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A bibliometric review of drug repurposing

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We have conducted a bibliometric review of drug repurposing by scanning >25 million papers in PubMed and using text-mining methods to gather, count and analyze chemical–disease therapeutic relationships. We find that >60% of the ~35,000 drugs or drug candidates identified in our study have been tried in more than one disease, including 189 drugs that have been tried in >300 diseases each. Whereas in the majority of cases these drugs were applied in therapeutic areas close to their original use, there have been striking, and perhaps instructive, successful attempts of drug repurposing for unexpected, novel therapeutic areas.

Introduction

Drug repurposing (also known as repositioning, reprofiling, redirecting or rediscovering [1]) is defined as developing new uses for a drug beyond its original use or initial approved indication. Drug repurposing has attracted increasing attention in recent years as drug companies seek potentially inexpensive alternatives to compensate for the high costs and disappointing success rate associated with the drug discovery pipeline [2]. Repurposing can help identify new therapies for diseases at lower cost and in a shorter time, particularly in those cases where preclinical safety studies have already been completed.

During recent years, several authors have reviewed drug repurposing [2–10]. These reviews for the most part analyze and describe the methodologies, often illustrated with examples of successful repurposing. The compelling case of the repurposing of sildenafil (Viagra®) for erectile dysfunction is common knowledge but there are other stories of repurposing that have gone on to be profitable: bupropion, originally used for depression, was repurposed for smoking cessation; and thalidomide, once a treatment for morning sickness, is now used for multiple myeloma.

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Herein, we report on a bibliometric analysis of drug repurposing conducted with the aim of measuring and understanding the scope of the practice over the history of modern drug discovery. We define repurposing as a PubMed report of the use or testing of a drug for a disease different from the originally reported one. Although inexact, this methodology gives unique insight into the scope of the practice. By examining a few drugs in-depth we see striking examples of reasoning and intuition applied to repurposing.

Literature analysis

Our analysis was based on PubMed's MEDLINE data (http://www.ncbi.nlm.nih.gov/pubmed). At >25 million entries, PubMed is the largest and most comprehensive source of biomedical research citations. To assemble a dataset for this bibliometric analysis, we built on earlier text-mining work [11] and identified articles in PubMed where a chemical entity was described in terms of its therapeutic association with a disease. We determined this relationship by examining the MeSH annotations in a stepwise manner (described in the supplementary material online). These chemical entities represent drugs or drug candidates. For simplicity, these entities will be referred to here as drugs.

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