How bacteria evolve into superbugs

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Researchers at McGill and Oxford Universities have applied ecological and evolutionary theory to demonstrate how bacteria become resistant to antibiotics in hospitals.

Their study, published in the July 25 online edition of *Proceedings of the Royal Society B: Biological Sciences*, shows how high rates of immigration of bacteria into an environment containing antibiotics introduces sufficient genetic variation to cause the evolution of antibiotic resistance, a finding that sheds light on the growing incidence of highly antibiotic-resistant "superbug" bacteria such as Pseudomonas aeruginosa.

"Bacteria that can mutate fast will quickly adapt to harsh environments containing antibiotics. Our study showed that a high rate of immigration significantly augments the regular process of genetic mutation commonly used to explain the evolution of antibiotic resistance," said co-author Dr. Andrew Gonzalez, a Canada Research Chair in Biodiversity and associate professor in the Department of Biology at McGill. Gonzalez explained that the flow of bacteria in the experiment is analogous to the immigration of bacteria-carrying individuals into a hospital, and "the rate at which bacteria are entering a particular environment – not just the fact that they are coming in – is a key factor."

In evolutionary theory, any population that adapts to cope with new challenges (such as antibiotics) will make trade-offs in ways that limit its competitive ability against its predecessors in their original environment (free of antibiotics). But "superbug" bacteria are an exception, spreading

to and persisting in many source environments, resulting in more infections. The study showed that as the rate of bacteria immigration increases, not only do those bacteria flourish by developing resistance to antibiotics, but they thrive as well as bacteria in places where there are no antibiotics.

Gonzalez explained that the source-sink model used in the study, a model employed by ecologists to measure how spatial variation in environmental conditions may affect population growth or decline, works on several scales. “The beauty of this theory is that it is broadly applicable to a range of clinical settings,” he said. While the principal sources of bacteria reside outside a hospital, the ventilation system and water supply inside frequently act as sources as well.

According to the US Centers for Disease Control (CDC), the bacterium Pseudomonas aeruginosa is the fourth most common pathogen found in hospitals. It accounts for 10 per cent of hospital-acquired infections in the respiratory, digestive and urinary tracts, bones and joints, and is a serious threat to patients with severe burns, cystic fibrosis and cancer. “With increased incidence of antibiotic resistance and a trend toward single-site super-hospitals, there is a growing need for greater understanding of how bacteria evolve,” said Gonzalez.

Source: McGill University