Chapter 10
Nanomaterials to Overcome Emergence and Re-Emergence of Superbugs:
Nanoarsenals for Superbugs

Manju Nagpal
Chitkara University, India

Malkiet Kaur
Chitkara University, India

Manjinder Singh
Chitkara University, India

Geeta Aggarwal
Delhi Pharmaceutical Sciences and Research University (DPSRU), India

ABSTRACT

Antimicrobial resistance remains a substantial global health concern, invigorating the critical need for alternate therapeutic options to combat chronic intracellular infections and biofilms so as to shorten the hospital stays, and hence mortality. Nanomaterials have been developed as delivery carriers for antibiotics to improve their penetration through these biofilms. Nanoformulations of existing antibiotics has led to enhanced bioavailability and site specificity. Moreover, diagnosis of infections using efficient nanosensors or probes may speed up the treatment process at earlier stages of infection.

DOI: 10.4018/978-1-7998-0307-2.ch010

1. INTRODUCTION

1.1 Concept of Emergence and Re-Emergence of Superbugs

Approximately 70 years ago, antibiotics were introduced to cure infectious diseases. These are the drug molecules used to kill bacteria and they reduce the risk associated with various infections. Antibiotics exhibited their action by inhibiting the proliferation process of bacteria. Overtime, antibiotics started showing resistance to different bacteria's called superbugs (Drug-resistant microbes). Antibiotic resistance is the tolerance developed by bacteria to overcome the effects of antibiotics (https://www.davolterra.com/content/antibiotic-resistance-wonder-drugs-facing-rise-superbugs). Antibiotic resistance increases the duration of infection, cost of treatment and decreased success of treatment which finally led to economic loss (Zaman *et al*., 2017). Drug resistance does not just prevail in healthcare environments but it is also increasing amongst community-acquired pathogens (Padhy *et al*., 2016). For example, penicillin was the first antibiotic developed and was successfully used to control infections. Just after four years, it causes resistance to major microbe *i.e. Staphylococcus aureus* (https://www.statnews.com/2016/09/12/superbug-antibiotic-resistance-history/, Ventola, 2015). Also, *Klebsiella pneumonia* causes fatal and untreatable infections in a healthy population. It may cause a danger to life of individual (Gu *et al.*, 2018). Some other examples of antibacterial discovery with their resistance are given in Figure 1.

World Health Organization (WHO) has already warned about the emergence of infectious diseases at a faster rate which has never seen before (https://www.who.int/newsroom/factsheets/detail/antibiotic-resistance). Several human activities have led to the emergence and spread of new diseases such as moving into wildlife habitats, improvisation in agriculture techniques, modern transport and misuse of antibiotics (Bloom *et al*., 2017). Re-emerging infectious diseases are those that once were foremost health problems across the globe and declined considerably, but they again became health problems for a significant population (https://www.sciencedaily.com/releases/2017/08/170831101508.html). Some of the re-emerging diseases with a causative agent are given in Table 1. The re-occurrence of old infections along with emergence of new infectious diseases and constant persistence of various intractable infections is a major challenge to the researchers.

One of the reasons for antibiotic resistance is a development of biofilms. Most of the bacterial strains occur in the form of a biofilm which are especially microbial aggregates that rely on a solid surface and extracellular products such as extracellular polymeric substances (EPS's). Bacteria tend to move reversibly on the surface, but the expression of EPSs makes this attachment irreversible. After settlement of bacteria, the synthesis of bacterial flagellum is suppressed and rapid multiplication