Medical Prescribing and Antibiotic Resistance: A Game-theoretic Model

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The availability of antibiotics presents medical practitioners with a prescribing dilemma. On the one hand, antibiotics provide a safe and effective treatment for patients with bacterial infections, but at a population level, over-prescription reduces their effectiveness by facilitating the evolution of bacteria that are resistant to antibiotic medication. A game-theoretic model is specified, equilibrium analysis is performed, and a unique evolutionarily stable strategy is identified. The fundamental theoretical implication of our analysis is that the strategic structure of the antibiotic prescribing game motivates payoff-maximizing doctors to prescribe antibiotics, irrespective of the extent of antibiotic resistance in the population and of the probability (as long as it is nonzero) that symptomatic patients are infected with pathogenic bacteria. This strategy is payoff-maximizing despite the possibility that it may lead to the diffusion of antibiotic resistance, ultimately rendering antibiotics useless for treating infection and hence reducing the doctors' own payoffs. Analysis based on replicator dynamics confirms that, whatever the pattern of prescribing behaviour at a particular time, as long as there is some antibiotic prescribing, doctors will tend to increase antibiotic prescribing. We have therefore proved that the antibiotic prescribing game is indeed a social dilemma of the tragedy of the commons type. Thus, doctors' decision making leads to an inexorable outcome that is worse for all of them and their patients than the outcome that would have resulted had they deviated from the game-theoretic rational strategy and exercised restraint. To avoid a catastrophic outcome, it is necessary to change the payoffs of the game.