

## Antibiotic abuse: post-antibiotic apocalypse, superbugs and superfoods

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*Cases of antibiotic abuse have reached a phenomenal level worldwide and become a global health concern affecting a larger number of people than those affected by the disease itself. Facilitating generation of multidrug-resistant superbugs, antibiotic misuse practices are a pressing issue worldwide, with the threat to developing South Asian countries like India, being insurmountable. This commentary summarizes our knowledge about this global pandemic; its causes, effects and severity, and discusses the preventive measures taken to curb antibiotic abuse. We highlight emergence of superfoods as natural antibiotics (or alternative medicine) that hold potential to change the face of modern therapeutics.*

Surprisingly, antibiotics which had emerged as a boon for curing bacterial infections are now the root cause of infections leading to death among humans globally<sup>1</sup>. The severity of the situation can be measured by the findings of Centers for Disease Control and Prevention (CDC), USA, which declared the use of two-third of the antibiotics as inappropriate or unnecessary. What is more alarming is the overuse or misuse of antibiotics which causes more morbidity than cancer and gives rise to some of the deadliest pathogens known as superbugs. Antibiotics are generally prescribed to treat bacterial infections such as tuberculosis, pneumonia, gonorrhoea, typhoid, stomach ulcers, strep throat, etc. It benefits the host by fighting infection either through bacteriostatic or bactericidal mode of action. In parallel, some bacteria escape treatment and develop resistance against the given antibiotic. Bacteria propagate, unaffected by the action of antibiotics and generate more of their kind. Antibiotic resistance thus is an inevitable process, leading to the formation of dangerous strains of bacteria, like methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant Enterococci, multidrug-resistant *Mycobacterium tuberculosis*, and drug-resistant *Streptococcus pneumoniae*, *Pseudomonas aeruginosa* and *Neisseria gonorrhoea*, to name a few<sup>1</sup>. The menace is further augmented as antibiotic-resistant bacteria, armed with better survival strategies, aid other bacteria in acquiring resistance genes through horizontal gene transfer, thereby producing a platoon of antibiotic-resistant bacteria. Unexpectedly, it is not the use of antibiotics, but their abuse which has been the root cause of generating antibiotic-resistant bacteria. Many factors are involved in the genesis of antibiotic abuse. Developing countries are more

affected due to easy availability of over-the-counter drugs, lack of required knowledge, over dosage or inappropriate usage of antibiotics<sup>2</sup>. One of the leading abuses is self-medication, especially to treat viral infections that are naturally insensitive to antibiotics. India itself houses the most dangerous antibiotic-resistant bugs of the century, some which are even resistant to colistin, the most potent and toxic antibiotic known to humankind. Recent reports have revealed the presence of genes like *NDM1* (New Delhi metallo-beta-lactamase-1) in *Klebsiella pneumoniae* and other Gram-negative bacilli, and *ESBL* (extended spectrum beta-lactamase) in *Escherichia coli*<sup>3,4</sup>. These genes confer total resistance on the host organism giving rise to totally resistant bacteria. Laxity in regulatory policies, ignorance of healthcare providers, poor sanitation, easy access to strong antibiotics, overly long and improper treatment regimens and unawareness among general public have made India the antibiotic capital of the world<sup>5,6</sup>. Antibiotic resistance is a global health crisis and hence requires mutual efforts. Antibiotic abuse is also highly prevalent in livestock maintenance, food industry, and human and animal healthcare settings. Due to serious health concerns of antibiotic abuse, the World Health Organization (WHO) has announced 'the beginning of post-antibiotic era', with rise in deaths by infections caused by superbugs (<http://www.who.int/mediacentre/factsheets/antibiotic-resistance/en/>). A 2016 report predicted around 10 million deaths due to antimicrobial resistance (AMR) by 2050 (ref. 7). Given the magnitude of damage caused by AMR, it is imperative to find new antibiotics. However, over the last five decades no new antibiotic has been launched in the market after fluoroquinolone in 1962 (ref. 8). This is mainly due

to factors such as cost-ineffectiveness, lower efficacies and less interest among big pharmaceutical companies. The situation demands prompt actions to curb the misuse of antibiotics and preserve their effectiveness in treating microbial infections, before the most potent antibiotics become futile<sup>9</sup>.

Immediate and coordinated cross-country measures are needed to combat antibiotic abuse, the global health problem of modern age. WHO has initiated a Global Action Plan on antimicrobial resistance to improve awareness, optimize use of antibiotics, conduct proper surveillance of infection and control its spread, besides suggesting economic policies for investment in medicines, diagnostic tools, vaccines and other interventions (<http://www.who.int/antimicrobial-resistance/global-action-plan/en/>). Similarly, India is also geared up to fight against AMR with its first National Action Plan to combat antimicrobial resistance (2017–21). The plan includes measures to prevent misuse of antibiotics by doctors, consumers and healthcare institutions, and aims to alter prescription practices and consumer behaviour together with scaling up infection control and antimicrobial surveillance programmes<sup>9</sup>. There is also room for lawmakers and healthcare providers to analyse the current situation and design proper guidelines, and ensure fulfilment of rules by healthcare institutions, pharmaceuticals and general public.

Importantly, a mindset of 'prevention is better than cure', is the need of the hour. It is not only the era of 'superbugs', but also 'superfoods', which by definition are foods packed with maximum nutrition and low calorie content. Superfoods have created enough buzz in the media due to their health-benefitting activities; however, they should not be

identified as miracle food to cure diseases. These foods if taken in regular diet can improve overall health and reduce the chances of infection. The health-improving potential, easy availability and no side effects make superfoods a preferred diet choice in society. Some of these famous superfoods packed with vitamins, minerals and antioxidants are wheatgrass, *Echinacea*, cranberry, apple cider vinegar, garlic, onion, honey, turmeric, extra virgin coconut oil, grape fruit seed extract, blueberry, cinnamon, avocado, broccoli, rabe, etc. Superfoods which can act as natural antibiotics are now becoming a focus of research. Garlic is the most ancient natural antibiotic, and contains allicin and other sulphur compounds which impart the characteristic aroma and strong antimicrobial, antimycotic, and immune system stimulating properties<sup>10,11</sup>. Turmeric is another medicinally important spice having antibacterial, antifungal and antiviral activities<sup>12,13</sup>. The rhizome extract of *Curcuma longa* has shown antibacterial activity even against the clinical isolates of *S. aureus*, suggesting that it has a broad-spectrum role<sup>14</sup>. Coconut oil is packed with lauric acid which has been found to be effective against bacteria causing acne and tooth cavities, and also effectively inhibits the growth of *S. aureus* and *Staphylococcus epidermidis* in both *in vitro* and *in vivo* studies<sup>15,16</sup>. The extract of grapefruit seeds is a rich source of antioxidants and polyphenols, and possesses strong antibacterial activity against *Salmonella*, *Staphylococcus* and *E. coli* infections<sup>17</sup>. Among all the superfoods, honey is a natural antioxidant containing hydrogen peroxide (inhibitor) that exhibits antibacterial potential<sup>18</sup>. Cranberries are a rich source of antioxidants possessing antibacterial activity against a wide range of bacterial species<sup>19</sup>. Green tea is loaded with copious amounts of 'catechins' that impart antimicrobial properties and other health benefits to it, which prevents bacterial infections<sup>20</sup>. The active compounds thymol and carvacrol in oregano oil have

shown potent antibacterial activity against *P. aeruginosa* and *S. aureus*<sup>21</sup>. Additionally, herbs like goldenseal and *Echinacea* have antimicrobial properties, and are treated as new-age natural antibiotics<sup>22,23</sup>.

Superfoods have prolific amounts of antioxidants, vitamins and minerals, which make them quality food and impart positive health benefits to the consumers. With regard to the antibiotic properties of these superfoods, their intake should be encouraged among people for longevity and general health improvement<sup>24</sup>. Additionally, proper exercise, enough sleep, diet, meditation and yoga would also aid in achieving wholesome health and in reducing the risk of many common infections<sup>25</sup>. In the world of choices, the aim should be to propagate alternative medicines with less/no side effects, low pricing and easy availability to common man, while sale of antibiotics must be regulated strictly in accordance with regulatory policies and must be against the prescription of a registered medical practitioner ([http://www.who.int/medicines/areas/rational\\_use/en/](http://www.who.int/medicines/areas/rational_use/en/)).

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