Infection Control for Plague

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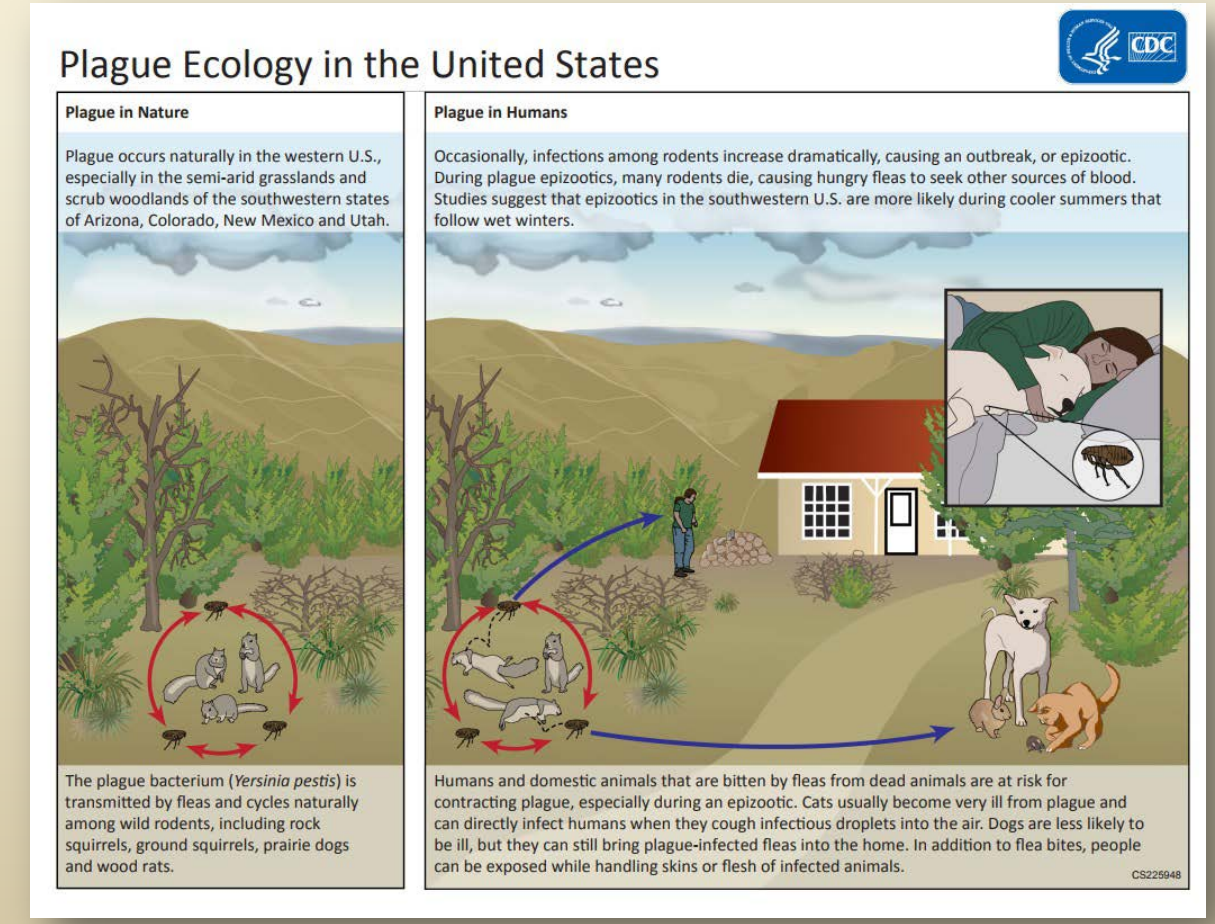
Infectious Disease Forum 28 Nov 2017

Mode of transmission of Plague



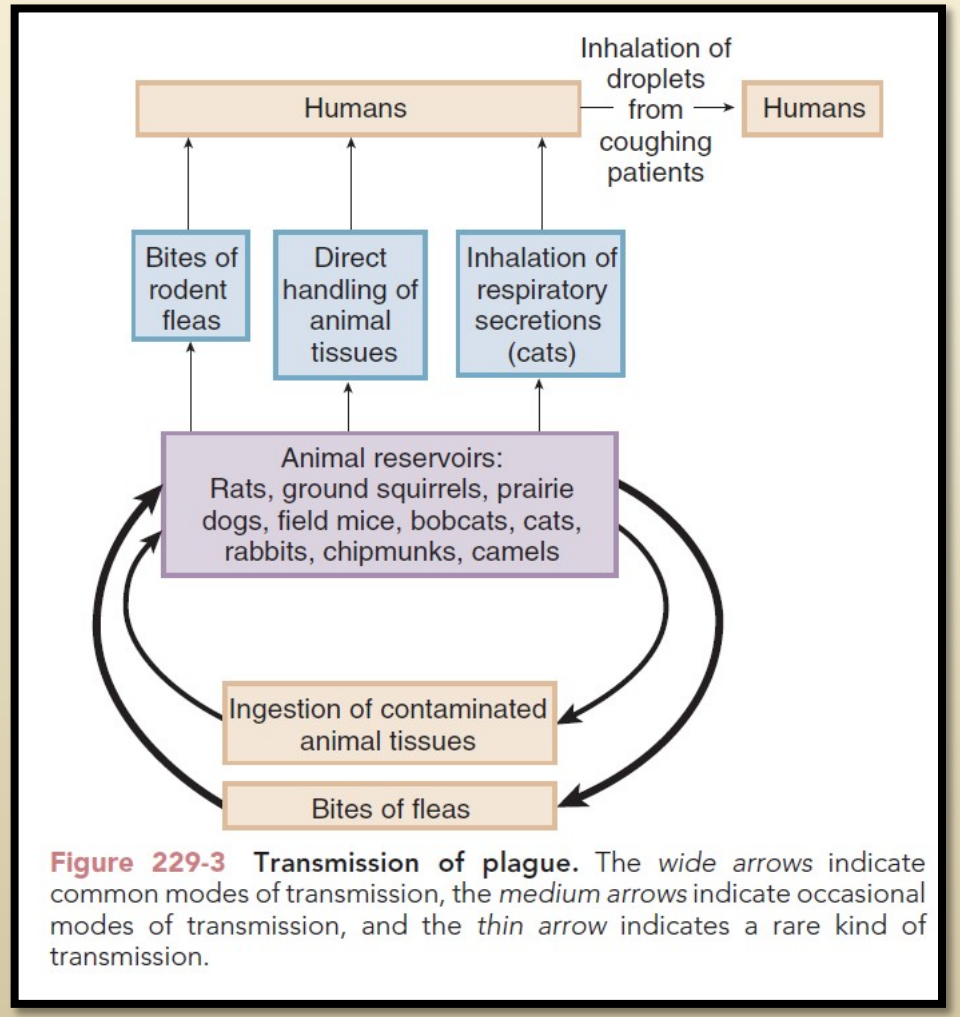


Figure 229-3 Transmission of plague. The *wide arrows* indicate common modes of transmission, the *medium arrows* indicate occasional modes of transmission, and the *thin arrow* indicates a rare kind of transmission.

Source: CDC, Mandell (7th Ed)

Bubonic Plague 腺鼠疫

- **Standard Precautions**
  標準防護措施

When contacting

- Blood血液
- Bodily fluids 體液
- Secretions & excretions (except sweat)分泌物
- Non-intact skin or mucosa傷口及粘膜


Health-care facility recommendati

KEY ELEMENTS AT A GLANCE

1. **Hand hygiene**[1]
   Summary technique:
   - Hand washing (40–60 sec): wet hands and apply soap; rub all surfaces; rinse hands and dry thoroughly with a single use towel; use towel to turn off faucet.
   - Hand rubbing (20–30 sec): apply enough product to cover all areas of the hands; rub hands until dry.

   Summary indications:
   - Before and after any direct patient contact and between patients, whether or not gloves are worn.
   - Immediately after gloves are removed.
   - Before handling an invasive device.
   - After touching blood, body fluids, secretions, excretions, non-intact skin, and contaminated items, even if gloves are worn.
   - During patient care, when moving from a contaminated to a clean body site of the patient.
   - After contact with inanimate objects in the immediate vicinity of the patient.
2. **Gloves**
   - Wear when touching blood, body fluids, secretions, excretions, mucous membranes, nonintact skin.
   - Change between tasks and procedures on the same patient after contact with potentially infectious material.
   - Remove after use, before touching non-contaminated items and surfaces, and before going to another patient. Perform hand hygiene immediately after removal.
3. **Facial protection (eyes, nose, and mouth)**
   - Wear (1) a surgical or procedure mask and eye protection (eye visor, goggles) or (2) a face shield to protect mucous membranes of the eyes, nose, and mouth during activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.
4. **Gown**
   - Wear to protect skin and prevent soiling of clothing during activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions.
   - Remove soiled gown as soon as possible, and perform hand hygiene.
5. **Prevention of needle stick and injuries from other sharp instruments**[2]
   Use care when:
   - Handling needles, scalpels, and other sharp instruments or devices.
   - Cleaning used instruments.
   - Disposing of used needles and other sharp instruments.
   - Post visual alerts at the entrance to health-care facilities instructing persons with respiratory symptoms to practise respiratory hygiene/cough etiquette.
   - Consider making hand hygiene resources, tissues and masks available in common areas and areas used for the evaluation of patients with respiratory illnesses.
7. **Environmental cleaning**
   - Use adequate procedures for the routine cleaning and disinfection of environmental and other frequently touched surfaces.
8. **Linens**
   Handle, transport, and process used linen in a manner which:
   - Prevents skin and mucous membrane exposures and contamination of clothing.
   - Avoids transfer of pathogens to other patients and or the environment.
9. **Waste disposal**
   - Ensure safe waste management.
   - Treat waste contaminated with blood, body fluids, secretions and excretions as clinical waste, in accordance with local regulations.
   - Human tissues and laboratory waste that is directly associated with specimen processing should also be treated as clinical waste.
   - Discard single use items properly.
10. **Patient care equipment**
    - Handle equipment soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures, contamination of clothing, and transfer of pathogens to other patients or the environment.
    - Clean, disinfect, and reprocess reusable equipment appropriately before use with another patient.

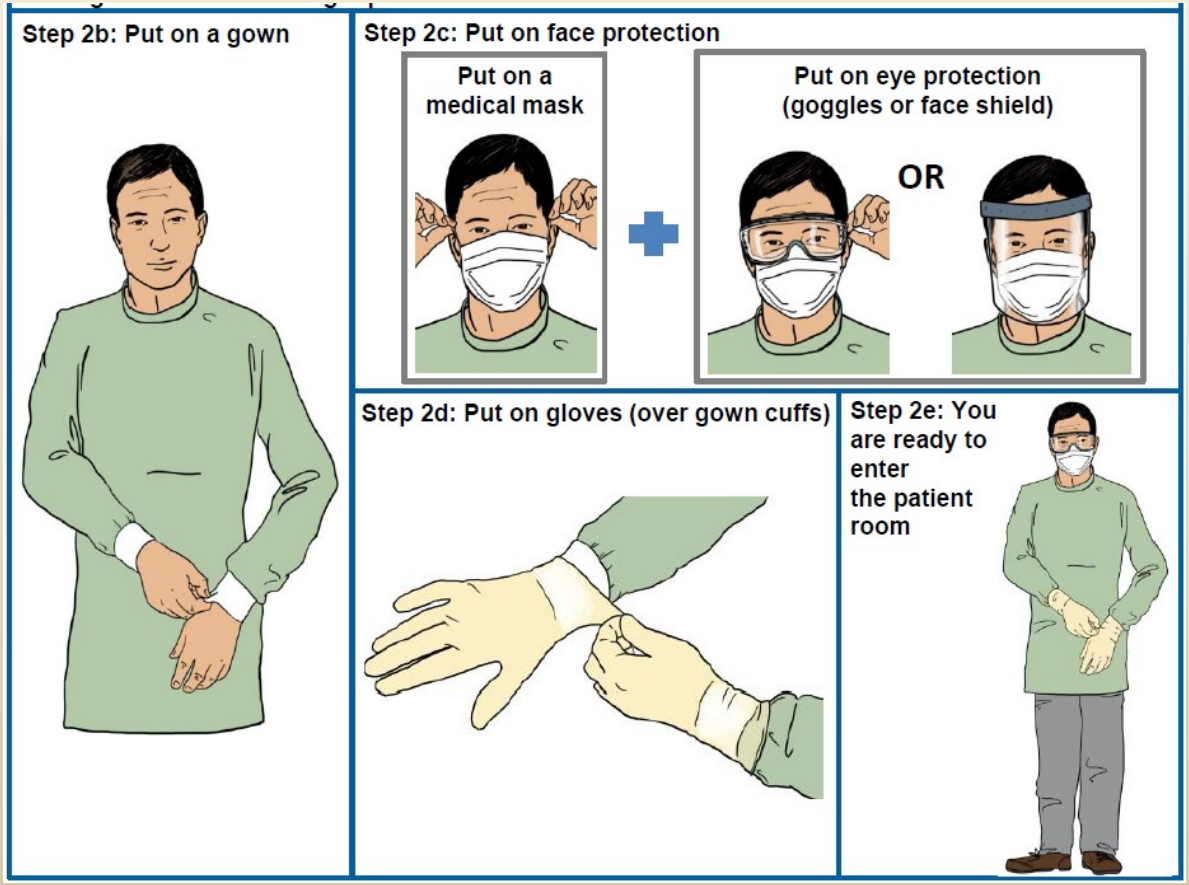
[1] For more details, see: WHO Guidelines on Hand Hygiene in Health Care (Advanced draft), at: http://www.who.int/patientsafety/information_centre/ghhad_download/en/index.html.
[2] The SIGN Alliance at: http://www.who.int/injection_safety/sign/en/

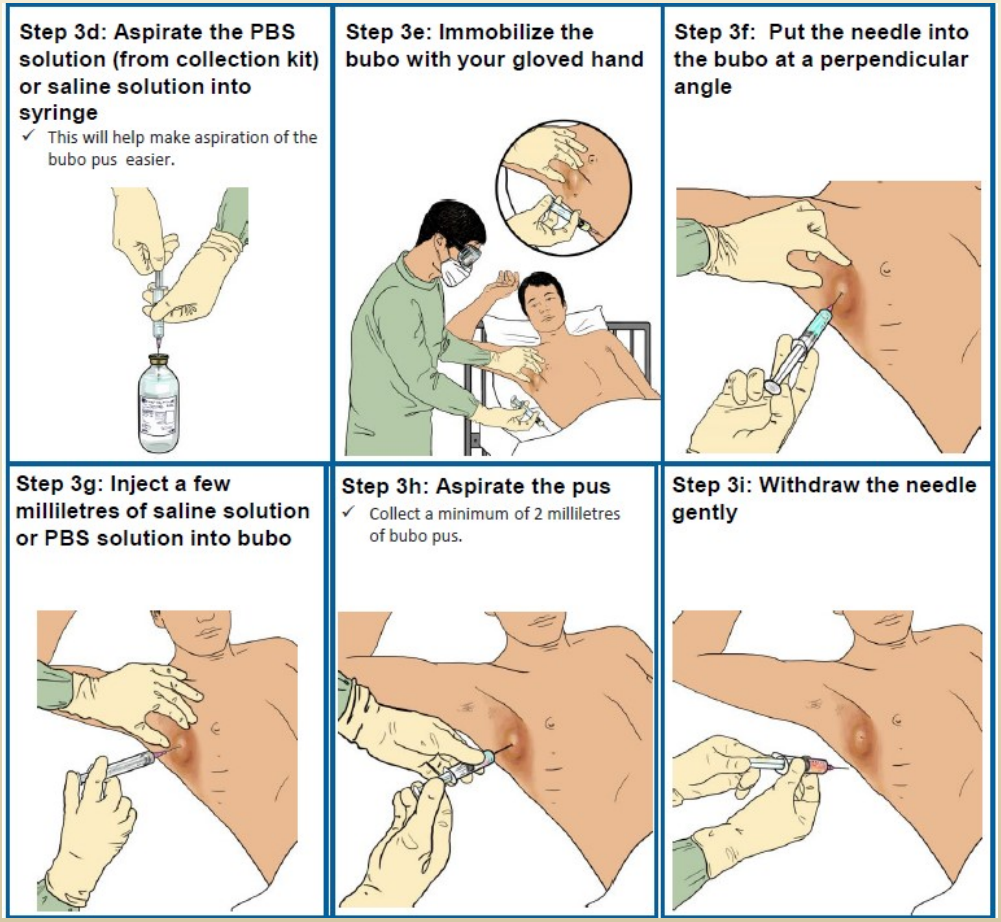
World Health Organization • CH-1211 Geneva-27 • Switzerland • www.who.int/csr

Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings (2007) CDC
Standard precautions in health care, WHO Oct 2007
Hospital Authority Infection Control Poster

Exception

Aspiration of buboes
(Standard + Contact + Droplet precautions)





How to safely collect pus samples from buboes of patients suspected to be infected with bubonic plague WHO Sep 2016

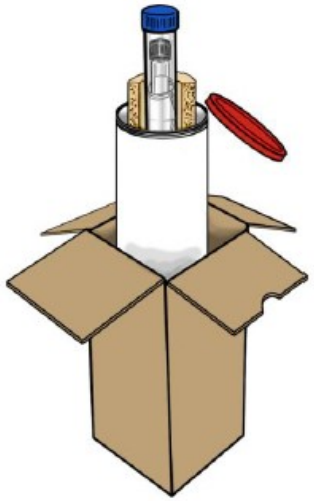
Precautions of transporting specimens of Plague

For the shipment of samples to the National Reference Laboratory follow sample shipment packaging requirements (Follow WHO documents about how to safely ship human samples from patients suspected to be infected with highly infectious pathogens)

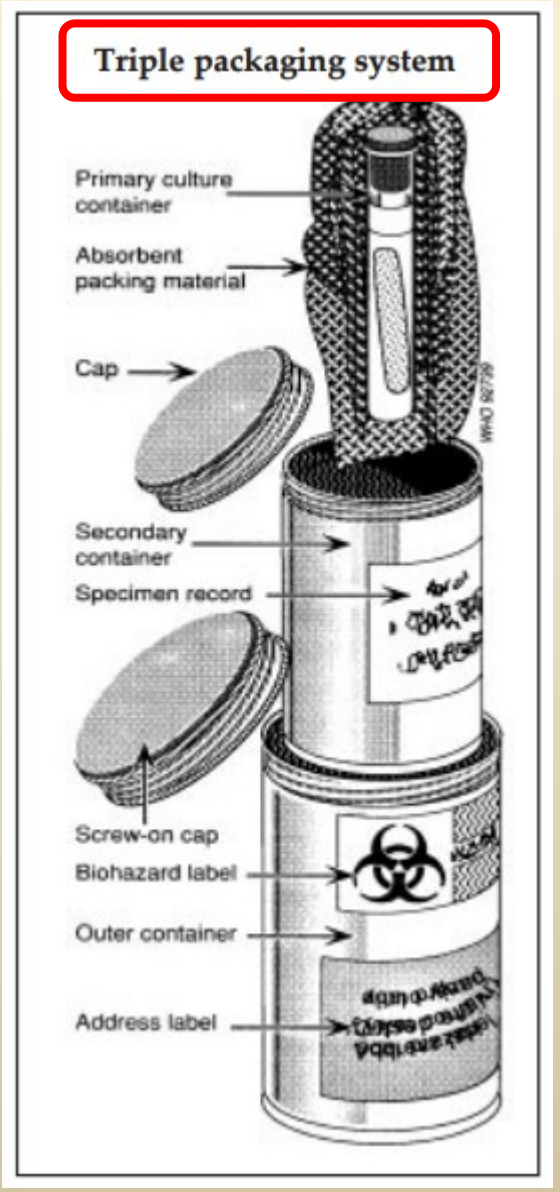
Primary Container

Secondary Container

Tertiary Container



Important: A designated assistant wearing gloves should be available to help you. This person should stand outside the patient room. He/She will help you prepare the sample for transport and will provide any additional equipment you may need. He/She will monitor you while you remove the personal protective equipment.



How to safely collect pus samples from buboes of patients suspected to be infected with bubonic plague WHO Sep 2016
Guidelines for the Safe Transport of Infectious Substances and Diagnostic Specimens, WHO

Precautions of transporting specimens of Plague

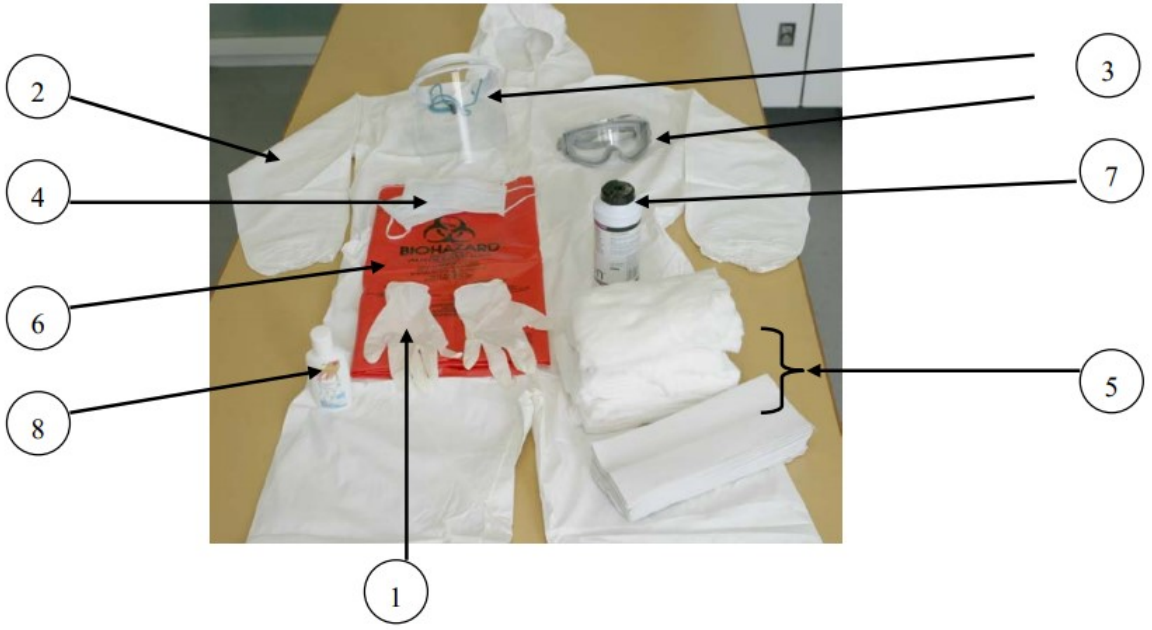
Maintain good personal hygiene

Use robust transport container

Biological spill kit

1. Disposable latex gloves
2. Disposable protective gowns
3. Face / eye protection devices
4. Surgical mask
5. Disposable absorbent material such as paper towels or cloth
6. Disposable waste bags (red) for clinical waste
7. Ready-to-use disinfectant (e.g. 1 part of household bleach in 4 parts of water)*
8. Hand hygiene products (e.g. alcohol-based hand-rubs)

* *Other ready-to-use disinfectant products can be used. The disinfectant must be prepared according to the instructions by the manufacturers and must be replaced when it is expired after preparation.*



Safety Guidelines on Transport of Clinical Specimens and Infectious Substances for Courier Team , PHLSB, CHP 2009

Pneumonic plague
肺鼠疫

Droplet transmission

- Single room (AIIR) for patient placement
- Dedicated equipment
- Limit patient transport to essential procedures only
- Surgical mask for patient as source control
- Cohort only when single rooms are inadequate
- Do not place suspected and confirmed cases together
- Cases should be separated by at least 2m
- Maintain droplet precautions till at least 48-72 hours of effective antibiotic treatment with clinical improvement

Plague - Hospital Infection Control (Including Autopsies and Burial). CIDRAP Last updated Feb 2013
Hospital Authority Fact Sheet on Plague Dec 2016

When to use airborne precautions?

- Resources are available and setting is feasible e.g. healthcare institution
- Staff adequate trained with valid respirator fit testing results
- Performing Aerosol Generating Procedures (AGPs) (1,2)
  - cough-generating procedures
  - Bronchoscopy
  - sputum induction
  - intubation and extubation
  - cardiopulmonary resuscitation
  - open suctioning of airways
  - (NPA/NPS/high flow oxygen)

1. Interim Infection Prevention and Control Recommendations for Hospitalized Patients with Middle East Respiratory Syndrome Coronavirus (MERS-CoV) Updated June 2015
2. Summary - Aerosol-Generating Procedures (AGP) under Alert and Serious Response Level (S1). Hospital Authority CICO Jan 2017.

How effective is human-to-human transmission for pneumonic plague?

Risk of Person-to-Person Transmission of Pneumonic Plague

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Plague has received much attention because it may be used as a weapon by terrorists. Intentionally released aerosols of *Yersinia pestis* would cause pneumonic plague. In order to prepare for such an event, it is important, particularly for medical personnel and first responders, to form a realistic idea of the risk of person-to-person spread of infection. Historical accounts and contemporary experience show that pneumonic plague is not as contagious as it is commonly believed to be. Persons with plague usually only transmit the infection when the disease is in the endstage, when infected persons cough copious amounts of bloody sputum, and only by means of close contact. Before antibiotics were available for postexposure prophylaxis for contacts, simple protective measures, such as wearing masks and avoiding close contact, were sufficient to interrupt transmission during pneumonic plague outbreaks. In this article, I review the historical literature and anecdotal evidence regarding the risk of transmission, and I discuss possible protective measures.

Figure 1. Cotton and gauze mask as worn by medical personnel during the second Manchurian epidemic. It was believed that these masks were quite effective in preventing infection. Photograph reprinted with permission from [27].

Table 3. Results of agar plate experiments on transmission of *Yersinia pestis* done by Strong and Teague [7] during the Manchurian epidemic of pneumonic plague in 1910–11.

Variable	No. of plates, by finding: *Y. pestis* captured on plate[a]	*Y. pestis* not captured on plate	Indeterminate[b]	All
Patient coughed during plate exposure				
Yes	15	16	6	37
No	1	40	3	44
Distance between plate and patient who coughed				
5–30 cm	6	13	1	20
70–85 cm	8	3	1	12
1 m	1	0	1	2
2 m	0	0	2	2

NOTE. Agar plates were exposed to hospitalized pneumonic plague patients at various distances from the mouth and for various periods of time. All patients had bloody sputum. Values in the table are based on a count made from the published line list of culture results, which differs slightly from a summary given by Strong and Teague [7].

[a] Confirmed by Gram staining and microscopy and/or inoculation in guinea pigs.
[b] The majority of plates with indeterminate results were overgrown with other bacteria.

Clinical Infectious Diseases 2005; 40:1166–72

Special scenario: bioterrorism生物恐怖襲擊

Level A

Level B

Level C

Level D

PPE used by healthcare workers in medical practice

RSD Yeung, JTS Chan, LLY Lee, YL Chan. The use of personal protective equipment in Hazmat incidents. Hong Kong j. emerg. med. Vol. 9(3) Jul 2002

https://www.gov.uk/government/publications/defence-chemical-biological-radiological-and-nuclear-centre-dcbrnc/defence-chemical-biological-radiological-and-nuclear-centre (accessed on 27-11-2017)

Prevention of Plague

- Rodent control & Flea protection
- Vaccination
  - Live vaccine (EV NIIEG strain) was made in 1930s and widely used in USSR
  - Whole-cell inactivated vaccine (Plague Vaccine U.S.P.)
    - Used in military personnels in US deployed to Vietnam
    - Requred booster every 6 months
    - Poor efficacy & highly reactogenic
    - No protection against pneumonic plague
  - *Currently there are no approved vaccine available in the developed world*

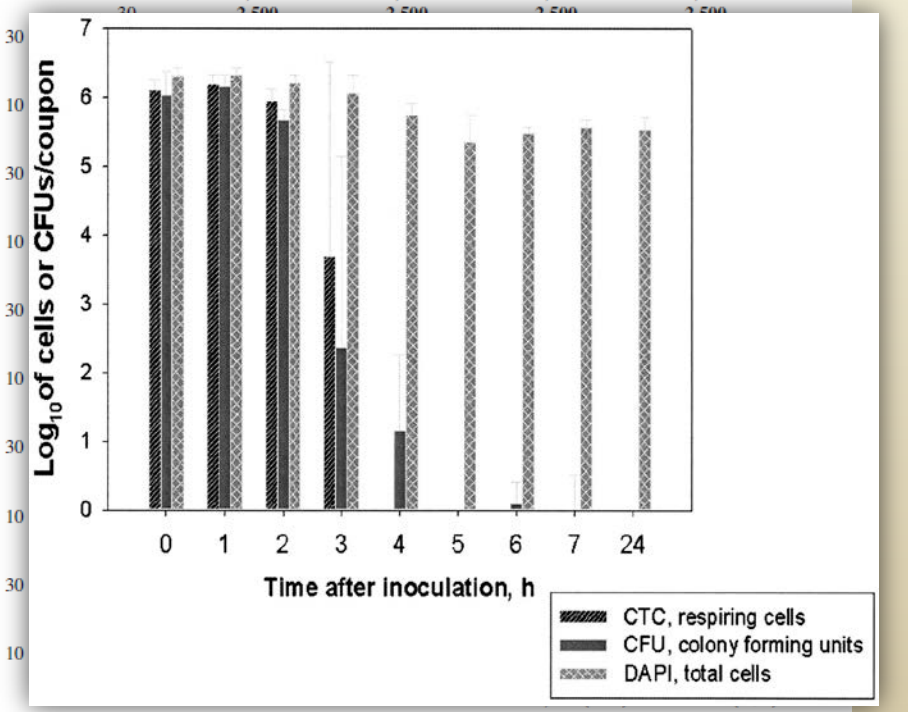
Valentina A Feodorova, et al. Prospects for new plague vaccines. Expert Rev. Vaccines 8(12), 1721–1738 (2009)
Verma SK and Tuteja U (2016) Plague Vaccine Development: Current Research and Future Trends. Front. Immunol. 7:602.

Environmental control

- *Y. pestis* has low environmental resistance and is easily killed by physical conditions and disinfectants e.g. 1:49 diluted household bleach
- 1:9 diluted bleach is recommended if bacterial spores may be present e.g. in biological attacks

TABLE 2. *Biocide levels[a] providing a minimum 5-log reduction of* Yersinia pseudotuberculosis *ATCC 29910 on stainless steel coupons in the presence of food residues[b]*

Biocide (active agent measured)[c]	Time (min)	Temp (°C)	Active agent level providing a minimum 5-log reduction (r^2 of model, if used): No residue	Wheat flour paste, 10%	Whole milk	Egg yolk emulsion, 50%
Sodium hypochlorite (free available chlorine)	10	10	**600**	**600**	5,510 (0.84)	7,020 (0.89)
		20	**600**	**600**	1,610 (0.66)	2,540 (0.91)
		30	**600**	**600**	730 (0.87)	1,380 (0.77)
	30	10	**600**	**600**	1,100 (0.76)	1,500 (0.87)
		20	**600**	**600**	**600**	**600**
		30	**600**	**600**	**600**	**600**
Acidified sodium chlorite, pH 2.8 (same)	10	10	**2,500**	**2,500**	**2,500**	**2,500**
		20	**2,500**	**2,500**	**2,500**	**2,500**
		30				
Hydrogen peroxide (same)		10				
		30				
Peroxyacetic acid (same)		10				
		30				
Peroxy–fatty acid mixture (total peroxyacids)		10				
		30				
Quaternary ammonium compound (same)		10				
		30				
Iodophor (total available iodine)		10				
		30	10	75	80 (0.98)	1,610 (0.97)	1,510 (0.73)
			20	75	75	700 (0.82)	750 (0.82)
			30	75	75	380 (0.90)	300 (0.90)



Laura J. Rose et al. Survival of Yersinia pestis on Environmental Surfaces. Appl. Environ. Microbiol. 2003;69:2166-2171

Dennis DT, Gage KL, Gratz N, Poland JD, and Tikhomirov E. Plague Manual: epidemiology, distribution, surveillance and control. World Health Organization, Geneva, 1999

J. Hilgren, et al. Inactivation of Yersinia pseudotuberculosis, as a Surrogate for Yersinia pestis, by Liquid Biocides in the Presence of Food Residue Journal of Food Protection, Vol. 72, No. 2, 2009, Pages 392–398

Waste disposal

- Although does not fulfill the full definition, items contaminated with Plague should be discarded as *clinical waste*

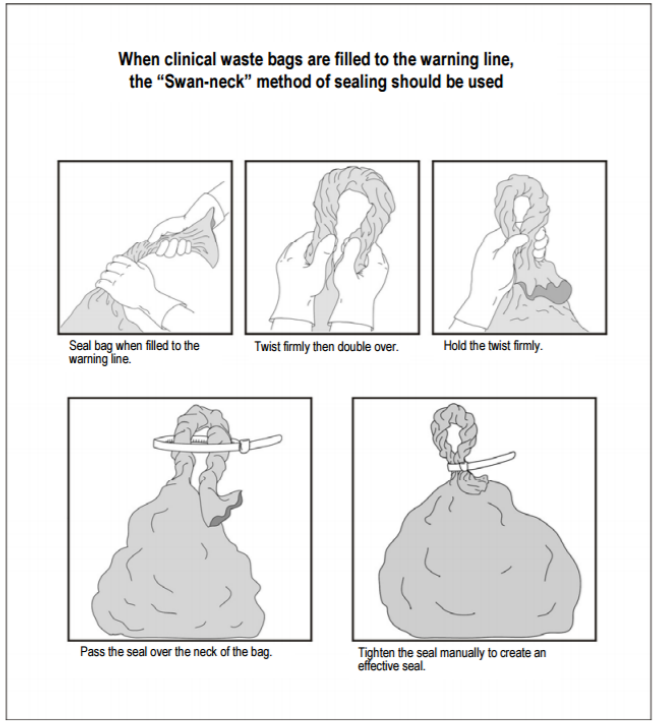


Figure 1: Sealing Method for Clinical Waste Bags.

Disposal of dead bodies for plague

Recommended precautions for relatives when handling dead bodies under Category 3

Danger of Infection 小心傳染 Category 類別 **3**

In handling dead bodies, Standard Precautions are required. 處理屍體時需要採取標準預防措施。
In addition, the following precautions are also required: 此外，下列附加的預防措施亦必須採納：

Bagging 入屍袋	Viewing in funeral parlour 殯儀館內瞻仰遺容	Embalming 防腐處理	Hygienic preparation in funeral parlour 殯儀館內裝身及化妝
Must 必須	Not allowed 不可以	Not allowed 不可以	Not allowed 不可以

You are advised of the following measures for your health protection:

1) Viewing in funeral parlour, embalming and hygienic preparation are NOT allowed.
2) The dead body should NOT be removed from the body bag.
3) Unzipping of the body bag is NOT allowed.
4) Wash hands immediately with liquid soap and water if accidentally have contact with blood or body fluids from the dead body.

Risk category	Bagging	Viewing in funeral parlour	Embalming	Hygienic preparation in funeral parlour	Disposal of dead body
Cat. 1 Other than those specified in Cat 2 & Cat 3 below	NOT necessary	Allowed	Allowed with PPE*	Allowed with PPE*	Coffin burial or cremation is optional
Cat. 2 1) Human Immunodeficiency Virus infection (HIV) 2) Hepatitis C 3) Creutzfeldt-Jacob disease without necropsy 4) Severe Acute Respiratory Syndrome (SARS) 5) Avian influenza 6) Middle East Respiratory Syndrome (MERS) 7) Others**:	Must	Allowed	NOT allowed	Allowed with PPE*	Cremation is advisable
Cat. 3 1) Anthrax 2) Plague 3) Rabies 4) Viral haemorrhagic fevers 5) Creutzfeldt-Jacob disease with necropsy 6) Others**:	Must	NOT allowed	NOT allowed	NOT allowed	Cremation is strongly advisable

Precautions for Handling and Disposal of Dead Bodies 10th Edition 2014

Disposal of dead bodies
in emergency conditions

WHO Regional Office for South-East Asia

Typhus and plague
To avoid infestation with the fleas and lice that spread these diseases, protective clothing should be worn. Body bags should be used to store the bodies prior to burial or cremation.

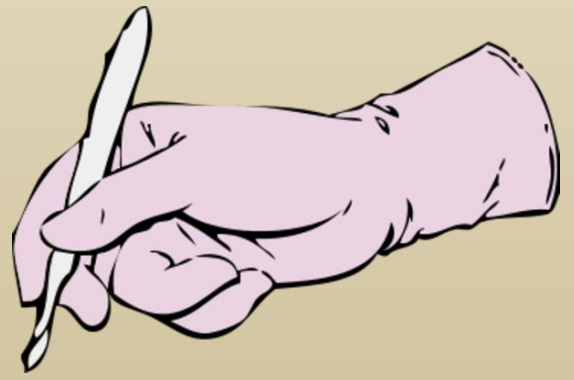
Volunteers remove bodies with extreme caution

Burial
Burial is the preferred method of body disposal in emergency situations unless there are cultural and religious observances which prohibit it. The location of graveyards should be agreed with the community and attention should be given to ground conditions, proximity to groundwater drinking sources (which should be at least 50m) and to the nearest habitat (500 m). An area of at least 1500m² per 10 000 population is required. The burial site can be divided to accommodate different religious groups if necessary. Burial depth should be at least 1.5m above the groundwater table, with at least a 1m covering of soil. Burial in individual graves is

Cremation
There are no health advantages of cremation over burial but some communities may prefer it for religious or cultural reasons. Factors against it are the amount of fuel required by a single cremation (approx 300kg. wood) and the smoke pollution caused. For this reason, cremation sites should be located at least 500m downwind of dwellings. The resultant ashes should be disposed of according to the cultural and religious practice of the community.

Precautions for autopsies

- Avoid autopsy if suspected plague infection if possible, as bone-sawing can cause aerosol and airborne contamination
- Wear N95 respirator
- Perform in Negative pressure room
- Observe standard, contact and airborne precautions
- The number of people allowed in the autopsy room should be limited to those directly involved in the operation
- Environmental control



Plague - Hospital Infection Control (Including Autopsies and Burial). CIDRAP Last updated Feb 2013

Disinsection 除蟲

Upon admission to hospital:

- The patient should be showered and applied insecticide, such as malathion emulsion which is effective and safe to people
- The contaminated clothing should be removed on admission and placed in a sealed bag pretreated with insecticide for autoclaving or incineration

Table 5 Insecticide dusts commonly employed in flea control

Insecticide	class	Concentration (%) rats (mg/kg oral)	Oral LD50 to
bendiocarb	carbamate	1.00	55.00
carbaryl	carbamate	2.0 –5.0	3,000.00
deltamethrin	pyrethroid	0.005	135.00
diazinon	OP	2.00	300.00
diflubenzuron	IGR	5.00	
fenitrothion	OP	2.00	503.00
jofenphos	OP	5.00	2,100.00
lambdacyhalothin	pyrethroid		
lindane	Org.chl	3.00	100.00
malathion	OP	5.00	2,100.00
methoprene	IGR		
permethrin	pyrethroid	0.50	430.00
propetamphos	OP		
pirimiphos–methyl	OP	2.00	2,018.00
propoxur	carbamate	1.00	95.00

Source: Gratz, N.G. & Brown, A.W.A.: 1983

Plague Manual Epidemiology, Distribution, Surveillance and Control. WHO.
Situation of Plague and Prevention Strategies, SCVD, CHP 2008