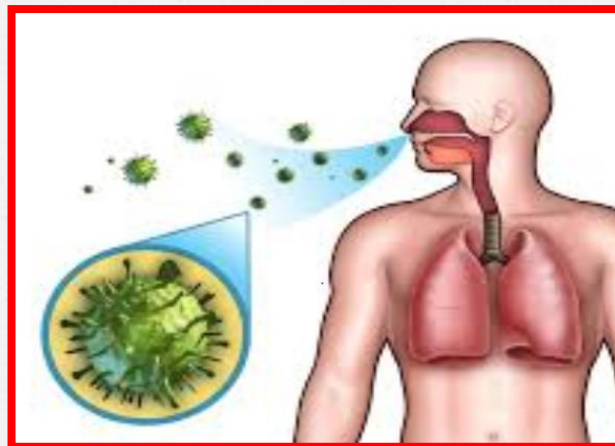
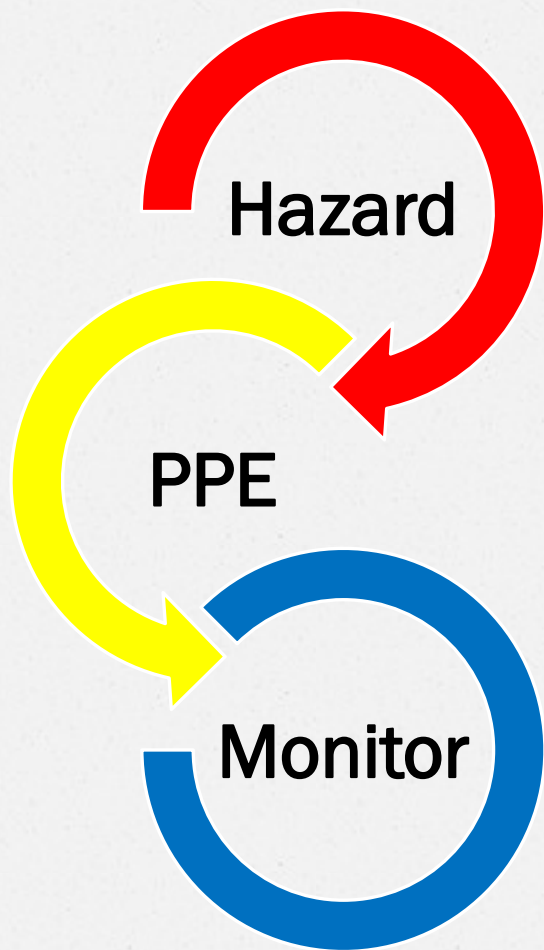
<출처: WHO>



Order: Mononegavirales  
Family: Filoviridae  
Genus: Ebola like viruses  
Species: Ebola







## Initial CDC Recommendations



## Revised CDC Recommendations





# **Core Contents (5)**

**The proper use & monitoring  
of PPE in ED**

# Donning PPE

## □ 개인보호장비 착의순서

- 긴 머리의 경우 짧게 묶어주고 시계나 장신구 등은 제거할 것
- 탈수를 예방하기 위해 수분을 보충하고 보호복을 입기 전 화장실에 다녀올 것
- 오염되었다고 판단되거나 소독용 장갑 또는 각 procedure 사이에는 반드시 겹장갑을 갈아 끼워야 함
- 속장갑을 바꿀 정도이면 근무 교대 필요





## Sequence\* for Donning PPE

- Gown first
- Mask or respirator
- Goggles or face shield
- Gloves

**\*Combination of PPE will affect sequence – be practical**



① 보호복  
(보호복의 후드는 미착용)



② 덧신 - 테이핑



③ 속장갑



④ 마스크 착용하기



⑤ 보호복의 후드착용 후  
고글착용



⑥ 겹장갑  
(2중으로 착용)





⑦ 덧신 및 속장갑 테이핑



⑧ 제거하기 용이하도록  
끝부분에 flap을 만들것



⑨ 안면보호대와 앞치마 착용

# 개인보호장비 탈의순서

- 개인보호장비 탈의 시 오염에 노출된 보호구 바깥면이 안구, 점막 등에 접촉되지 않도록 주의
- 가장 오염된 앞치마, 안면보호대, 걸 장갑을 먼저 제거한다.





## Sequence for Removing PPE

- Gloves
- Face shield or goggles
- Gown
- Mask or respirator



① 겹장갑  
(소독용 티슈로 닦기)



② 버리기



③ 안면보호대 벗기  
-버리기



④ 앞치마 벗기  
-버리기



⑤ 고글을 앞쪽으로  
최대한  
당겨 벗기 - 버리기



⑥ 테이프 제거하기  
-버리기



⑦ 방수용 덧신을 추가로  
신었을 경우 덧신 벗기  
- 버리기



⑧ 겹장갑 벗기  
-버리기



⑨ 보호복 벗기





⑩ 보호복 벗기 2  
(안쪽면이 밖으로 가도록 벗기)



⑪ 덧신까지 같이 벗기  
-말아서 버리기



⑫ 앞쪽으로 최대한  
당겨 마스크 벗기



⑬ 마스크 벗기  
- 버리기



⑭ 속장갑 벗기  
- 버리기



⑮ 소독용 티슈로 손 닦기



⑯ 손씻기

## [N95마스크 착용의 6단계]

1  
STEP



Wash your hands thoroughly with soap and water or hand sanitizer before putting on the mask.

2  
STEP



Select a suitable N95 mask that fits well.

3  
STEP



Determine which side of the mask is the top & side. Hold the N95 mask with a cupped hand and place it firmly over your nose, mouth & chin.

4  
STEP



Stretch and position top band high at the back of head. Stretch and position bottom band under the ears.

5  
STEP



Make sure the Pre-shaped nose cushion is fits nicely on your face and adjust the length of headstrip.

6  
STEP



Perform a fit test by inhaling and exhaling. During exhalation, check for air leakage around face.



# How to Properly put on and take off a respirator

## Putting On The Respirator



Position the respirator in your hands with the nose piece at your fingertips.



Cup the respirator in your hand allowing the headbands to hang below your hand. Hold the respirator under your chin with the nosepiece up.



The top strap (on single or double strap respirators) goes over and rests at the top back of your head. The bottom strap is positioned around the neck and below the ears. Do not crisscross straps.



Place your fingertips from both hands at the top of the metal nose clip (if present). Slide fingertips down both sides of the metal strip to mold the nose area to the shape of your nose.



CS 207843

DHHS (NIOSH) Publication No. 2010-131

# How to Properly put on and take off a respirator

## Checking Your Seal<sup>2</sup>



Place both hands over the respirator, take a quick breath in to check whether the respirator seals tightly to the face.



Place both hands completely over the respirator and exhale. If you feel leakage, there is not a proper seal.



If air leaks around the nose, readjust the nosepiece as described. If air leaks at the mask edges, re-adjust the straps along the sides of your head until a proper seal is achieved.



If you cannot achieve a proper seal due to air leakage, ask for help or try a different size or model.



CS 207843

DHHS (NIOSH) Publication No. 2010-131



# How to Properly put on and take off a respirator

## Removing the Respirator



DO NOT TOUCH the front of the respirator! It may be contaminated!



Remove by pulling the bottom strap over back of head, followed by the top strap, without touching the respirator.



Discard in waste container. WASH YOUR HANDS!

Employers must comply with the OSHA Respiratory Protection Standard, 29 CFR 1910.134 if respirators are used by employees performing work-related duties.

1 Manufacturer instructions for many NIOSH approved disposable respirators can be found at [www.cdc.gov/niosh/nppt/topics/respirators/disp\\_part/](http://www.cdc.gov/niosh/nppt/topics/respirators/disp_part/)

2 According to the manufacturer's recommendations



CS 207843

DHHS (NIOSH) Publication No. 2010-131



<https://www.youtube.com/watch?v=Tzpz5fko-fg>



## 호흡보호구 밀착도 검사란?

- 착용자의 안면과 얼마나 적합하게 밀착되었는가를 측정하는 것



얼굴 안면과 호흡보호구가 적합하게 밀착되지 않으면 호흡으로 인한 유해물질 침투 가능

## 호흡보호구 밀착도 검사 방법



**정성적 방법(Qualitative)**  
**주관적**

- 시험물질(사카린, Bitrex)의 맛, 냄새 자극을 감지할 수 있는 착용자의 능력에 의존하여 누설여부 확인



**정량적 방법(Quantitative)**  
**객관적**

- 검사 장비를 이용하여 fit factor를 산출한 뒤 기준과 비교하여 누설여부 확인



- 밀착 계수(Fit Factor) = 500은 호흡보호구 안이 밖보다 500배 깨끗함을 의미



## 정량적 방법(QNFT)



### Fit Factor

- 호흡보호구 안과 밖에서 각각의 에어로졸 농도를 측정하여 비(ratio)로 나타냄

$$\text{Fit Factor} = C_o/C_i$$

$C_o$  : 호흡보호구 밖의 에어로졸 농도

$C_i$  : 호흡보호구 안의 에어로졸 농도

- Fit Factor(FF) 값은 높을 수록 안면과 호흡보호구간의 밀착도 정도가 우수



- 반면형 호흡보호구 Fit Factor 100 이상
- 전면형 호흡보호구 Fit Factor 500 이상



Full face respirators  
Fit Factor  $\geq 500$



# OHSA QNFT Protocol



- 8가지 요구사항 : 작업장에서 모니터링

1. 일반 호흡

2. 깊은 호흡

3. 머리 좌우로 흔들기

4. 머리 위아래로 움직이기

5. 말하기

6. 얼굴을 찡그림

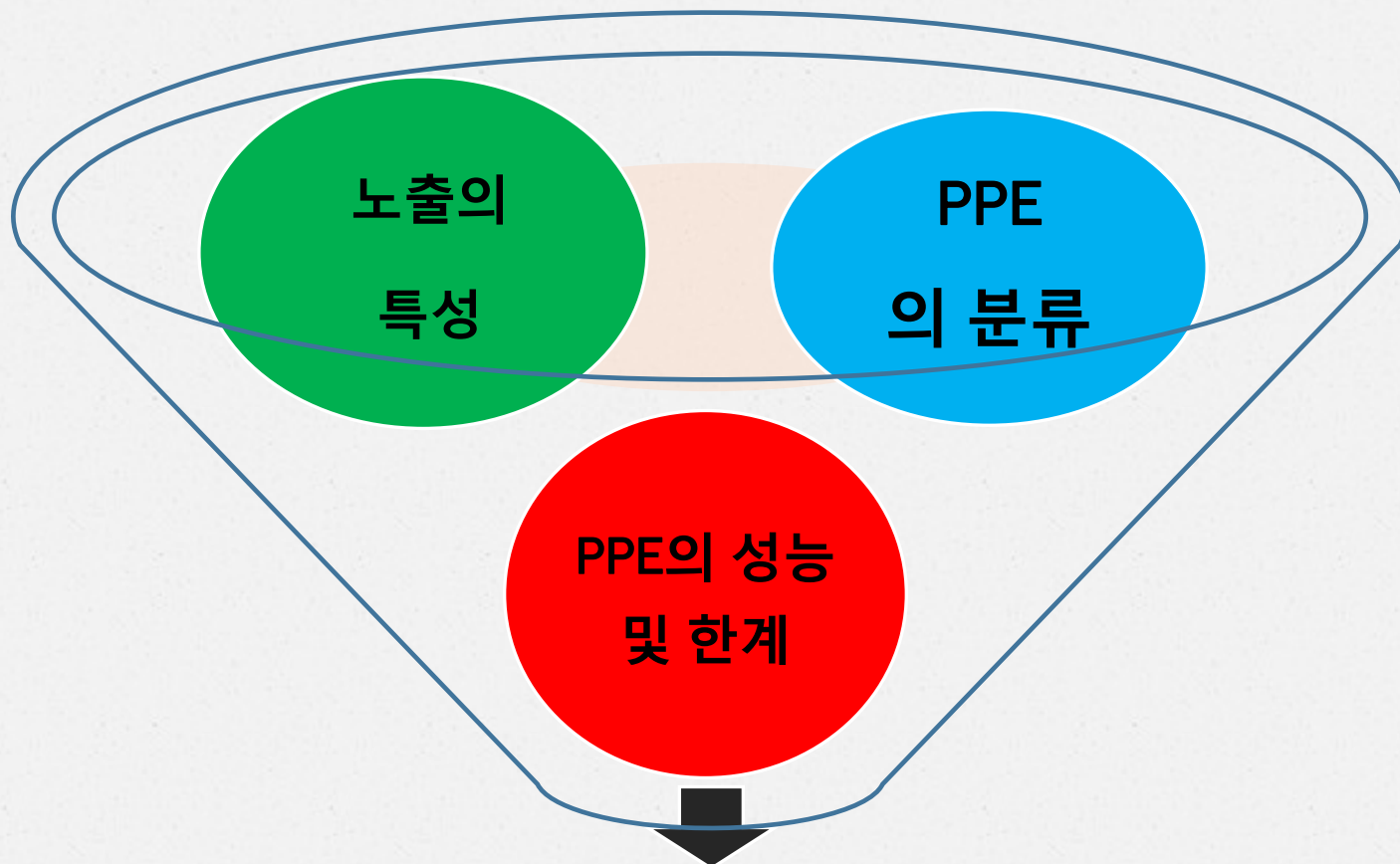
7. 몸을 위로 굽히기

8. 일반 호흡

각각의 운동에 해당하는 Fit Factor 측정



# Take home messages



적합한 PPE의 선택 및 사용



# Take home messages

- 적절한 개인보호 장비의 선택 및 장비의 활용 및 모니터는 중요하다.
- 모든 Hazard에 대응할 수 있는 개인보호구 세트는 없다.
- Hazard의 노출의 특성 및 경로, 개인보호구의 종류, 특성 및 한계의 이해가 중요하다.





# Reference

- 1. Hospital Respiratory Protection Program Toolkit, Resources for Respirator Program Administrators, CDC  
available at: <https://www.osha.gov/Publications/OSHA3767.pdf>
- 2. How to Properly put on and take off a disposable respirator, CDC,  
available at:  
<https://www.cdc.gov/niosh/docs/2010-131/pdfs/2010-131.pdf?id=10.26616/NIOSH PUB2010131>