

**Outbreak of Severe Acute Respiratory Syndrome (SARS)**  
**at Amoy Gardens, Kowloon Bay, Hong Kong**  
**Main Findings of the Investigation**

## **INTRODUCTION**

An outbreak of Severe Acute Respiratory Syndrome (SARS) occurred among residents of Amoy Gardens, Kowloon Bay, towards the end of March 2003. In order to identify the cause of the outbreak, the Department of Health, in collaboration with eight other government agencies<sup>1</sup>, conducted a detailed investigation covering epidemiological, environmental, public hygiene, building design and utilities considerations. The major findings of the investigation are set out below.

## **EPIDEMIOLOGICAL INVESTIGATIONS**

2. The index patient (first case of the outbreak) was a 33-year-old man who lived in Shenzhen and visited his brother in Amoy Gardens regularly. He had chronic renal disease, which was being treated at the Prince of Wales Hospital. He developed SARS symptoms on 14 March 2003. On 14 March and 19 March, he visited his brother who owned a flat in Block E of Amoy Gardens. He was having diarrhea at that time and he used the toilet there. His brother, his sister-in-law and two nurses who attended to him at Prince of Wales Hospital subsequently developed SARS.

3. As of 15 April 2003, there were a total of 321 SARS cases in Amoy Gardens. There was an obvious concentration of cases in Block E, accounting for 41% of the cumulative total. Block C (15%), Block B (13%) and Block D (13%) recorded the second, third and fourth highest incidence of SARS infections. The rest of the cases (18%) were scattered in 11 other Blocks.

4. Like other Blocks in Amoy Gardens, Block E has 33 floors with 8 apartment units on each floor. Unit 8 (73%) and Unit 7 (42%) of Block E registered the highest attack rates. Floors 10 and above were more affected than the lower floors.

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<sup>1</sup> These agencies include Electrical and Mechanical Services Department, Environmental Protection Department, Buildings Department, Food and Environmental Hygiene Department, Water Services Department, Drainage Services Department, Hong Kong Police Force and Government Laboratory.

5. In terms of onset dates, the outbreak reached its peak on 24 March 2003 and declined steadily afterwards. Block E cases appeared earlier in the outbreak and showed a point-source type of distribution. Cases in other Blocks which appeared 3 days later were more evenly spread out in time.

6. A questionnaire survey conducted by the Department of Health found that in addition to the commonly identified symptoms associated with SARS (i.e. fever, chills and headaches), another notable feature with the patients was diarrhea, which was present in some 66% of the cases. The survey also showed that only 4% had history of contact with SARS patients and 8% had visited the Mainland between 17 and 23 of March 2003.

## **ENVIRONMENTAL INVESTIGATIONS**

### *Sewerage*

7. Each block has eight vertical soil stacks each collecting effluent from the same unit of all floors. The soil stack is connected with the water closets, the basins, the bathtubs and the bathroom floor drains. Each of these sanitary fixtures is fitted with a U-shaped water trap (U-trap) to prevent foul smell and insects in the soil stack from entering the toilets. For details, please see Annex. For this preventive mechanism to function properly, the water traps must be sufficiently filled with water.

8. Interviews with Amoy Gardens residents revealed frequent complaints about foul smell in toilets, which suggest that the U-trap arrangement might not be functioning properly in some units. As the water closets, the basins and the bathtubs were frequently used, their U-traps should be charged with water and should have been functioning properly. However, as most households had the habit of cleaning the bathroom floor by mopping instead of flushing it with water, the U-traps connected to most floor drains were likely to be dry and would not have been functioning properly. Indeed, in tests carried out in one of the units in Block E, reflux of air from the soil stack into the bathroom through the floor drain was demonstrated when the exhaust fan in the bathroom was switched on. It is postulated that the reflux could have contained droplets of contaminated sewage present in the soil stack, be dispersed into the bathroom, and be extracted by the bathroom exhaust fan into the light well between adjacent units. The contaminated

droplets could then enter other units through open windows.

9. Tests confirmed that there was no leakage in the sewage pipe. However, other tests detected leakage from a sewer vent pipe<sup>2</sup> at the 4/F of Block E, and was confirmed by a large visible crack. The cracked sewer vent pipe could have emitted droplets carrying contaminated sewage into the light well every time a toilet was flushed. This large crack on the sewage vent pipe was repaired prior to the return of the Block E residents. In general, any leakage or seepage in the sewerage system is important as it could allow droplets carrying contaminated sewage to be ejected into the lightwell. By using an oil droplets test, the aerodynamics of the lightwell demonstrated a “chimney effect”. The “puff” of droplets was shown to rise inside the lightwell, expanding laterally as it traveled up the height of the building in a matter of minutes under certain wind conditions. This was further illustrated in quantitative terms using SF<sub>6</sub> as a tracer gas during the oil droplets test. However, it was not possible to quantify the amount of virus, if any, and the velocity of the emission of the droplets from the sewer vent pipe.

### ***Pest Infestation***

10. There were signs of cockroach infestation at Amoy Gardens, in particular around the carpark, food premises and drain openings. Rodent activities were also detected around refuse collection chambers, the carpark and food premises.

## **LABORATORY INVESTIGATIONS**

11. A collection of air samples, water samples, environmental swabs and animal swabs/droppings/serum were taken in Amoy Gardens to identify the extent of environmental contamination by the causative agent. No abnormalities were detected in the air and water samples. One environmental swab collected from the inner rim of a toilet in Block E (where a SARS patient had lived) was positive for coronavirus. Coronavirus was also detected in rodent droppings and the bodies of cockroaches. As the rodents showed no signs of infection or disease, the findings only point to environmental contamination at Amoy Garden and that pests are likely to be no more than mechanical carriers for the virus in this outbreak.

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<sup>2</sup> The sewer vent pipe is designed to equalize the pressure between the water closet pan and the soil stack.

## **PROBABLE EXPLANATION OF THE OUTBREAK**

12. Given the unique distribution pattern of infected Block E residents and taking into account of the contact with SARS patients and the reported large number of patients with diarrhea symptom, we observe that environmental factors played a major role in this outbreak.

13. Recent laboratory studies have shown that many patients with SARS excrete coronavirus in their stools, where it could survive for longer periods than on ordinary surfaces. As many as 2/3 of the patients in this Amoy Garden SARS outbreak were also having diarrhea, contributing to a significant virus load being discharged in the sewerage in Block E.

14. It is probable that the index patient initially infected a relatively small group of residents within Block E and subsequently to the rest of the residents in that block through the sewage system, person-to-person contact and the use of shared communal facilities such as lifts and staircases. These residents subsequently transmitted the disease to others both within and outside Block E through person-to-person contact and environmental contamination.

15. The bathroom floor drains with dried-up U-traps provided a pathway through which residents came into contact with small droplets containing viruses from the contaminated sewage. These droplets entered the bathroom floor drain through negative pressure generated by exhaust fans when the bathroom was being used with the door closed. Water vapour generated during a shower and the moist conditions of the bathroom could also have facilitated the formation of water droplets. The chance of exposure was increased given that the bathrooms in apartment units of Amoy Gardens were generally small in size (about 3.5 square metres). Contaminated droplets could then have deposited virus on various surfaces, such as floor mats, towels, toiletries and other bathroom equipment.

16. Transmission of the disease by airborne, waterborne route and infected dust aerosols have been examined but these were not supported by the epidemiological picture and laboratory results.

## **GOVERNMENT ACTIONS**

17. A thorough cleansing cum disinfection operation was conducted

with the cooperation of the Owners' Corporation, residents concerned and the joint efforts of various government agencies for all flats and common areas of Block E, Amoy Gardens between 7 and 10 April. Particular attention was paid to sinks, bathtubs, washhand basins, toilet bowls and floor drains in the toilets and kitchens. Water storage tanks were also cleansed. Subsequent test for E-coli showed that the disinfection of the drainpipes was effective.

18. The Food & Environmental Hygiene Department (FEHD) gave advice to residents of other Blocks in Amoy Gardens to disinfect their flats as precautionary measures, particularly sinks, bathtubs, washhand basin, toilet bowls and floor drains in the toilets and kitchens. Guidelines and disinfectants were provided to residents.

19. Residents of Amoy Gardens were advised to ensure the water level at the U-traps of drainage outlets to ensure proper functioning.

20. The management company of Amoy gardens has repaired the crack in the sewer vent pipe found at the 4<sup>th</sup> floor level of Block E. The Administration has also asked the management company to carry out a comprehensive inspection of the drainage system of all blocks within the development.

21. To minimize the likelihood of similar outbreaks in future, the Administration has produced a guide to educate the public on the cleaning and disinfection of households, including bathroom cleansing and how to ensure the proper functioning of the water seal in U-traps. Improvements to environmental hygiene will be made and pest control stepped up on a territory-wide basis.

22. The Administration has published a set of guidelines to draw the public's attention to the proper maintenance and repair of the drainage system and sanitary fitments. The guidelines are available from the Buildings Department website and are being distributed to all management companies and owners' corporations.

23. The building management authorities of buildings where confirmed SARS patients reside has been notified of the infection and are required to take proper disinfection measures. FEHD will inspect these buildings to see if they meet the required standard. Names of these buildings are also placed on the homepage of the Department of Health to allow residents to take appropriate precautionary disinfection measures.

24. Major cleansing/disinfection operations were conducted in the Lower Ngau Tau Kok Estate, Telford Gardens and the surrounding areas by the building management with advice given by FEHD.

Department of Health  
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