Legionnaires' Diseases – Public Health Perspective

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About the origin

- The American Legion – the veterans service organization in the USA

About the first outbreak

- In 1976, the American Legion Convention in Philadelphia
  - 182 cases of pneumonia, 34 died

The Bellevue-Stratford Hotel - Broad Street in Philadelphia's Center City since the early 1900s

About the first outbreak

- Retrospective study showed outbreaks:
  - in 1974 (in same hotel!),
  - in 1968 (in Pontiac, Michigan)
  - in 1965 (a hospital in Washington DC),
  - in 1957 (a meat-packing plant in Minnesota)

About the bacterium

- In January 1977, Dr. Joseph E. McDade, a microbiologist at the CDC, discovered the bacterium.

- The national commander wrote a letter to the CDC requesting that the disease be named Legionnaires' disease and that the organism itself be named McDade-Legionnaire, recognizing the CDC microbiologist.

Sources of LDB

- Water is the major natural reservoir for LDB, which thrive in warm damp places and are commonly found in lakes, rivers, creeks, hot springs, etc

- LDB proliferate in poorly maintained or designed artificial water system, such as cooling tower waters, hot and cold water systems in buildings, whirlpool spas (Jacuzzi), water fountains, humidifiers, respiratory therapy equipments, etc

Transmission

- Disease spread via aerosols and inhalation
- Infective dose is unknown, but can be assumed to be low for susceptible humans, as patients have been known to be infected
  - after exposure of only a few minutes to sources
  - at up to 3.2 km from the sources (Addiss et al., 1989)
  - recent evidence suggests that infection may be possible at even longer distances (Tran Minh et al., 2004)
- No evidence of human to human transmission of legionnaires disease and Pontiac fever (WHO, 2007)

Public Health Significant of LD

- The LDB is important because of its ability to survive in high temperature environments (Amato-Gauci and Ammon 2007)
- Modern architecture has provided it with an evolutionary advantage as it can thrive in
  - cooling towers
  - evaporative condensers
  - Humidifiers
  - decorative fountains, and
  - hot water systems
- Outbreaks have been linked to large modern building complexes, such as tourist resorts
- Treatment with antibiotics is generally effective but case fatality rates are disproportionately high among elderly and immunocompromised individuals

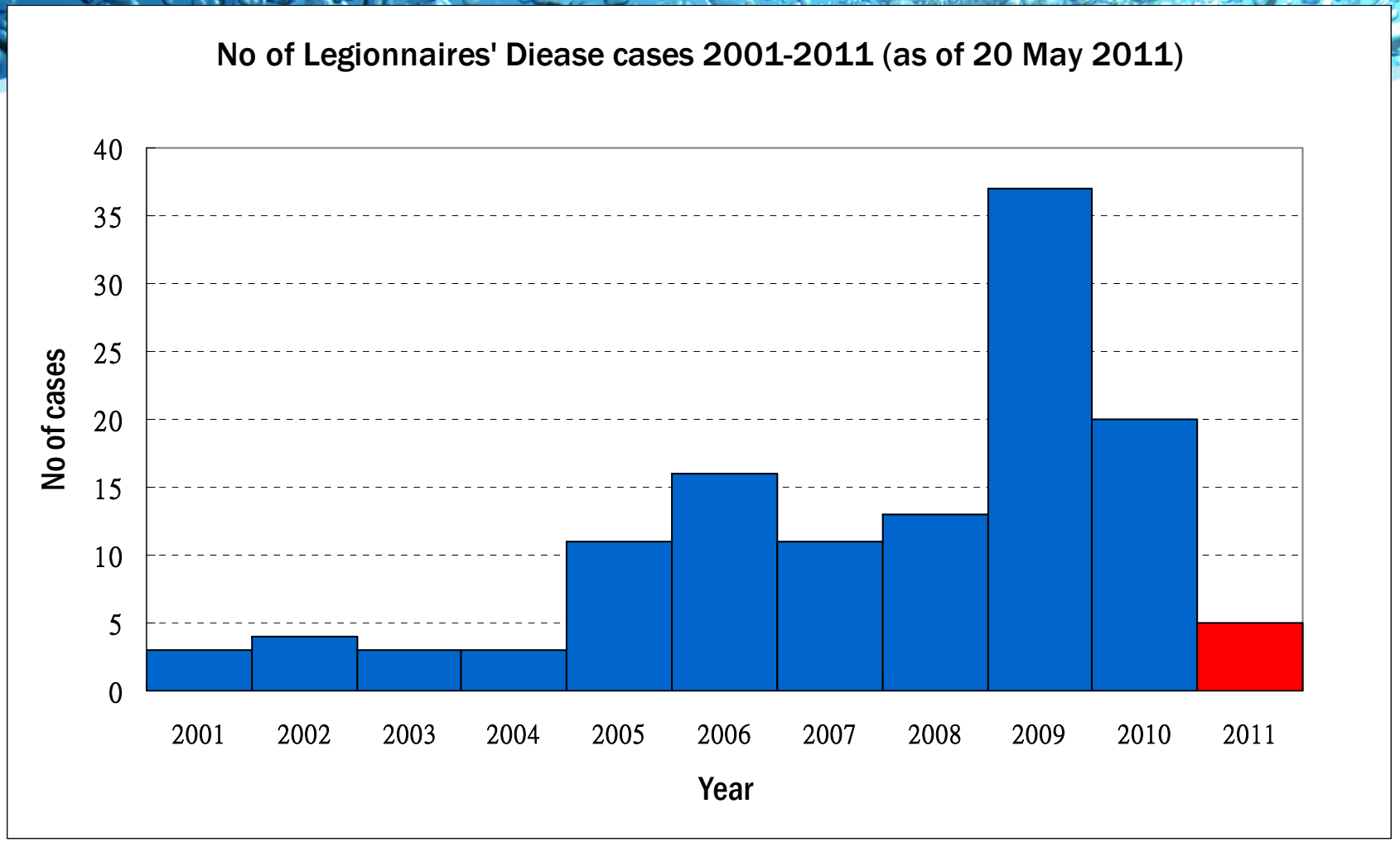
A notificable disease

- In March 1994, LD has been listed as a notifiable disease under the Quarantine and Prevention of Disease Ordinance (Cap. 141) (former ver. Of Prevention and Control of Disease Ordinance Cap. 599)

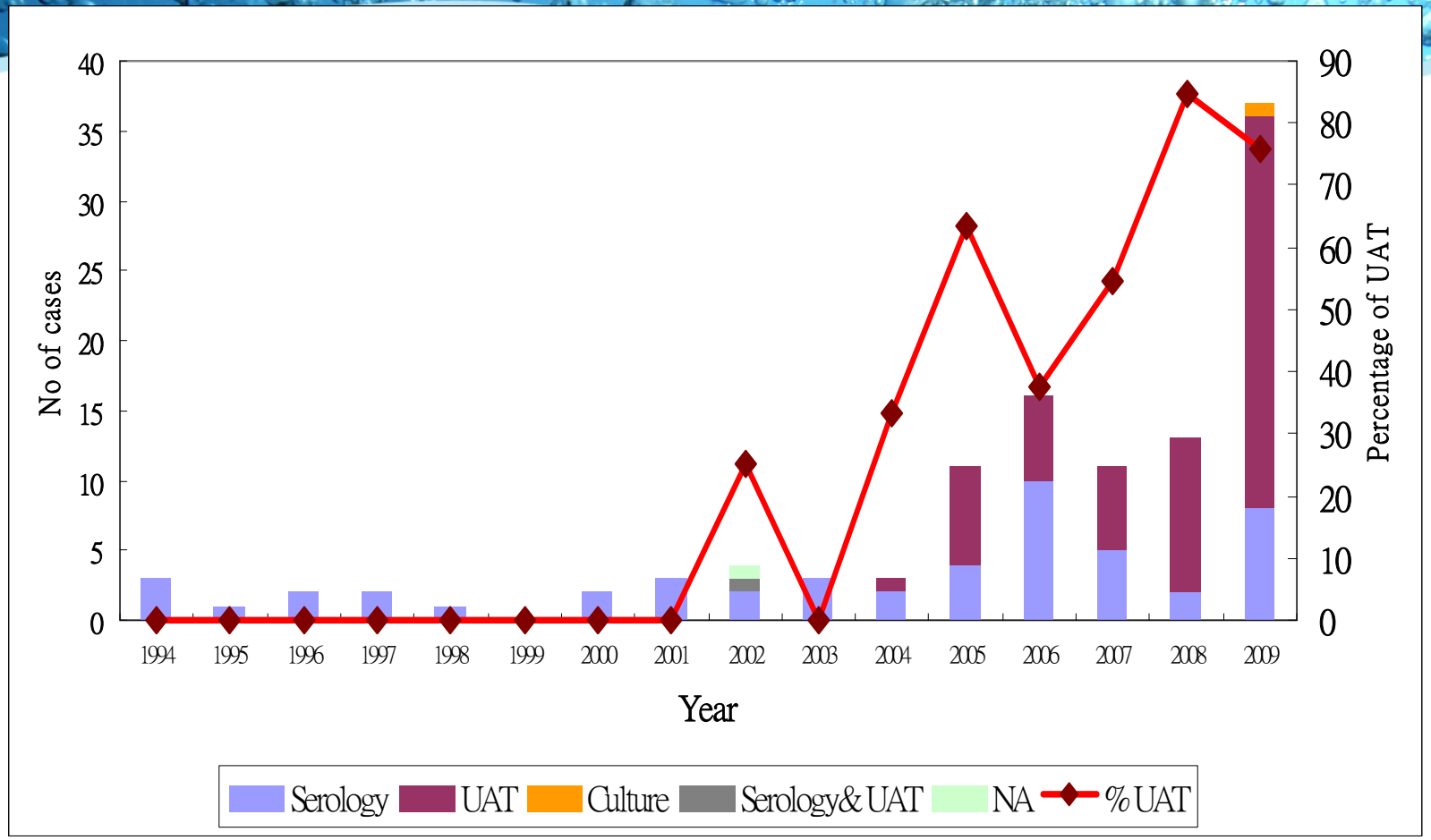
- LD was added into the list of notifiable occupational disease under the Occupational Safety & Health Ordinance (Cap. 509) in June 1999

Epidemiology of LD in HK

Number of reported LD cases (2001-2011)



Diagnostic Method of LD

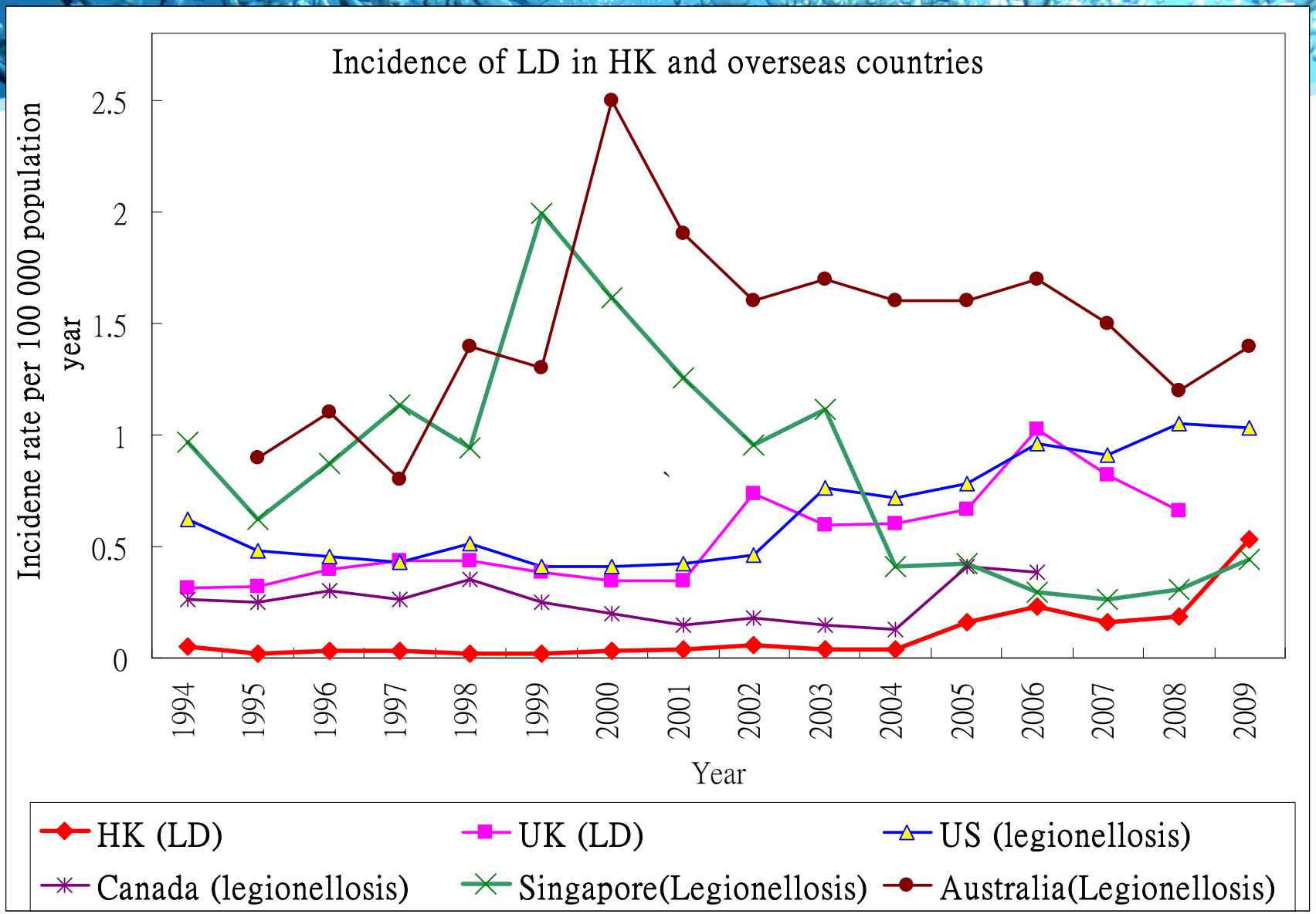


Percentage of using UAT for diagnosis of LD in 2004 33%

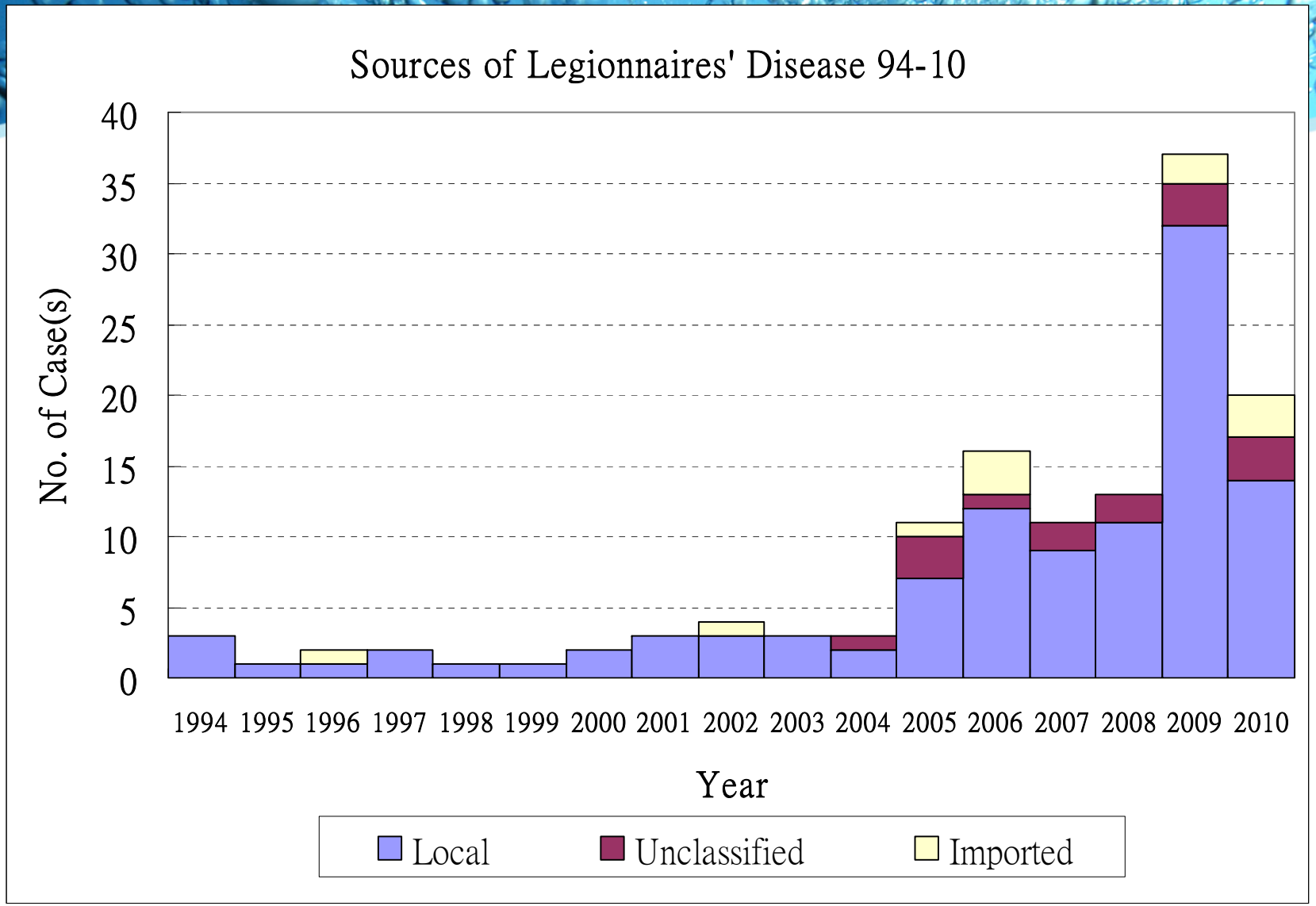
2005-2008 59%

2009 73%

HK and overseas incidence



Sources of LD 1994-2010

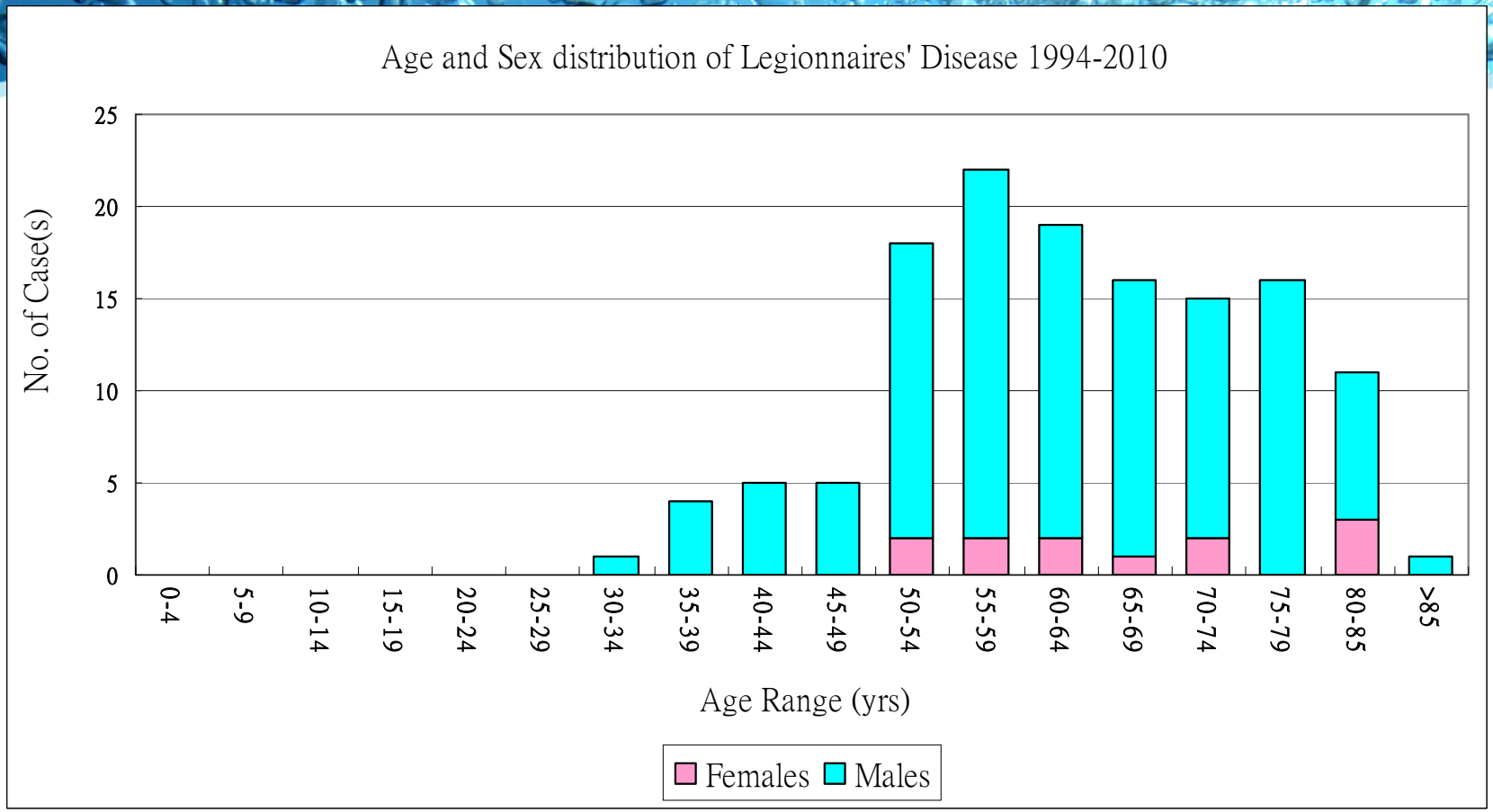


Risk factors – patient perspective

- Risk factors
  - Age >40
  - Male
  - Smokers, alcohol abuse
  - Underlying disease: Diabetes mellitus, Chronic heart disease, chronic pulmonary disease, chronic renal disease, immunosuppression, haematological malignancy, iron overload
  - Recent Travel with overnight stay outside home
  - Exposures to whirlpool spa
  - Recent repairs or maintenance work on domestic plumbing

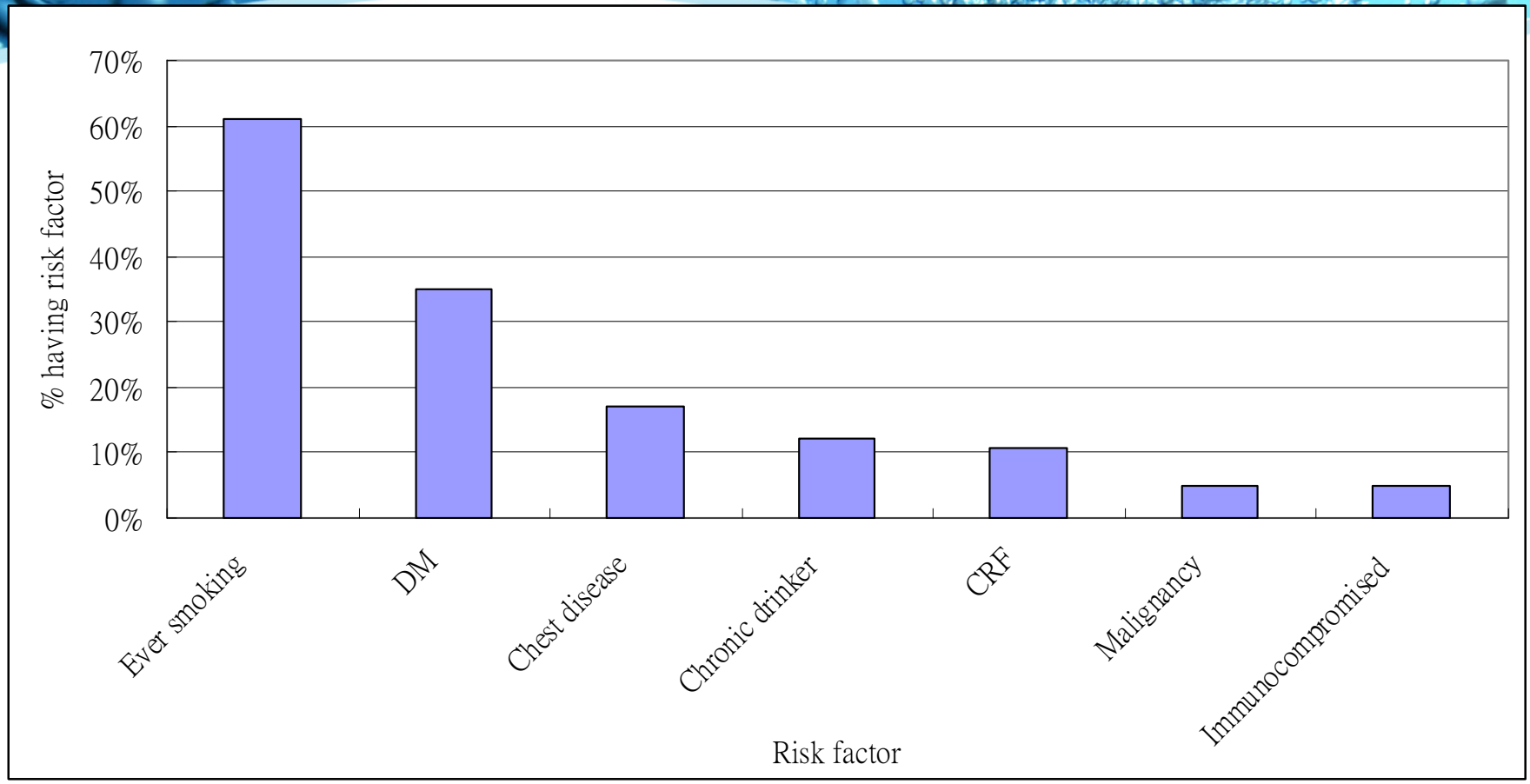
CDC and WHO

Age & Sex distribution of LD 1994-2010

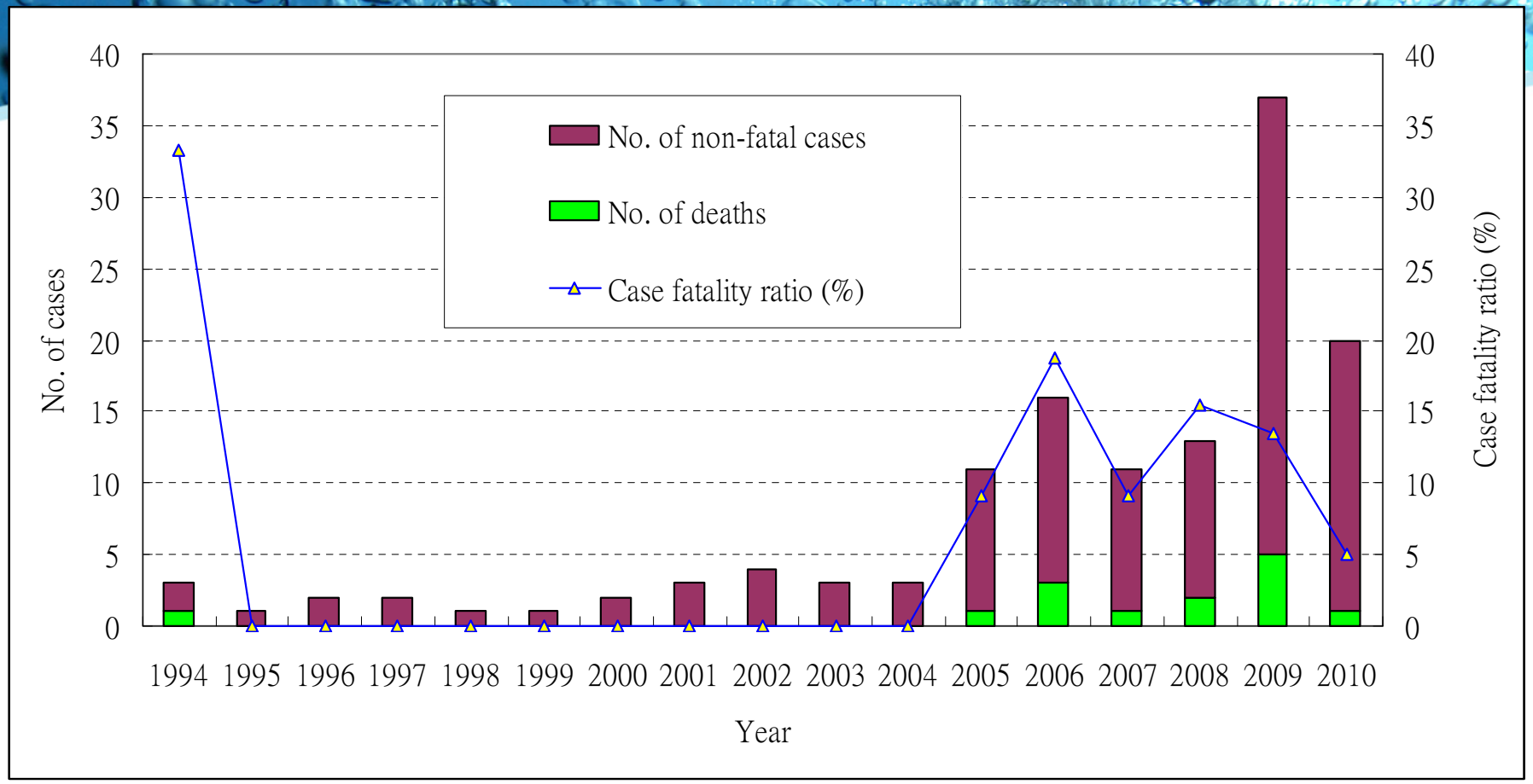


89% of cases in >=50 years
91% affected male

Risk factors of LD cases 2000-2010

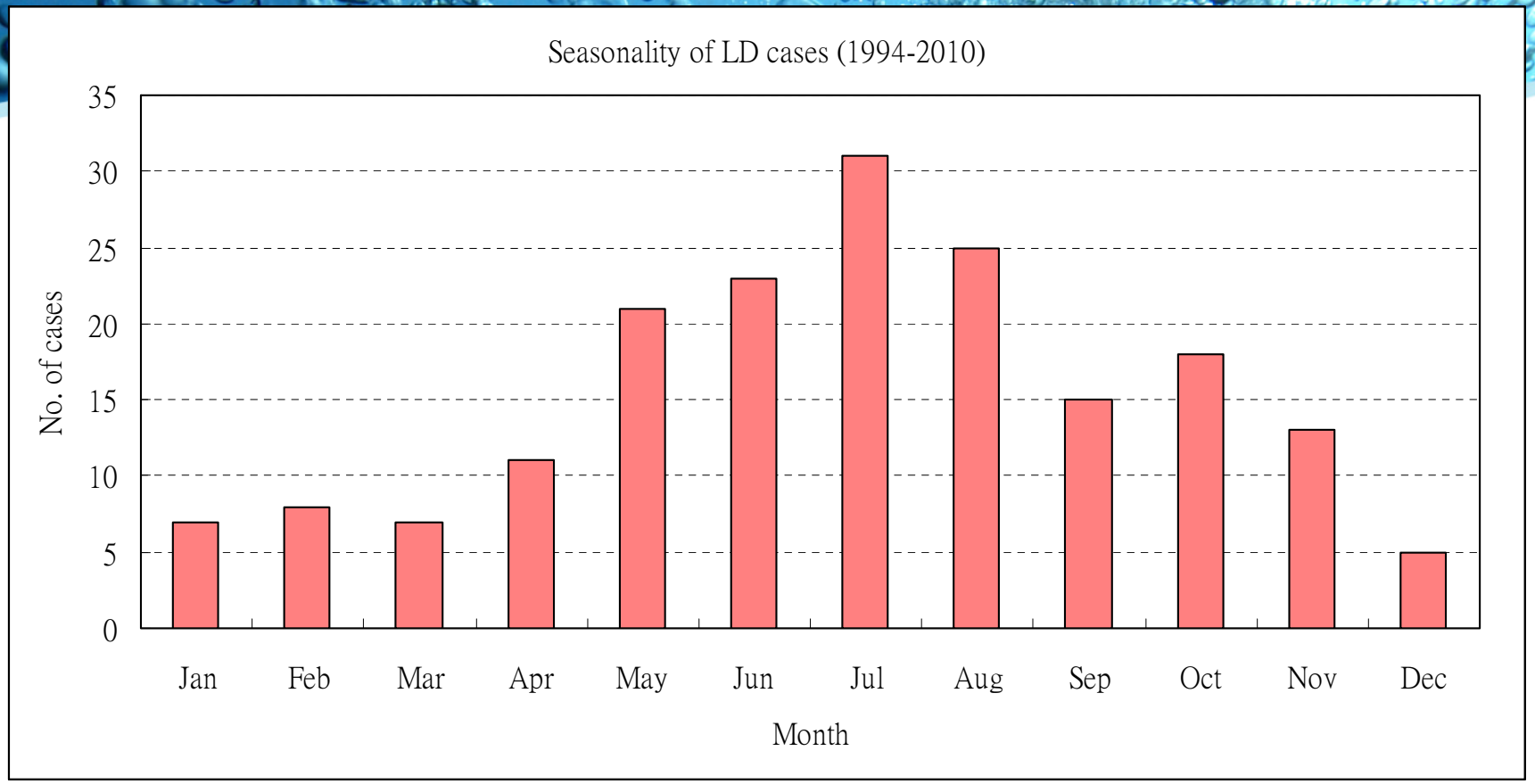


Fatal cases and case fatality ratio



Case fatality ratio 1994-2010: 10.5%

Seasonality of LD 2005-2009



More cases (54%) occurred in summer months from May to Aug.

Environmental Factors for Infection

- **HPA of UK press release, 17 September 2008**

Climate change may lead to an increase in cases of Legionnaires' disease

A recent study conducted by the Health Protection Agency, one of the first of its kind in Europe, has found that higher temperatures and increases in humidity are associated with an increase in cases of Legionnaires' disease…..

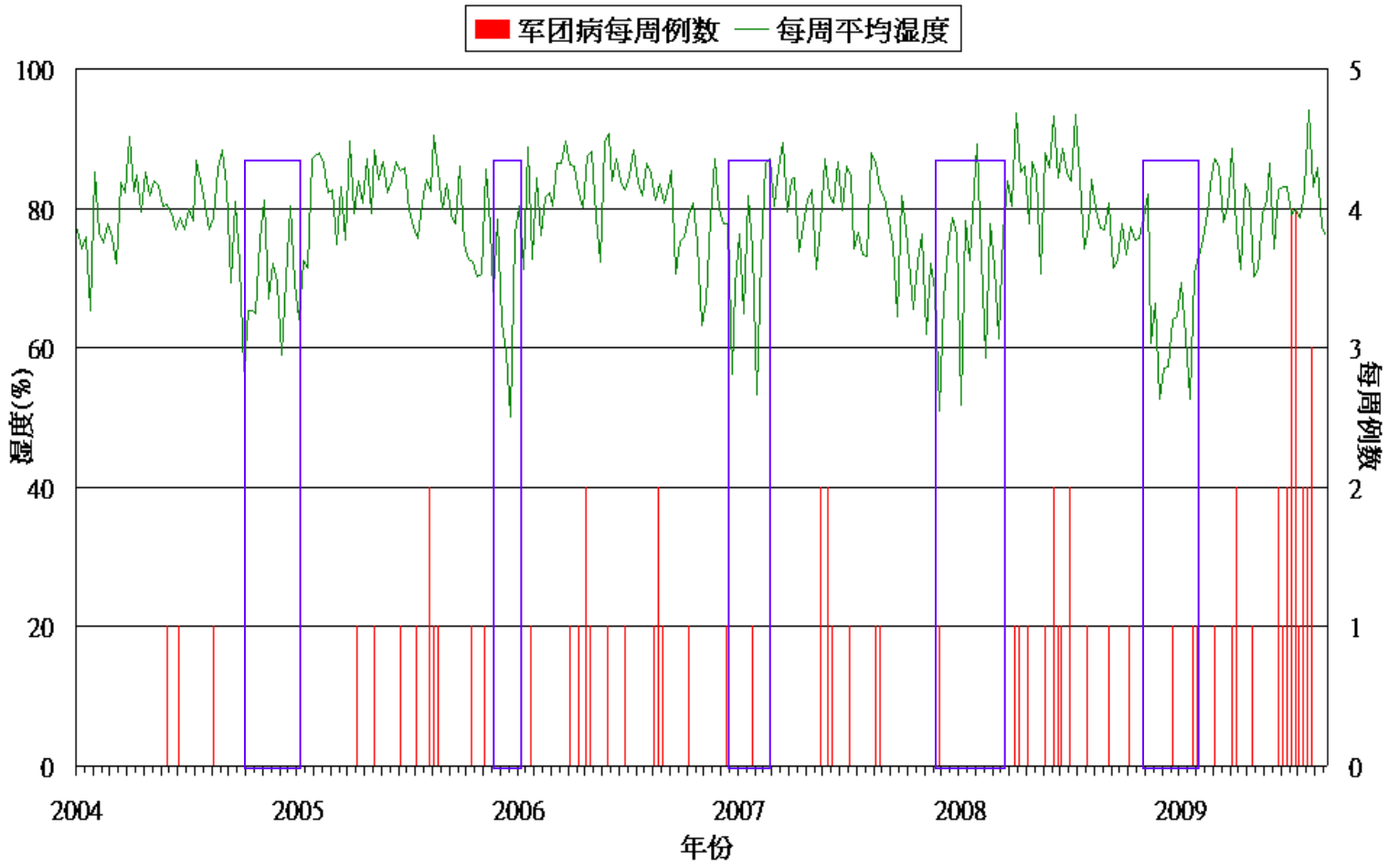
Temperature and Humidity

- Naturally occurring *L. pneumophila* survived and multiplied in water at temperatures between 25 °C and 45 °C, with an optimal temperature range of 32–42 °C. (Yee & Wadowsky (1982))

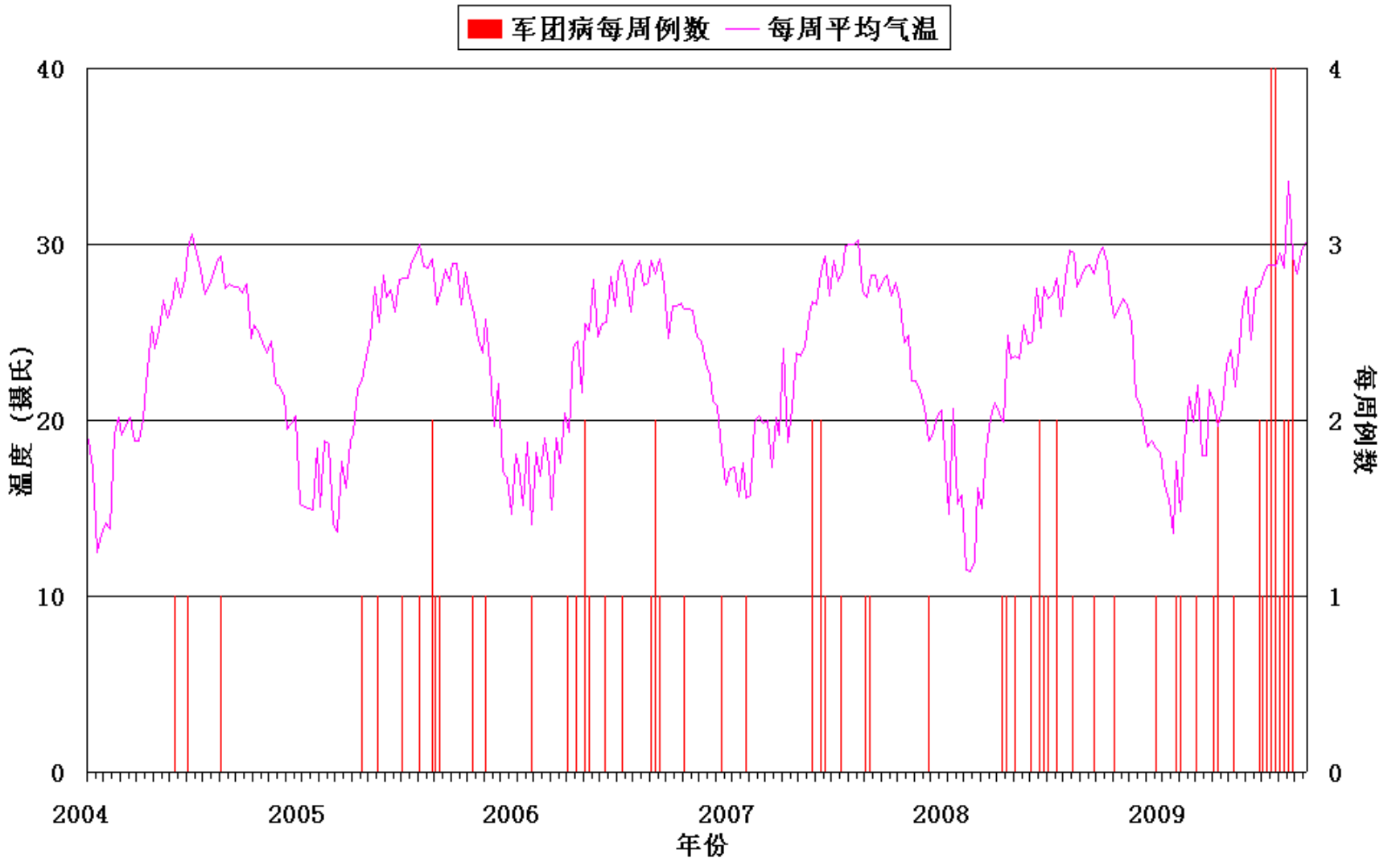
- An optimum temperature can cause a rapid increase in numbers of the organism

- As transmission of the bacterium occurs by aerosol, humidity is an important factor in its survival

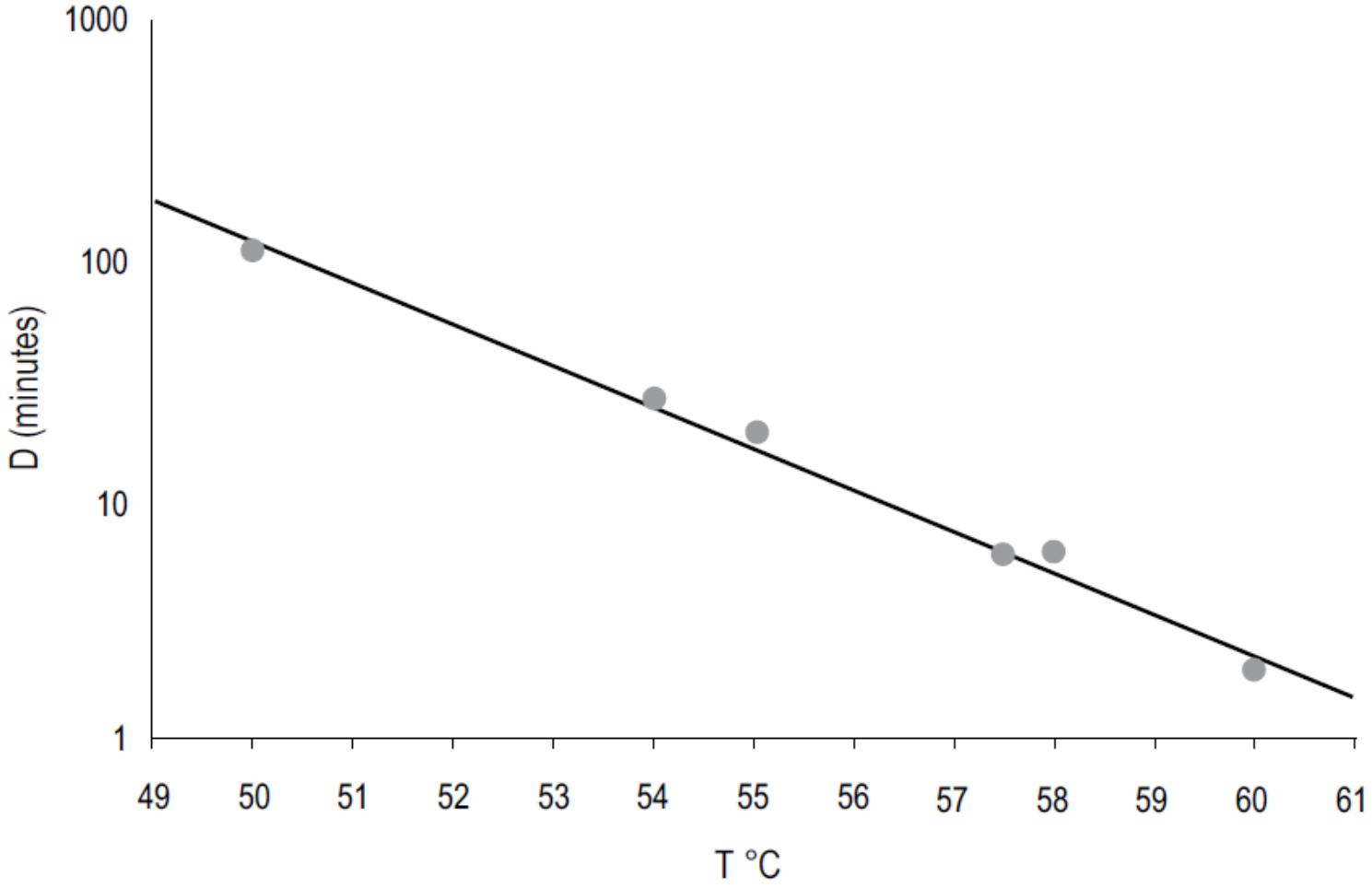
Humidity and LD



Temperature and LD in HK



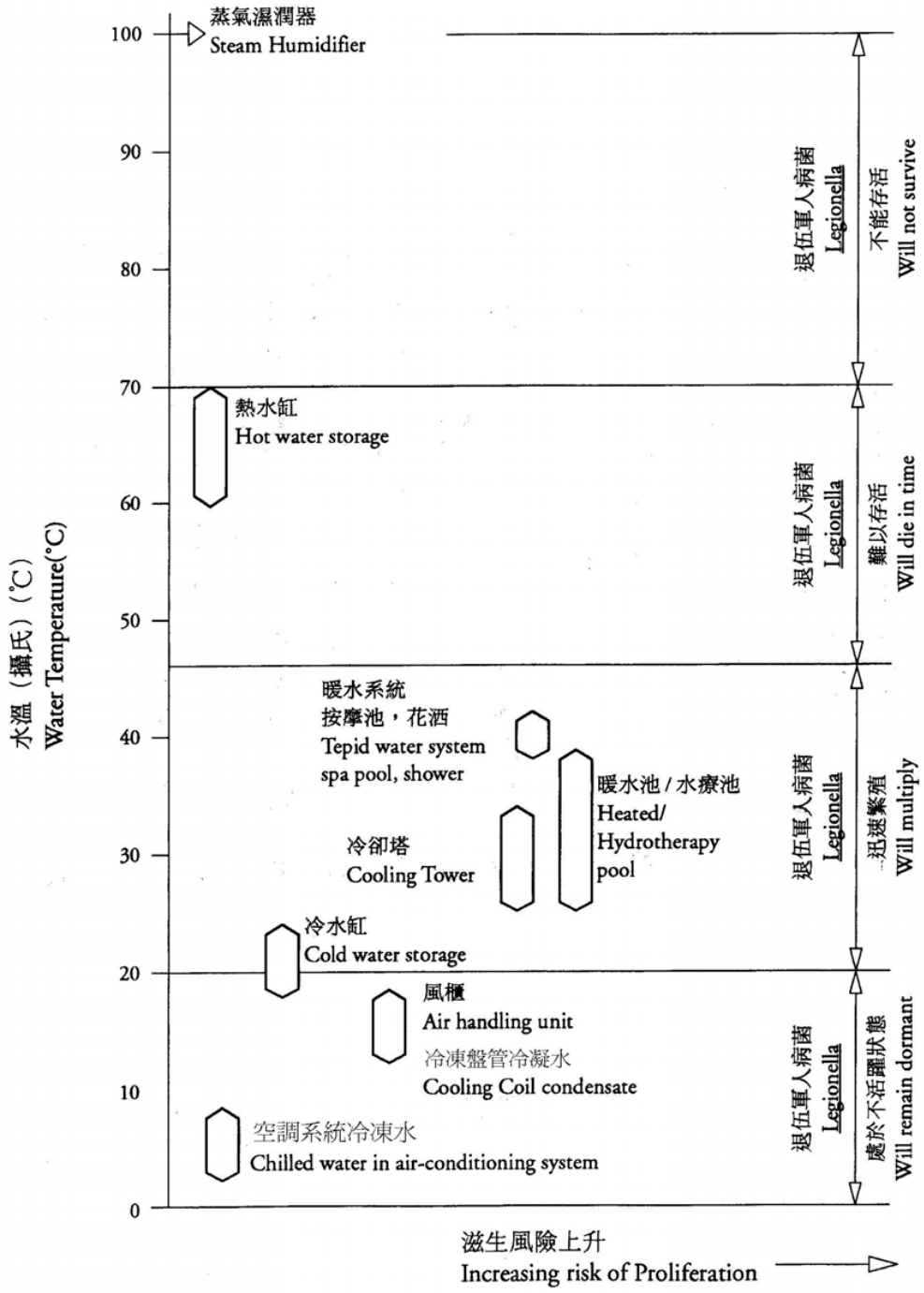
Decimal reduction times for *L. pneumophila* serogroup 1 at different temperatures



Decimal reduction time (D) = time in minutes to kill 90% of the population of *Legionella*

Source: data combined from Dennis, Green & Jones (1984); Schulze-Robbecke, Rodder & Exner (1987)

Relationship between *Legionella* proliferation & temp. of water systems



(Source: PLDC, CoP of prevention of LD, 2007)

Risk factors for *Legionella* infection, by reservoir

	Cooling water systems	Hot and cold-water systems	Hot tubs Natural spa pools Thermal springs	Humidifiers Respiratory equipment	Potting mixes Compost
Commonly implicated *Legionella* species	Predominantly *L. pneumophila* sg 1	*L. pneumophila* sg 1, 2, 4, 6, 12, *L. micdadei*, *L. bozemanii*, *L. feeleii* and others	*L. pneumophila* sg 1, *L. micdadei*, *L. gormanii*, *L. anisa*	*L. pneumophila* sg 1, 3, and others,	Exclusively *L. longbeachae*
Risk factors (environmental)	Proximity of population, seasonal/ climatic conditions, intermittent use, poor maintenance, poor design	Complex water systems, long pipe runs, poor temperature control, low flow rates/ stagnation	Poor maintenance, stagnant areas in system	Use of non-sterile water, poor maintenance/cleaning, operation at temperatures conducive to *Legionella* growth	Seasonal (spring and autumn), use of potting mixes/compost, gardening

sg = serogroup

Example of poorly maintained sap pool

Location of water samples	*Legionella* culture	Total bacterial count (per ml)	Water Temperature
Indoor swimming pool in Club Siena	No *Legionella* species isolated	Nil	21℃
Male whirlpool bath in the changing room of Club Siena	***Legionella pneumophila*** **serogroup 1 (c.f.u.per ml): 210** ***Legionella pneumophila*** **serogroup 2-14 (c.f.u. per ml): 12**	>30,000	34.5℃

Mechanism of Cooling Towers

Figure 1a Forced draft

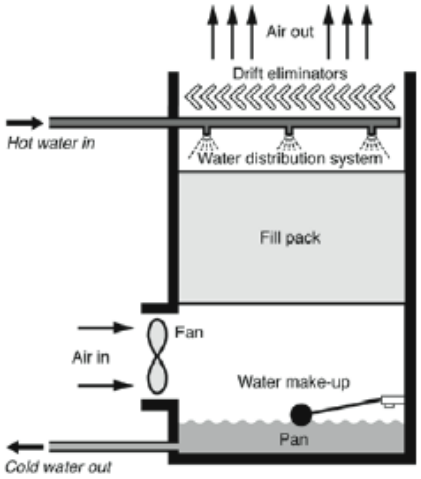
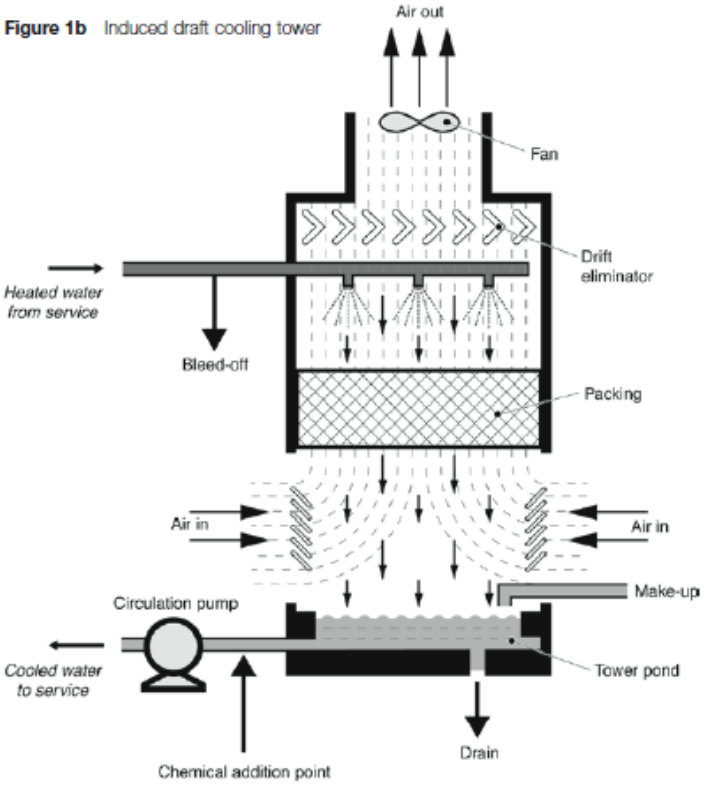


Figure 1b Induced draft cooling tower



Distance from the cooling tower as a risk factor for infection (Brown et al. (1990))

- Risk of illness 20% less for each 0.1 mile (160 m) increase in distance from the hospital (up to one mile away)
- Transmission mainly within 0.25 miles (400 m)
- Infection associated with frequent and extended exposure to the source
- Cumulative exposure as a risk factor for illness, as well as proximity to the source

Legionella count and risk of infection

- No established dose-response relationship for *Legionella* infections
- The likelihood depends on
  - load of bacteria
  - effectiveness of dissemination
  - the way in which it multiplies
  - and its ability to form aerosols
  - strain virulence
- Recovery of *L. pneumophila* by culture is poor. These uncertainties and differences in susceptibility of *Legionella* populations make it difficult to interpret the colony count values for *Legionella* in relation to disease risk
- *Legionella* Count, however, provide useful information about the degree of amplification of *Legionella* in a system
- A high degree of amplification results in a higher exposure, which may be related to a higher infection risk

Legionella and TBC

- Water alone is insufficient to allow *L. pneumophila* to proliferate*Legionellae* can grow in association with many different organisms
- Presence of other microorganisms allow *Legionella* to amplify (Yee & Wadowsky, 1982)
- *Legionellae* grown in biofilms are more resistant than the same bacterial species in the water phase of the system (Barker et al., 1992; Cargill et al., 1992; Surman, Morton & Keevil, 1993; Santegoeds, Schramm & de Beer, 1998)
- It is important to control other microorganisms to reduce the proliferation of *legionellae*

Action Plan for environmental samples with laboratory confirmed *Legionella* Bacteria in Hong Kong

	Action level (cfu/ml)					
Site of Env. Samples collected	***HCC/TBC***	***LD serogp 1***	***Other LD species***	***Actions ****	***Other Action parties***	***Reference***
Cooling Towers	(HCC) 100,000	10	10	Inform EMSD; Inform the owner and request proper online disinfection according to the advice from EMSD; Re-sample within 3 to 7 days after disinfection	EMSD SEB	CoP WACS, EMSD, 2006; SA
Spa pools/ Jacuzzi / Swimming Pool/ fountain	(TBC) 200	0.1	0.1	Inform FEHD if appropriate and EMSD; Inform the owner and request proper disinfection; advise to suspend the facility until further sampling demonstrates that the organism is no longer present.	FEHD, EMSD, ICB	Cap 132CA (FEHD); Austria, Switerland, US, UK
Domestic-use resp. equipments	(TBC) 0	0.1	0.1	Inform the owner and request to disinfect / discard / replace as appropriate; Seek advice from ICB if necessary; Inform EMSD if necessary	SEB ICB/EMSD if necessary	

Action Plan for environmental samples with laboratory confirmed *Legionella* Bacteria in Hong Kong

Site of Env. Samples collected	Action level (cfu/ml)		Actions *	Other Action parties
	LD serogp 1	***Other LD species***		
Water sample from Hot and Cold water system (include tap, water tank, piped water system, instantaneous water heater, etc.)	0.1	0.1	Inform WSD if appropriate; Inform the owner / property management and request proper disinfection immediately according to the advice from WSD. Re-sample after maintenance	WSD
Water sample from tap with filter	0.1	0.1	Inform the owner and suggest to discard / replace the filter if tap water sample is negative	SEB
Water sample (storage-type water heater)	0.1	0.1	Inform the owner and EMSD; Seek advice from EMSD; If all other samples are negative (e.g. water tank and outlet swab), suggest replacing the heater or carry out disinfection according to EMSD's advice. Resample after disinfection/ maintenance.	EMSD SEB
Swab sample From Tap / Shower / piping	Positive	Positive	Inform the owner and suggest to discard / replace the tap/shower; re-sample after replacement if water sample was also positive	SEB

Action Levels for *Legionella* in Cooling Towers

	Sources	Legionella Count (cfu/mL)		
UK	Legionnaires' disease: The control of legionnella bacteria in water systems. Approved CoP & guidance: (HSE, 2000) www.hse.gov.uk/pubns/books/l8.htm	*(<100 LDB cfu/L=0.1 cfu/mL)* **System under control**	*(=0.1 to 1 cfu/mL)* **Review programme operation** (a) A review of the control measures and risk assessment should be carried out to identify any remedial actions and the count should be confirmed by immediate resampling.	*(>1 cfu/mL)* **Implement corrective action** (a) The system should immediately be re-sampled. It should then be 'shot dosed' with an appropriate biocide, as a precaution. The risk assessment and control measures should be reviewed to identify remedial actions.
EU	European Guidelines for Control & Prevention of Travel Associated Legionnaires' Disease (EWGLI, 2005) www.ewgli.org/data/european_guidelines/european_guidelines_jan05.pdf	*(<1000 LDB cfu/L = 1 cfu/mL)* **System under control**	*(=1 to 10 cfu/mL)* **Review programme operation** (a) The count should be confirmed by immediate resampling. If a similar count is found again, a review of the control measures and risk assessment should be carried out to identify any remedial actions	*(>10 cfu/mL)* **Implement corrective action** (a) The system should immediately be re-sampled. It should then be 'shot dosed' with an appropriate biocide, as a precaution. The risk assessment and control measures should be reviewed to identify remedial actions

Action Levels for Legionella in Cooling Towers

	Sources	Legionella Count (cfu/mL)			
		<10	**≥10 to <100**	**≥100 to <1000**	**≥1000**
SA	Guidelines for the Control of legionella in Manufactured Water Systems in South Australia (South Australian Health Minister, 2008) www.dh.sa.gov.au/pehs/PDF-files/legionella-guidelines-2008.pdf	(a) Continue effective maintenance procedures	(b) Investigate problems (check cleanliness, maintenance procedures, biocide dosing, structural integrity) (c) Review water treatment programs (d) **Take necessary remedial action** including immediate on-line disinfection & undertake control strategy (f)	(e) Follow (b) (f) Retest water within 3 to 7 days of plant operation after on-line disinfection	(g) Inform relevant authority of result (h) Follow (b)(c) (i) Take necessary remedial action including immediate system decontamination (j) Follow (f)

Action Levels for Legionella in Cooling Towers

	Sources	Legionella Count (cfu/mL)			
		<10	**≥10 to <100**	**≥100 to <1000**	**≥1000**
US	Legionnaires' Disease eTool: Water Sampling Guidelines (assessed Mar 2010) www.osha.gov/dts/osta/otm/legionnaires/sampling.html	* apply only to water systems being used by healthy individuals and are not necessarily protective for people who are immuno-compromised *These numbers are only suggested guidelines, and the goal is zero detectable LDB in a water source		(a) **Cleaning** followed by **biocide treatment** of the system, if appropriate.	(a) Cleaning and/or biocide treatment (b) Take **immediate steps** to prevent employee exposure.
EMSD	CoP for Water-cooled Air Conditioning Systems Part 2: Operation and Maintenance of Cooling Towers (EMSD, 2006) www.emsd.gov.hk/emsd/e_download/pee/wacscode_p2_eng_2007A.pdf	**System under control** (a) Maintain quarterly monitoring. (b) Maintain water treatment programme.	**Review programme** (c) Investigate problem (d) Review water treatment programme (e) Take necessary remedial action including immediate **on-line disinfection** (f) Collect and test a water sample within 3 to 7 days after on-line disinfection		**Implement corrective action** (g) Same as (c) to (d) (h) Take necessary remedial action including immediate **emergency decontamination** (i) Collect and test a water sample within 3 days after emergency decontamination

Action Levels for *Legionella* in Hot & Cold Water Systems

	Sources	Legionella Bacteria (cfu/ml)				
		>0.1 to <1	**>1**	**≥1 to <100**	**>10**	**>100**
UK	(HSE, 2000)	(UK1) Action depends on whether just one or two or the majority of samples are positive; review of control measures and risk assessment required; possible disinfection.	(UK2) Immediate review of the control measures and risk assessment required; possible disinfection.			
SA (warm water systems only)	(South Australian Health Minister, 2008)				(a) **Required immediate decontamination**	
EU	(EWGLI, 2005)		(a) Same as (UK1)		(a)Same as (UK2)	
The Netherlands	(WHO, 2007)		**Immediate action** is needed to prevent closure of (part of) system involved.			
US					**Prompt cleaning** and/or biocide treatment of the system	Immediate cleaning and/or biocide treatment; **take prompt steps to prevent employee exposure**

Guidelines in legislation and/or guidance for hot tub water quality (Whirlpool / Jacuzzi / Hot spring)

Country	**Spa whirlpool / hot tub legislation / guidance**	***Legionella* limit in hot tubs (CFU)**
Czech Republic	Decree, Ministry of Health No. 135/2004	<1000/l (=1/mL)
Austria	Decree, Ministry of Health BGBI II 1998/420 Baderhygieneverordung	0/100 ml (=0/mL)
Spain	Spanish legislation and Basque guidance for *Legionella* control Basque guidance for spa control	100–1000/l (=0.1-1/mL)
Switzerland	SIA Norm 385/1 Edition 2000 (guidance)	0/ml
USA		0
Germany	DIN 19643	1000/l (=1/mL)
United Kingdom	HSE / HPA Guidance (HPA 2006)	<100ml (=0.1/mL)
[CFU = colony forming units; HPA = Health Protection Agency; HSE = Health and Safety Executive.] Note: Data refer to situations where water temperature is >30 ºC and where aerosols could be produced.		

(Source: WHO, 2007)

Investigation of a Sporadic case

Case investigation

Environmental investigation

Management of exposed persons

Control Measures and Follow-up

Communication

Aims of Ix

- Source identification (risk-based approach)
- Apply control measure to prevent further spread
- Risk communication

Field Investigation

- Home visit
  - Potential sources are poorly maintained water system with generation of water droplet / aerosol as well as re-circulated / stagnant water
  - Common items: humidifiers, cool fans, shower facilities, respiratory therapy equipments
  - Storage vs Instantaneous type water heater
  - Filter unit

Field Investigation

- Inspection route formulated according to local movement
- Water Cooling Towers
- Water Fountains
- Spa / Jacuzzi

Possible Control Measures

- Suspension of contaminated facilities
- Source elimination (e.g. replace shower head and host, remove high risk device)
- Disinfection+ Follow-up sampling
- Maintenance plan
- Notify country of importation for public health action

Limitations in source identification

- LDB are ubiquitous in natural and artificial water environments worldwide
- Genetic sequencing of bacteria from suspected source and patient is required to establish causal relationship
- Majority of cases were diagnosed by serology/urine test. Bacteria isolate not available for high proportion of cases
- Sampling error does occur during Env. Ix.
- Other *L.* species may mask water contamination by *L. pneumophila*

Positive rate of water samples

Year	No of cases with positive water samples/Total no. of confirmed cases	Percentage of cases with positive specimen	No. of positive water sample/ Total no. of water samples taken	Percentage of positive sample
2004	0/3	0%	0/20	0%
2005	3/11	27.3%	14/94	14.9%
2006	2/16	12.5%	3/80	3.75%
2007	2/11	18.2%	4/100	4%
2008	5/13	38.5%	11/108	10.2%
2009	12/37	32.4%	17/215	7.9%
2010	4/20	20.0%	10/104	9.6%

Way forward

- No specific legislation to control and regulate fresh water cooling towers or high risk device

Regulatory Control Measures in respect of Operation and Maintenance of high risk devices

vs

Surveillance and inspection program + public education

Major references

- PLDC, CoP of prevention of LD, 2007
- LEGIONELLA and the prevention of legionellosis, WHO, 2007
- Legionnaires' disease, The control of legionella bacteria in water systems, Approved Code of Practice and guidance, Health and Safety Executive, UK, Third edition, 2000

Thank you