

A Review of Worldwide Patents

Innovations in Peak Flow Meters for Asthma

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Background: Contemporary healthcare nurses increasingly rely on innovative technology for assessment, treatment, and patient self-management. Funding opportunities as well are increasingly steering toward technology development and innovation. Health researchers, including nursing scientists, who are engaged in medical device innovation need to assess the state of the art of current technology. This requires an intellectual property analysis, or patent search, which is not covered by the types of literature reviews customarily used in health science research.

Purpose: The purposes of this article are to illustrate a methodical review of worldwide patents and to show how those results can be used to identify possible products available for use.

Approach: An application of peak flow meters for use by patients with asthma is used to illustrate the process. The Derwent Innovations Index interface with keyword searching is illustrated, as is the use of Google Patents. From the 14 patent document results, six possible technologies were identified. The patent search revealed innovations in asthma peak flow meters for use in future research and identified future directions for device development.

Discussion: These results support the claim that patent literature must be included in reviews that seek to identify technology state-of-the-art healthcare applications and that advances in the nursing research paradigm should include patents as background and scholarly products.

Key Words: asthma • intellectual property • nursing research • patents • respiratory system diagnostic techniques • state-of-the-art review • technology

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Contemporary healthcare nurses increasingly rely on innovative technology for assessment, treatment, and patient self-management. As frontline providers, nurses are well positioned to identify the need for technology development and contribute to innovative design concepts. Traditionally, clinical nurses and nurse scientists have had a passive role in using commercially available technology for research and patient care. However, nurses can expand their roles to engage in multidisciplinary collaborations on healthcare devices and technology (Mangell, 2013; Patel, Goel, & Larson, 2013). Nurses bring a pragmatic understanding of the end user's needs, potential clinical impact, and required functionality to the innovation process (Shah, Robinson, & AlShawi, 2009).

Funding opportunities as well are increasingly steering toward technology development and innovation. For example, nurse researchers applying for funding via National Institutes of Health's (NIH's) R21 mechanism (Exploratory/Developmental Research Grant Award) would likely be involved in technology

innovation. A recent search of NIH's National Institute of Nursing Research for sponsored R21 funding opportunities and notices (NIH, 2015) yielded 16 active announcements, with nine of those in areas that would likely include technology innovation. The funding announcements included terms such as "mHealth Tools" (PA-14-181), "technological interventions" (PA-15-015), "innovative measurement tools" (PA-13-212), and "innovative research methods" (PA-13-119), whereas six of the funding announcements focused on self-management or family management of chronic diseases or conditions. With the ubiquity of technology in today's society, management of chronic diseases will likely be delivered via technological innovations. In crafting responses to such funding announcements, nurse researchers who show full understanding of existing technologies in the proposed field of study would enhance the foundation of their proposed research.

One essential skill for nurses engaging in technology innovation design as part of product development, or as independent research, is to ascertain the state of the art of existing inventions also known as an "intellectual property analysis." This intellectual property analysis consists of a patent search (Pietzsch, Shluzas, Paté-Cornell, Yock, & Linehan, 2009). Like a literature review, a patent search can be useful to the nurse to generate additional ideas or identify gaps in existing technological solutions. In addition, a patent search can be followed

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with a general search of the marketplace to determine if products incorporating identified intellectual property are readily available for patient care. The purpose of this article is to describe a patent search and synthesis of the state of the technology, using the example of peak flow meter inventions for asthma self-management as the example technology. The overarching goal of this article is to encourage nurse researchers to recognize that patent documents parallel other resources traditionally considered as scholarly works in the discipline's literature.

BACKGROUND

Patents give their owners exclusive rights to making, using, and selling the inventions for a certain period—usually 20 years (United States Patent and Trademark Office, 2014a; World Intellectual Property Organization [WIPO], n.d.a). However, not every new invention is patented, leaving the idea free for replication. Often, when a patent is granted, the patent owner may simply lay claim to the idea and never actually make, use, or sell what is disclosed in the patent. Thus, many patented ideas never end up in the marketplace. Sometimes, patented inventions are part of a larger product, and the link between the marketplace item and the patent can be more difficult to ascertain.

Patent literature contains useful information regarding inventions (new technology) that is not typically available elsewhere. Patent documents must explicitly relay the science and summarize prior art in the field of the invention. Because patent documents are required to include information on both the new invention as well as other related patents and other literature, such as relevant journal articles, they can be a wealth of current and background information for researchers. Nevertheless, a patent search has limitations in synthesizing a complete accounting of the state of the art and science in technology innovation. For example, some patents are never marketed, used, or even realized. Other new inventions may not be patented as a strategy to keep proprietary information private. We have illustrated this idea in Figure 1.

There are two types of patent documents: applications and granted patents. Both types of documents follow standard formats, comprising several major sections. Patent documents consist of a front page followed by detailed information. The front page contains patent/patent application number, title, abstract, inventor, assignee (entity or organization that owns the rights to the patent), classification (per international and/or local standards), and cited references, along with filing dates and other details. Inventor and assignee are not always the same; inventors who develop technology while working for an organization typically sign over rights to their employer, who would then be the assignee. Patent classification (PC) is a standardized hierarchy of language used to group inventions into similar categories; the classification tree varies from general classes to several depths of subclasses. The U.S. Patent

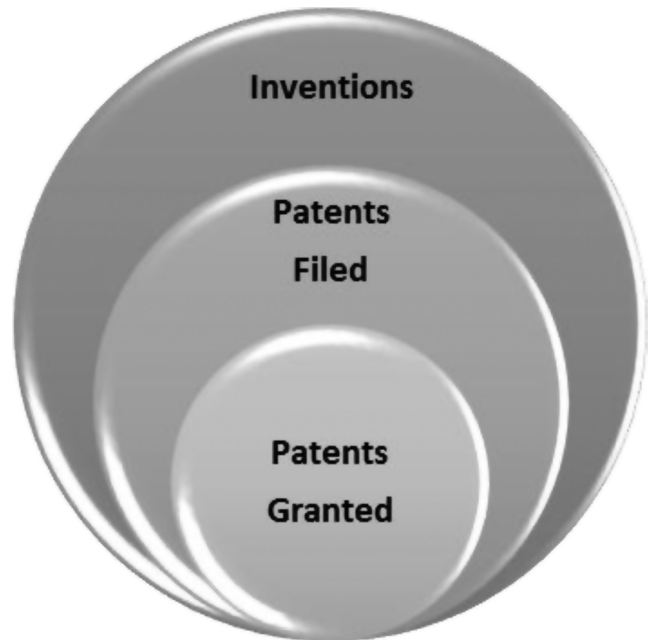


FIGURE 1. Limitations of a patent search. A patent search would not identify inventions falling in the darkest area (i.e., inventions that were used—or not used—and did not go through the process of filing for a patent).

Classification System is described in the training video available through the U.S. Patent and Trade Office (<http://www.uspto.gov/video/cbt/ptrcsearching/>) and outlined on the U.S. Patent and Trade Office Web site (United States Patent and Trademark Office, 2014c), whereas the International Patent Classification System (IPC) is outlined on the WIPO Web site (<http://www.wipo.int/classifications/ipc/en/>). A new Cooperative Patent Classification system is being adopted by the United States and Europe and will likely, eventually, replace both of these older systems. The main body of the patent document describes the general science/technology of the invention in the “background of the invention” and then meticulously details the invention in the remaining sections: “brief summary of the invention,” “brief description of the drawings,” and “detailed description of the invention” sections; specific claims (what specifically is protected by the patent) are listed at the end of the detailed description, and any drawings referenced are also included. Additional information, such as a full description of the various fields in patent documents, can be found at FreePatentsOnline.com or in the guide provided by WIPO (2013; http://www.wipo.int/edocs/pubdocs/en/patents/434/wipo_pub_434_03.pdf), for example.

Patent documents are not included in databases typically utilized by health science researchers. For example, MEDLINE/PubMed, PsycINFO, CINAHL, and the Cochrane databases cover hundreds of journals, standards, clinical trials, dissertations, and conference proceedings but do not index patent documents. In fact, traditionally, nurses may not have been trained to consider patent documents to be scholarly works

on par with peer-reviewed journal manuscripts and grant proposals, so patents are often ignored or overlooked. With a conventional approach, then, nurses may form an incomplete understanding of the state of nursing science, especially in relation to technology innovation. In engineering, physics, chemistry, and other natural sciences, for example, patents are recognized as essential to understanding contributions of colleagues to their fields of study.

Assessing state of the technology by a patent search was important to our team as a way to increase the depth of understanding we had gained about the science of peak flow meters for asthma from our more traditional assessments. In the following sections, we provide a description for the nurse researcher and innovator of how to conduct a patent search by using accessible portable incentive spirometers for peak flow monitoring in patients with asthma as the example technology. Knowledge of marketplace availability may also offer critical information to research teams as a way of identifying possible products that could be tested with a target population. Thus, we also provide a description of how we traced the patent search results to products that might be available in the marketplace. Combining these two steps (patent search followed by analysis of assignees' product lines) should provide a thorough compilation of the state of the art of our example technology.

METHODS

Similar to a literature review, our patent search strategy began with identifying relevant keywords, databases, filters, and limits, with inclusion and exclusion criteria. Figure 2 illustrates the overall process. After executing a database search, relevant patents were included, and full-text items were reviewed and summarized in a matrix of key features. The reference list for each included patent and patent application and was screened for additional, potentially relevant patents. Once a final list of included patents was determined, we searched for possible commercially available products employing the patented inventions. Although commercially available products may be identified through a variety of methods, we opted to search for product lines associated with assignees of the identified patents.

Database Options

We considered several databases for our search strategy in consultation with our multidisciplinary team and an engineering librarian affiliated with our university. A variety of features that can facilitate or impede the process of compiling, retrieving, and cataloging relevant patents are tabulated against several search engines in Table 1. The Derwent Innovations Index database (Thomson Reuters, 2014)—to which our university library subscribes—was selected here based on years covered, countries covered, ease of search interface, ready linkage to full

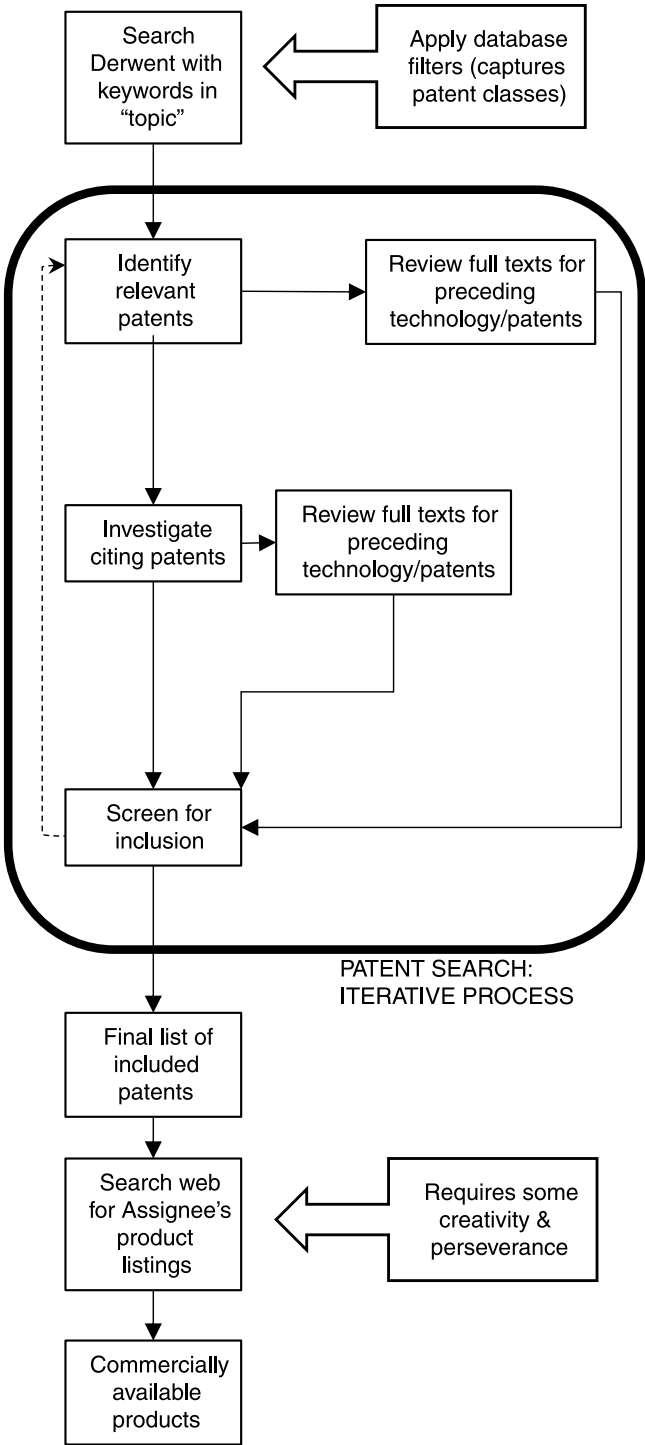


FIGURE 2. Assessing state of the art patent search to identify technology.

text, convenient exportation of bibliographic information, and ability to track the search, with the following rationale:

- Identification of “current” technology. This enables the use of databases that cover only the last 5–10 years; databases covering longer time frames are not especially advantageous in the example of determining current state of the art of a healthcare application, such as low-cost self-management of asthma. There

TABLE 1. Patent Database Features

Database/URL	Coverage		Documents		Availability		Hits ^b	Interface
	Cost	Date ^c	Area	View	Download	Listed		
Derwent	Fee ^d	2008	International ^e	Yes	Yes	Yes	Yes	• Text
Varies								• Field selection
Google Patent	Free	1790	International ^f	Yes	Yes	Yes	Yes	• Freeform search boxes
patents.google.com								• Limiters
Patentscope	Free	1790	International ^g	Yes	No	No	Yes	• Formatted Boolean
patentscope.wipo.int								
USPTO	Free	1790	United States	Yes	Yes	No	No	• Formatted Boolean
patft.uspto.gov								

Note: USPTO = United States Patent and Trademark Office. ^aExportable to reference program(s). ^bNumber of "hits" shown. ^cEarliest date. ^dSubscription required. ^eDerwent: see <http://ip-science.thomsonreuters.com/support/patents/coverage/>. ^fGoogle Patents: see <https://support.google.com/patents/answer/2539193?hl=en>. ^gWorld Intellectual Property Organization: see http://patentscope.wipo.int/search/en/help/data_coverage.jsf.

- may, however, be applications that require lengthier time limits, as described later in the Discussion section.
- Maximization of geographical coverage. Databases covering only a few technologically advanced countries could lead to overlooking salient technologies.
 - Advantageous databases. Patent databases that have features and appearances similar to traditional literature databases are advantageous. Some patent databases require the user to have intimate knowledge of patent field definitions and strictly format the search in Boolean terms. Such specialization will likely impede the usability for the nurse researcher or innovator who is otherwise unfamiliar with patent searches.
 - Reference to original source. We wanted a database that would easily link the reference to the original source document (full-text patent or application). We considered the ability to directly download and save the source from within the database.

In addition, databases that facilitate direct export to reference management tools (e.g., EndNote or Refworks) were prioritized to help prevent translation errors that might be incurred by manually recording or electronically copying/pasting reference information into a separate document. Furthermore, not all databases and search engines provide the number of patent documents identified at each stage. A database display of the number of related patent documents enables the user to systematically track their review of the patent literature.

As can be seen in Table 1, the Derwent database meets all of the above criteria. The ability to export patent citation information directly to reference software saved time and improved accuracy over having to manually transcribe information. Derwent is not free, however; a paid subscription is required. In comparison, although Google Patents lacks the direct export of citation information, it is free and offers the familiarity and power of its parent Google search engine; Figure 3 outlines the basics of using Google Patents. One drawback of Google Patents is its bias to identifying superfluous documents; it appears that all text is searched, so that any mention of a search term (e.g., be it in background or reference list) will flag a patent document as relevant. Although the other free interfaces shown in Table 1 lack some features, their results are more streamlined than those of Google Patents. Therefore, we include a comparison of Derwent, Patentscope, and Google Patents in the Findings section.

Options Within Derwent

Patents can be searched using several techniques within Derwent. This is similar to a literature review, where the researcher can choose to search for the subject heading or keyword in the title, abstract, or entire text. Two options in Derwent include using IPC or by selecting "topic." We chose to search by "topic" because the title and abstract fields are searched (Thomson Reuters, 2013), which enables retrieval of patent documents that the respective authors chose to describe their inventions with those terms: topic is the only field provided by Derwent that searches inventor-created wording

Go to URL patents.google.com

Google
Patents

Type first term in search box

Results will be listed

Number of results at top of list

Leave results sorted by relevance

The grouped by classification (top of list) appears to not allow viewing of all documents within a classification

Use boxes for "search term" on upper left of results list to refine

Words in a search box appear to be combined with "OR"

e.g., "peak flow meter" finds peak OR flow OR meter

use + Synonym in search term boxes for user-defined terms to "OR"

Different search term boxes combined with "AND"

Results listing order depends on order in which terms are entered

e.g., asthma, peak, flow, meter returns results in a different order than peak, flow, meter, asthma

See and select additional search limiters using the "more" chevron on bottom left

Click on item in list to see details of individual patent document

View complete patent document

Download pdf or find prior art using buttons on upper right

Find citing patents in "Info" line on middle right

NOTE:
Entering "google.com/patents" into the address bar leads to a different version of Google Patents. After entering a search term in the mid-screen Google search box, an advanced search option is available by clicking on the tool icon in the upper right of the results screen. However, as Google refers to this as the "old version" (<https://support.google.com/faqs/answer/6261372?hl=en>), the procedure for its utilization is not shown here.

FIGURE 3. Google Patents search process.

within the patent. Searching body of the patent or claims fields, for example, is not an option. When compared with other search strategies, this method appeared to be the most efficient way to identify possible patent documents without having to scan through all documents within relevant PCs, as described in the next paragraph.

Alternatively, the search could have been conducted to view all patents within the relevant IPCs. Unfortunately, this strategy requires some knowledge of the IPC codes that might include one's desired technology. Omission of key classifications could cause omission of relevant documents. For example, the most relevant IPC code for our "peak flow meter" search is likely A61B-005/08, which is found several layers deep within the IPC hierarchy under the general heading of "Human Necessities" at the subcategory "measuring devices

for evaluating the respiratory organs"; IPC code scheme can be explored via the WIPO Web site (<http://web2.wipo.int/ipcpub/#refresh=page>). One might also choose to go deeper into the A61B hierarchy to focus on "measuring breath flow" (A61B-005/087) or "measuring impedance of respiratory organs or lung elasticity" (A61B-005/085). However, to identify patent documents related to "algorithms that calculate peak flow" from a flow meter signal and send that result to a laptop computer, the most relevant IPC might be G06F-015/16 "Physics" at the subcategory "combinations of two or more digital computers each having at least an arithmetic unit, a programme unit and a register, e.g., for a simultaneous processing of several programmes." This example illustrates the convenience of ability to implement keyword searches for nurses as intimate familiarity with different PCs is not necessary.

Keywords, Limits, and Filters

For our purposes, we utilized keyword searching with truncation/wild-card endings. However, readers should be aware that using keywords to search is not as comprehensive as searching through complete classification codes because many inventors will use generic terms like “pressure sensitive recording” for carbonless copy paper, for example. To explore for new methods of peak flow detection in community-based patients with asthma, the following four search strings for “topic” (Figure 4) were each utilized with Derwent: “spiromet* and peak*,” “asthma* and peak*,” “spiromet* and asthma*,” and “spiromet* and mobil*.” For years covered, we utilized the full capability of Derwent, which goes back only as far as 2008; although not a hindrance for the goals of our search, years before 2008 may be required for some applications, as described

later in the Discussion section. We did not filter results by limiters such as “instruments and instrumentation” or “engineering” as there were few enough results returned to read through manually. However, for patent searches that retrieve numerous documents, such filters assist in focusing the search on technologies of interest.

Translating Patent Document Findings to Available Products

Determining commercial availability of technology described in the patent documents presented some challenge. Our initial planned strategy was to utilize the Internet to search for the assignees’ Web sites and/or product listings. This approach yielded results for only one of the identified technologies (Foxwell, Lawson, & Lawson, 2013). The other technologies

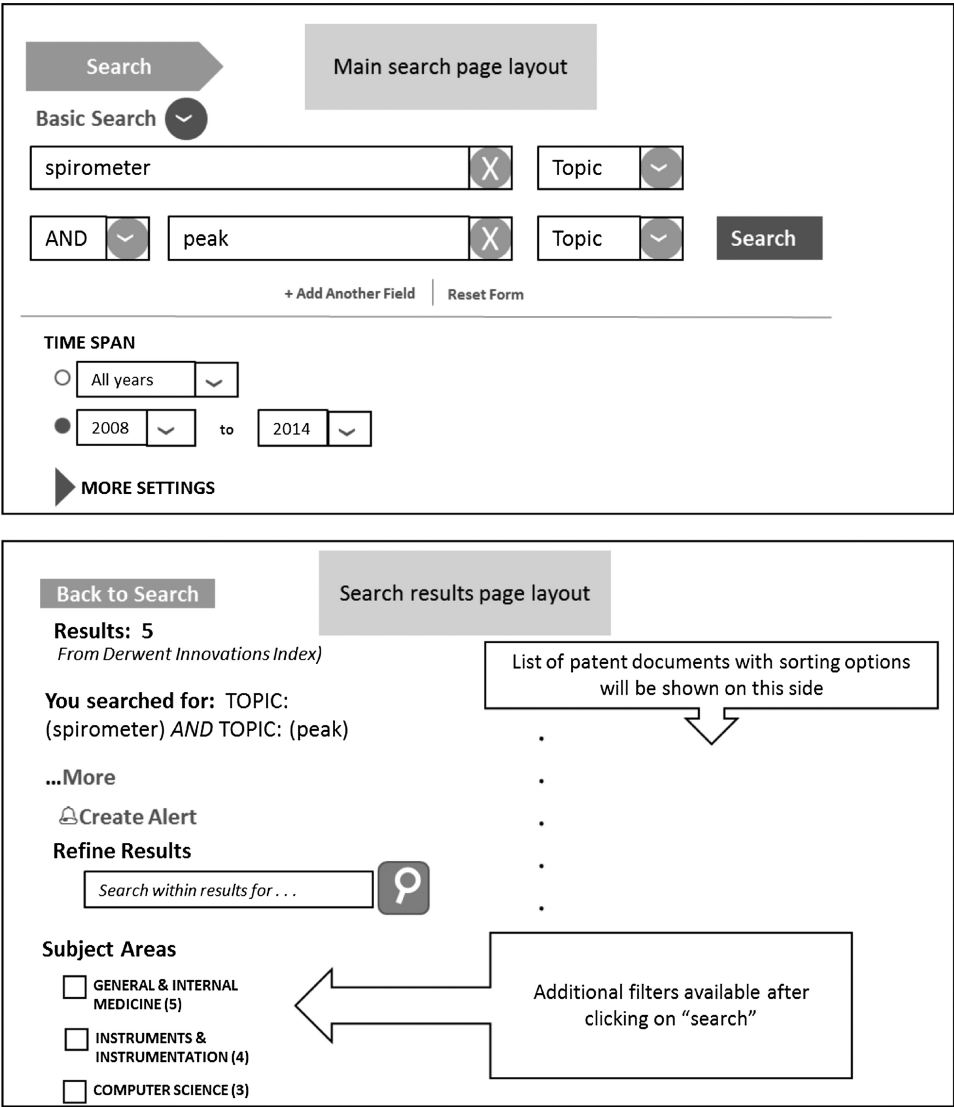


FIGURE 4. Using keywords and limiters in Derwent. Certain data included herein are derived from Thomson Reuters Derwent Innovations Index, Web of Science. Copyright 2015 by Thomson Reuters. All rights reserved.

may not be available as products because of time required to commercialize products or delays between filing and receipt of patent.

We also searched three of the U.S. Food and Drug Administration (FDA) databases for medical devices that might have been registered by inventors or assignees (U.S. FDA, 2015): (a) premarket approval, (b) premarket notifications, and (c) registration and listing. One of the identified technologies (Weiss, Fuller, Frowijn, Gholami, & Krumholz, 2011) was found in the premarket notifications database. In addition, searching the Internet with other phrases that included assignee information and “spirometer” or “asthma” or “patent” and/or unique phrases related to the envisaged product yielded results of commercially available products for 40% of the documents. We also searched the Internet for available commercial products using inventor names, assignee names, and keywords from the patent title in various combinations: assignee names with “patented technology” (and synonyms of that phrase).

FINDINGS

Patent Document Yield

Using the keyword/Derwent topic method described above yielded $n = 14$ relevant patent documents from $n = 206$ initially identified. The totals were distributed as follows: “spiromet* and peak” ($n = 8$, three relevant plus two additional patents that cited one of the others), “asthma* and peak*” ($n = 170$, six relevant), “spiromet* and asthma*” ($n = 17$, three nonduplicate relevant), and “spiromet* and mobil*” ($n = 11$, no nonduplicate relevant items). Cited patents were also searched but yielded no additional relevant patents. As can be seen in Table 2, five granted patents ($n = 3$ American, $n = 1$ Russian, and $n = 1$ Chinese) and nine applications ($n = 1$ Japanese, $n = 1$ Chinese, $n = 1$ American, $n = 4$ American/international, $n = 1$ Great Britain/international, $n = 1$ Swedish/international, and $n = 1$ international only) were identified. Full-text documents for four of the patents/applications ($n = 2$ Chinese, $n = 1$ Japanese, $n = 1$ Russian) were not readily retrievable through Derwent, Google Patents, and similar search engines.

Types of Technology

Overall, we identified several types of technology, various methods of communicating between devices, and some unique forms of peak flow meters. For example, among the documents summarized in Table 2, we found two turbine flow meters that differ from traditional blow-through spirometers (Foxwell et al., 2013; Mangell, 2013), two applications that utilize microphones to generate and interpret peak flow signals (Gonnen, Groberman, Solomon, & Cohen, 2011; Patel et al., 2013), an alternative to measuring flow through a tube that does not incorporate pressure drop (Wang, Young, Huang, & Chou, 2009), use of a metered-dose inhaler to measure expiratory flow rate (Wekell, 2011), a novel-shaped spirometer with pointer-type peak flow scale

(Jiang, 2009), and a new type of filter apparatus (Nakajima, 2010). We found inventions described in terms of using remote sensors that are not integral parts of the spirometers (Weiss et al., 2011; Gonnen et al., 2011; Huang, 2014; Mangell, 2013; Patel et al., 2013), a method for interpreting peak flow curves (Meshcheryakov & Titova, 2009), and the use of bluetooth technology to transmit flow signals (Huang, 2014). We also found peak flow meters in the form of a toothbrush handle (Baruti, 2012; Baruti & Dean, 2011) and in the form of a wheeze detector that listened to breathing via microphone (Fu, 2011).

Product Discovery

Tracking from 14 patent documents to products yielded six possible products. We based the $n = 6$ possible products on the assumption that a product might exist if we were able to find Web sites or news articles that mentioned assignees/products that corresponded with their respective patent documents (see two rightmost columns in Table 2) or if they were listed in the FDA premarket and registration databases mentioned above. Two of the patents with shared inventors (Baruti, 2012; Baruti & Dean, 2011) likely comprise the FlowBrush combination toothbrush spirometer as seen on this Web site: <http://www.flowbrush.com/>. Product(s) employing one of the other patents for turbine spirometer may be available—the assignee's Web site was located, but no product obviously using the new technology was found on the Web site (Foxwell et al., 2013). For the optically detected turbine peak flow meter (Mangell, 2013), the assignee's Web site was located (<https://www.linkedin.com/company/pond-healthcare-innovation>), but no specific products were identifiable; however, the Web site has contact information, which may be useful. For the mobile phone peak flow app (Patel et al., 2013), a University of Washington Web site was located (<http://ubicomplab.cs.washington.edu/wiki/SpiroSmart>), and several other news articles describing the app were found. We also searched for “SpiroSmart download” but were unable to find a way to download the app at the time of writing this article. Furthermore, the invention that analyzes frequency of sound-flow signals to determine peak flow (Gonnen et al., 2011) is alluded to on the inventor's LinkedIn page, but the business appears to be currently focused on nonasthma applications. In addition, the Waldo Networks technology for remote sensing of diagnostic information (Weiss et al., 2011) was found in the FDA Premarket Notifications database with a decision date of 2011. We also searched two crowdfunding sites—a “search projects” option (Kickstarter.com and RocketHub.com)—without success. Contacting some of the assignees and/or inventors directly may be required to determine whether they are actually using the technologies described in their respective patents. Table 2 shows the search strategies that ultimately enabled identification of the (potential) products described above. Ultimately, the use of

TABLE 2. Derwent Interface: Peak Flow Meter Patent Documents

Patent ID(s) ^a	Assignee(s)	Description	Use ^b	Google search term ^c
WO2012038903-A2, WO2012038903-A3, US2013190641-A1	Meytar Digital Engineering & Inventors	• Microphone creates audio signal	Maybe ^d	Meytar Digital Engineering
CN201337451-Y ^e	Inventor	• Frequency interpreted to yield peak flow • Peak flow then transmitted • Unclear • Could be orifice flow meter with pointer for pressure drop signal • Blow-through turbine flow meter	Unclear	Not found
WO2013184066-A1, SE201250597-A1, SE536800-C2	Pond Innovation & Design	• Flow rate detected by optically sensing turbine blade motion	Maybe ^f	Pond Innovation & Design AB
WO2013170131-A1	University of Washington	• Microphone creates sound signal from breathing • Sound signal interpreted as breath flow • Stored as flow signal • Transmitted digitally to mobile device for analysis • Remote sensing of diagnostic information	Maybe ^g	University Washington mobile spirometer, then "spirosmart"
US 2011282168 A1	Waldo Networks	• Alternative to blow-through spirometer	Maybe ^h	Waldo Networks patent
US201010137733-A1, WO2010065452-A1, EP2369989-A1, CN102300502-A, JP2012510319-W	Tricorn Tech Corp.	• Alternative spirometer type (i.e., not pressure drop across orifice)	Unclear	Not found
GB2500893-A, WO2013150267-A1	Medchip Solutions	• Hardware for PFT equipment • Toothbrush handle is spirometer	Yes ⁱ	Medchip Solutions
JP3164406-U ^e US8308651-B1	Ask Corp. Inventor	• In combination with data transmission strategy • Toothbrush head is part of spirometer • Wheeze detector	Unclear Yes ^j	Not found "asthma toothbrush spirometer"
US7867172-B1	Inventors	• Bluetooth asthma signal transmission • Interprets peak flow curve	Yes ^k Unclear	"asthma toothbrush spirometer" Not found
WO2011115239-A1, US2011230777-A1, EP2547256-A1, CN102781318-A, JP2013521833-W, US8506501-B2, JP5464627-B2	Sharp Corporation, Sharp Laboratories America, & Inventor		Unclear	Not found
CN203388855-UI	Inventor		Unclear	Not found
RU2348352-C2 ^e	Surgut State University		Unclear	Not found

(continues)

TABLE 2. Derwent Interface: Peak Flow Meter Patent Documents, Continued

Patent ID(s) ^a	Assignee(s)	Description	Use ^b	Google search term ^c
WO2013028705-A2, US2013053719-A1, WO2013028705-A3	Bioguidance LLC & Inventor	• Expiration rate • Part of metered-dose inhaler	Unclear	Not found

Note. CTO = chief technical officer; PFT = pulmonary function test. ^aPatents granted are underlined; applications are in regular face font. ^bLinks are evidence of availability of device. ^cGoogle search term yielding product-patent connection/FDA database in which found. ^dOne inventor lists himself as CTO of medical device companies; see <http://li.linkedin.com/pub/david-groberman/21/770/297>. ^eFull text of patent/application document not found. ^fSee <https://www.linkedin.com/company/bond-healthcare-innovation>. ^gContact University of Washington <http://ubicomplab.cs.washington.edu/wiki/SpiroSmart>. ^hArticle found describing the corporation settling patent infringement suit (see <http://mobilehealthnews.com/1775/walco-health-settles-bosch-suit-licenses-patents/>). ⁱSee <http://www.medchipsolutions.com/>. ^jSee <http://www.flowbrush.com/flowbrush.html>. ^kSee <http://www.flowbrush.com/flowbrush.html>.

inventions in products depends on a variety of factors and is no reflection on the scientific merit of an idea.

Comparison of Derwent, Patentscope, and Google Patents

For point of reference, we compared searches for “peak flow meter” and “asthma” using Derwent, Patentscope, and Google Patents from January 1, 2014, to September 15, 2015. The short time frame was used for comparison because of the large numbers of irrelevant results returned by Google Patents, as discussed below. For Derwent, the topic field was searched (peak flow meter *and* asthma with time span of 2014–2015); for Patentscope, the front page field was searched (FP: [asthma *and* peak flow meter], then analyzed by date); and for Google Patents, four search fields were used (peak *and* flow *and* meter *and* asthma, with “after filing date” of January 1, 2014). Results were $n = 4$ for Derwent, $n = 0$ for Patentscope, and $n = 186$ for Google Patents. All four of the Derwent documents and three of the Google Patents documents were relevant to our application. Whereas the differences between Derwent and Patentscope results may have been because of different synonym language, or possibly differences in countries covered, the number of documents found by Google Patents far exceeded those found by either Derwent or Patentscope. Yet, only one of the four Derwent-identified documents was included in the $n = 186$ found by Google Patents; the other three may have been missed because of date-limiting differences. Google Patents did identify two possibly relevant Chinese documents that had not been found by either Derwent or Patentscope, although they described turbine flow meter devices that overlap with that (Mangell, 2013) found in our previous Derwent search. However, the remaining $n = 183$ documents were not related to our application.

The significant number of irrelevant documents retrieved by Google Patents (and not identified by the other two search engines) appears to be associated with a search of all text within a document for keywords. In screening the $n = 186$ documents identified for this comparison, we noticed that the keywords often appeared in background sections or cancelled claims or were interspersed separately in the document and, thus, not in the context of interest. Google Patents does not provide the option to limit searches based on patent document sections, for example, to include only active claims or exclude the background section. The number of results returned by Google Patents was reduced to $n = 37$ if quotes were used (“peak flow meter” *and* asthma); however, these $n = 37$ results did not include the three relevant documents that had been among the $n = 186$ identified using the four separate search terms. It may be that synonyms are missed when quotes are used; for example, terms such as “peak expiratory flow meter” might be missed if “peak flow meter” is entered as a search term. It is difficult to determine what search terms should be used with Google Patents to optimize the number

of relevant results without overlooking worthwhile patent data. In addition, there are two versions of Google Patents (see Figure 3) that appear to provide different result lists for the same search terms. Thus, use of Google Patents to search patent databases, although free of charge, likely requires more attention to search strings and synonyms and may require screening and elimination of more irrelevant documents, when compared with the other engines such as Patentscope (free of charge) or Derwent (for a fee).

DISCUSSION

A patent search is an essential step to determining the state of the art in healthcare technology for nurse researchers. We detailed a simple patent search for recent patents for technology related to portable peak flow monitoring for patients with asthma. This search uncovered recently commercialized innovative technology of which the team had not been aware: one product/service that is clearly available and in use (spirometer integrated into toothbrush [Baruti, 2012; Baruti & Dean, 2011]) and four others that were not yet on the market (microphone peak flow meter [Gonnen et al., 2011], Spirosmart mobile device [Patel et al., 2013]), blow-through turbine flow meter [Mangell, 2013], and alternative flow meter [Foxwell et al., 2013]). This patent search was an essential link in understanding the state of the technology and complemented our literature review with additional findings. The search revealed novel ways in which the peak flow of the asthmatic patient was measured, communicated, and interpreted. Much of the detailed information about the technology found in our patent search is not available in the peer-reviewed literature.

We found Derwent to be the most promising patent database for the nurse researcher who is a novice to the patent search process and taxonomy. However, because there is a user fee, Derwent may not be a reasonable option for nurses who are not in large academic settings. Of the free patent search engines, Patentscope may be the most efficient tool for retrieving relevant patents, although its search logic may require a learning curve. Google Patents is also free, but results of Google Patents searches seem to include many irrelevant documents, and users may be required to meticulously choose search terms or manually scan and reject hundreds of documents that are not on topic. Searching in Derwent with keywords in the "topic" option enabled a user-friendly process that proceeded quickly and thoroughly. Steps in the process were readily documented, for example, how many items were retrieved for each search string, so that the patent search procedure could be systematically documented to be reproduced by others. In addition, the ability to directly export data to a bibliographic software package was convenient, and automated accuracy was available in tracking and reporting results. In addition, ready access in the patent search database to other citing patents provides a safety net to other patents that might not be otherwise identified with selected

search strings. However, in our example of peak flow meter technology, cited patents yielded no pertinent results.

Finding commercially available technology from a patent search was challenging. For our team, determining how patents translate into commercially available products was an iterative procedure. Although a predefined, protocol-based method of looking for assignees' product listing and searching the FDA's databases seemed logical, more creative searching was required to find the products. Contacting the assignee directly may have been a more productive strategy when a limited list of relevant patents is in the final inclusion list.

There are limits to what a patent search can reveal. There may be technology that is commercially available but was never patented. A patent that represents a small integrated part of a commercially available product may not accurately depict the potential clinical innovation and relevance of the larger product of interest to the nurse. Another issue is that the patent database used in our search covered only the most recent 7 years. A more reasonable time frame to search may be 10–20 years: Health technologies and innovations commonly take 15–20 years from inception to practice, and patent searches should accommodate that reality. Researchers wishing to explore commercializing their own innovations would need to consider a time frame of about 20 years (the typical patent term) to capture currently active patents. Although our team determined that searching the past 7 years incorporated a sufficient time frame, there may be other areas in which technology is changing more slowly and, therefore, requires a search that reaches farther back in time.

Limitations

Nurses engaged in technology innovation may be involved in development of procedures, software, mobile apps, treatment algorithms, diagnostic or screening questionnaires, and other discoveries that are not patented or may not be patent eligible. Although software and procedures can be patented (United States Patent and Trademark Office, 2014b; WIPO, n.d.b), developers may instead choose to copyright and license their inventions (United States Copyright Office, n.d.), or they may choose to proceed without protection (as illustrated in Figure 1). Thus, a thorough patent search will not exhaustively identify all existing innovations.

Furthermore, it is possible to directly identify new products by searching the Internet, reviewing conference proceedings, scanning trade journals, and using similar resources. However, marketplace availability of products does not reveal the full state of the art available for research and does not yield the rich background of science behind discovery of the innovation.

Conclusions

The patent literature is rich with information not found elsewhere and should be explored by health scientists reviewing current technologies or procedures. Nurses, in particular,

should consider patent documents on par with the scholarly works traditionally used for nursing research—a paradigm shift from tradition. A strong foundation for technology-inclusive research would incorporate an assessment of state-of-the-art related technologies. With the right patent database and interface, searching the patent literature can be accomplished methodically with a process that is similar to conducting a literature search, which is already familiar to health science researchers.

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