How can we use bibliometric analysis to guide research forward?—an editorial for "*Research trends and hotspots on human papillomavirus: a bibliometric analysis of 100 most-cited articles*"

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Human papillomavirus (HPV) is the most common sexually transmitted infection, and between 70–80% of all people will be infected at least one time in life (1,2). With cervical cancer being one of the leading cancers in women substantial efforts have been focused on finding the aetiology. In the early 1980s, zur Hansen discovered the link between infection with certain high-risk HPV-types and later occurrence of cervical cancer (3). At present between 13–15 high-risk HPV-types have been identified (4,5), and HPV is now known to be a contributing aetiological agent for several cancer types, besides cervical cancer, including head and neck and anogenital cancers (1,3). Annually, 630,000 new cancer cases are estimated to derive from HPV-infections (6). The identification of the causal link between HPV and cervical cancer lead to improved screening for cervical cancer, increased treatment ability as a consequence hereof, and to the development of vaccines against HPV (2). Currently, three prophylactic vaccines against HPV are on the market; bivalent, quadrivalent and nonavalent. The bivalent (HPV 16, 18) vaccine protects against infection with the two most prevalent high-risk HPV-types, while both the quadrivalent (HPV 6, 11, 16, 18) and nonavalent (HPV 6, 11, 16, 18, 31, 33, 45, 52, 58) vaccines also protects against infection with the HPV-types responsible for genital wards, and the nonavalent vaccine protects against seven high-risk HPV-types. The optimal effect is gained when vaccination takes place before sexual debut (6), and such vaccination programs have been widely implemented. The Unites States Food and Drug Administration (FDA) approved the first HPV-vaccine for women in 2006, and for men in 2009 (7).

In the present study, bibliometric analysis (BA) is used to analyse the top 100 most-cited articles in the field of HPV research. BA is a quantitative technique to analyse publications (8) to measure research activities in a specific field (9). The bibliometric methodology has become increasingly used and accepted throughout the scientific community (8), making it important for researchers to understand the methodology. According to Kumar *et al*.: "… *a well-done bibliometric study can build a solid foundation for advancing a field in novel and meaningful ways …*" (9). BA is differentiated from a systematic review (SR) and meta-analysis (MA) primarily because SR and MA aim to answer a research question. In contrast, BA focuses on summarising publications, such as author details, quality of journals, citation counts, and cluster keywords, and can focus on massive numbers of publications (9,10). Data are often retrieved from the Web of Science or Scopus and analysed

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statistically to find correlations and significance. The core principle of BA is to conduct a citation network, which can be done by one or both of the following methods called (I) performance analysis or citations analysis and (II) science mapping or bibliometric mapping (9-11). Selecting and retrieving the articles used in the analysis is often based on keywords carefully selected by the authors to represent the area under investigation. Performance analysis is descriptive and counts the performance of a published article based on citations. The numbers of citations can then again be correlated with authors, impact factors or research institutions etc., as a way of showing that high citation numbers equal high productivity, based on the number of times other researchers have mentioned the work (9). Science mapping is used to identify patterns in publications by performing co-authorship analysis, co-word analysis, co-citation analysis or bibliographic coupling. The findings of the science mapping are often visualised. The visualisation is made with software designed for this purpose (e.g., VOSviewer), and it creates a 2-dimensional space, a network, where, e.g., related words are located closely (11) and the bigger the area for a word, the more often the word is mentioned in the publications of interest (10). The performance analysis and science mapping results are combined in a bibliometric summary and discussion.

Gong *et al.* have conducted one of the first bibliometric studies in HPV research (12). To the best of our knowledge, only one previous study has been made; but Bruel *et al.* focused on HPV-vaccination only (2). Gong *et al.* had a comprehensive focus seeking hotspots and trends in HPV—research by analysing the top-100 most cited articles, aiming to find out where the HPV-research is heading in the future (12). The authors used the Web of Science (WoS) for their search, and a total of 39,134 references were retrieved, giving an insight into how extensive the HPV-research is. Out of the 39,134 articles, the top 100 articles were selected and analysed. As only 7% of these 100 articles were published after 2013, the authors screened an additional 13,646 articles published after 2013 to understand better the current trends and hotspots. All analyses are nicely visualised. The most cited article was "Human papillomavirus is a necessary cause of invasive cervical cancer worldwide" by Walboomers *et al.*, published in 1999 and cited 6,426 times (12). The top-100 most cited articles were published between 1983–2017, with a peak of 34% between 2003–2007 (12), right around the time of

the release of the first HPV-vaccine. Science mapping of other research areas have found authors to come primarily from the USA, UK, Germany and other European countries (13). However, for the HPV-research area, the distribution of authors across countries was more widespread including countries from all over the world (12), showing that HPV was a global health issue. Cooperation between countries and research centres was common. When Gong *et al.* analysed the correlation between citations and publication year, the results indicated that an article's importance was constant over time. Gong *et al.* based this conclusion on a non-significant Mann-Kendall trend analysis between citations and year. However, when analysing the citation density (the total number of citations divided by the number of years since a work was published), they did find a positive correlation (12). An important message following this is that researchers should be aware of not only concentrating on newly published research but still pay attention to older well, documented papers. We find it very encouraging for new and not well-established researchers that the study showed only a weak positive correlation between impact factor and citation (12), indicating that an article can become important in a research field even if published in journals with lower impact factor. Finally, the study showed that the presently hot areas in HPV-research is vaccination, cervical screening, head and neck cancers, therapy and males.

The bibliometric analysis can create a foundation for understanding better the current state and priorities in a research area, and the analysis can document when and where the research area started, and where it is headed. In this way the bibliometric analysis can encourage researchers to fill gaps in the current knowledge and make grounds for creation of new directions. The work by Gong *et al.* (12) fits perfectly well within this purpose.

Acknowledgments

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Annals of Translational Medicine*. The

article did not undergo external peer review.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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