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1 **The ‘Antibiotic Apocalypse’ – Scaremongering or Scientific Reporting?**

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Jonathan A. G. Cox* & Tony Worthington

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5 *Correspondence: j.a.g.cox@aston.ac.uk

6 Twitter: @originaljoncox

7 School of Life and Health Sciences, Aston University, Aston Triangle, Birmingham

8 B4 7ET

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10 **KEYWORDS**

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12 Antimicrobial resistance, Antibiotic, Apocalypse

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14 **ABSTRACT**

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16 Antimicrobial resistance is dominating scientific media. We are warned of an
17 impending ‘antibiotic apocalypse’, where mankind faces its biggest threat, untreatable
18 microbes. However, the world isn’t ending. Scientists are responding to the threat;
19 new knowledge and chemotherapeutics are being created to safeguard our future. The
20 future is bright, not gloomy.

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25 In the past few years the emergence of antibiotic resistant infections has increased
26 dramatically. This is largely due to the misuse of antibiotics: misprescribing and
27 overprescribing by clinicians, patient failure to adhere to the treatment course and the
28 extensive use of antibiotics in agriculture and aquaculture [1-3]. There is a public
29 expectation to receive some form of medication when visiting a general practitioner,
30 and although the medical profession is adapting its practices accordingly, antibiotics
31 have often been prescribed as a means to satisfy the patient rather than as a course of
32 treatment [4]. Currently around 700,000 antibiotic resistance-related deaths are
33 recorded annually, with a projected rise to 10 million by 2050, overtaking cancer as
34 the leading cause of death worldwide [i]. These projections have led to media hysteria
35 that has been catalysed by the support of the scientific community. This gloomy
36 outlook is considered to be a window into a future where all known antibiotics will be
37 rendered ineffective due to widespread antibiotic resistance. Previously treatable
38 minor bacterial infections may develop into potentially fatal diseases, invariably
39 resulting in a dramatic increase in bacteria-borne mortality [ii]. The slim, but real
40 possibility of a future without antibiotics is recognised by leading academics,
41 government advisors and doctors worldwide, but does this warrant the casual usage of
42 the term ‘antibiotic apocalypse’?

43

44 The word apocalypse is defined as "the end of the world or some other event of great
45 destructive violence" [5]. Can we really consider a return to the days pre-advent of
46 streptomycin and penicillin as the end of the world? Mankind survived and thrived for
47 around 200,000 thousand years until the antibacterial properties of penicillin were
48 discovered in 1928 [6]. The cavalier use of this expression in mainstream media and
49 scientific articles will undoubtedly impact the general public’s perception of the issue

50 of antimicrobial resistance (AMR). Recently, this perception was examined and it was
51 found that the majority of people do not believe their actions or decisions can
52 contribute to the development of AMR and that it is not their responsibility to tackle
53 antibiotic resistance [7]. Indeed, 88% of people believe that antibiotic resistance is
54 when a human becomes resistant to antibiotics, rendering the antibiotic ineffective
55 [7]. These misconceptions may in part be down to the dramatisation of the issue as an
56 unstoppable force, a plight of humanity so great that one person's input couldn't
57 possibly make a difference. In reality, AMR has developed and escalated as a global
58 healthcare concern as a result of the lack of education and understanding of
59 individuals about antibiotics. However, the battle is far from lost. In 2015, 1618 peer-
60 reviewed scientific articles were published containing the phrase 'antimicrobial
61 resistance' and the Medical Research Council awarded £10.7 million for UK research
62 into AMR during the 2015-2016 round [8]. Supporting the hypothesis of an antibiotic
63 apocalypse among the general public at large serves only to mislead rather than
64 inform.

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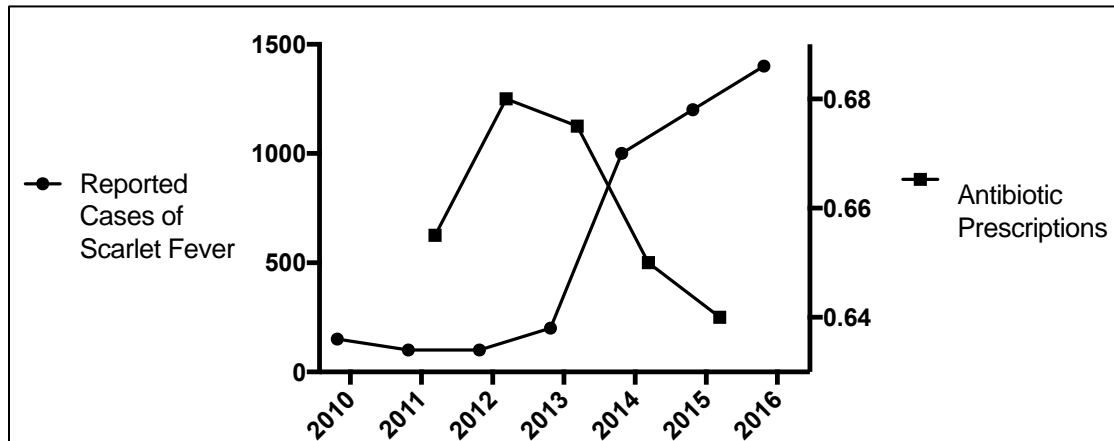
66 Instead of supporting over-reaction to the subject of AMR, we should encourage
67 thinking of AMR as an example of a natural coevolutionary system. The Red Queen
68 hypothesis of coevolution goes some way to explain AMR whereby predators
69 (bacteria) and prey (humans) sequentially evolve to overcome an evolutionary
70 advantage of their opponent, driving a continuum of evolutionary push and pull [9].
71 Differing speeds of genetic evolution between humans and bacteria result in humans
72 evolving intellectually rather than physically, with the advent of β -lactam antibiotics
73 [10]. Bacteria then respond accordingly by exploiting β -lactamases, regaining the
74 upper hand. Humans discover new antibiotics, with each discovery, evolving

75 intellectually, driven by the eventual resistance of bacteria to each new chemical
76 class. Bacteria have recently gained the upper hand due to a reduced rate of antibiotic
77 discovery [10]. However, new advances such as combination antibiotic therapy and
78 the discovery of new drugs, novel targets and innovative technologies will help
79 humans regain and retain the evolutionary advantage. Furthermore, our improved
80 understanding of how resistance occurs, spreads and how to prevent it will ensure our
81 advantage is not short lived. As Sun Tzu put it in *The Art of War*, “If you know the
82 enemy and know yourself, you need not fear the result of a hundred battles. If you
83 know yourself but not the enemy, for every victory gained you will also suffer a
84 defeat” [11]. It is rather fortunate we have been studying bacterial resistance almost as
85 long as we have been discovering antibiotics.

86

87 Evidence for the complexity of this push and pull dynamic between bacteria and
88 humans can be exemplified by recent epidemiological data. In our possibly
89 overzealous attempts to tackle AMR by reducing the quantities of antibiotics
90 prescribed for non-bacterial or immune-susceptible infections such as tonsillitis, we
91 may have neglected to consider those rare occasions where antibiotics are absolutely
92 necessary. In the UK, the incidence of Scarlet fever (a complication of untreated or
93 inappropriately treated tonsillitis due to *Streptococcus pyogenes*, the group A
94 streptococcus) has increased since 2013, an inverse correlation to the number of
95 antibiotic prescriptions per head in the UK (Figure 1). Clearly, improved diagnostics
96 at the point of care are essential to making the decision for or against antibiotic
97 administration. Sudden and dramatic changes to our antibiotic prescribing behavior
98 will invariably result in an epidemiological backlash. A more considered clinical
99 response to AMR maybe required wherein prevention is pursued instead of panic-

100 induced kneejerk reactions in response to media hysteria. Our transition into a society
101 where clinicians are fearful of prescribing antibiotics, and the general public are
102 equally fearful of taking them needs to be halted. Public perception is key; the
103 antibiotic apocalypse is not upon us.
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106 **Figure 1. The number of reported cases of Scarlet Fever (UK) versus the yearly**
107 **antibiotic prescriptions per head (UK).** Responding to antimicrobial resistance
108 requires improved, rapid clinical diagnostics at the point of care to ensure antibiotics
109 are provided when necessary. Data shown in this figure are from [iii-iv].

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111 Government and private funding is integral to sustaining scientific research and a
112 wider public understanding of the important issues of the day drives this funding, but
113 I believe there are considerable ethical boundaries that scientists must operate within.
114 Feeding and supporting inaccurate sensationalist journalism because it fits our
115 funding aspirations serves only to mislead the public. As scientists we strive for truth,
116 we therefore should not discredit scientific fact with sensationalism. When discussing
117 AMR publically we must provide clear and objective summaries based on hard data,
118 not assumptions that will fuel public misconception. Referring to the highly unlikely
119 possibility of a future without antimicrobial treatment as the post-antibiotic era, or

120 AMR as a global antibiotic crisis, resonates true without unnecessary scaremongering,
121 as in this authors view, the truth is scary enough! (Figure 2).

122



123

124 **Figure 2. The Antibiotic Apocalypse.** Is this the end of the world as we know it?

125 Unlikely. Scientists should promote education over sensationalism using facts, not
126 fear.

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128 ONLINE RESOURCES

129 i. https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf

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133 ii. <http://www.bbc.co.uk/news/health-21702647>

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135 iii. http://www.antibioticresearch.org.uk/wp-content/uploads/2015/11/EXASOL-Analyses_Antibiotic-Research-UK-Final-121115.pdf

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138 iv. <https://www.gov.uk/government/collections/group-a-streptococcal-infections-guidance-and-data>

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