Tool creates personalized catch-up immunization schedules for missed childhood vaccinations

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The catch-up immunization scheduler for missed childhood vaccinations developed by researchers at Georgia Tech is available for download from the CDC Web site. Credit: Georgia Tech

A new downloadable software tool will help pediatricians, parents and other health care professionals determine how to adjust complex childhood immunization schedules when one or more vaccine doses aren't received at the proper time.

Children commonly miss recommended times to receive vaccines. A report issued last month by the Centers for Disease Control and Prevention (CDC) found an alarming 28 percent of toddlers have not been vaccinated according to U.S. guidelines. Another recent survey found that only nine percent of children received all of their vaccinations at the recommended times and that only half received all recommended doses by their second birthday.

Once a child falls behind in the vaccination schedule, health care professionals are left to figure out when it's appropriate to give any missed vaccines and any future vaccines. They typically have to construct a unique, personalized catch-up schedule for each child – often while the child sits in the treatment room.

Researchers at the Georgia Institute of Technology are taking the guesswork out of developing individualized catch-up vaccination schedules. A new online tool allows parents and pediatricians to ensure that the missed vaccines and future vaccines are administered without violating guidelines regarding vaccines and doses.

"Physicians have been telling us for years that they needed a computerized program to tell them when to give vaccines after a child misses scheduled immunizations," said Larry Pickering, executive secretary of the Advisory Committee on Immunization Practices (ACIP) of the CDC and a collaborator on the project. "Now this tool is available for health care professionals and parents to use and they are excited to use it."

The tool, designed by Pinar Keskinocak, associate professor in Georgia Tech's H. Milton Stewart School of Industrial and Systems Engineering, and graduate student Faramroze Engineer, is available for download from the CDC Web site
[http://www.cdc.gov/vaccines/scheduler/catchup.htm].

The program removes the challenging task of simultaneously considering complex rules, guidelines and discretionary considerations when creating a catch-up schedule. A physician or caregiver simply inputs a child's date of birth and previous immunization dates, and the program displays a personalized schedule of the recommended dates to administer all future vaccines.

The tool removes the numerical and computational aspects of constructing a catch-up schedule by hand and provides two options: administer the vaccines as soon as possible or administer the vaccines when recommended.

"Sometimes a physician sees a child that he or she knows will not return for all follow-up visits. In this case, the tool provides the physician flexibility in administering as many vaccines as possible while the child is in the office rather than waiting," said Pickering.

It is important that children are protected against diseases by getting vaccinated. Since vaccines contain weakened viruses or parts of organisms that cause disease, the body's immune system reacts to the vaccine the same as it would if it were being invaded by the disease, but without getting sick.

The body makes antibodies and stimulating cells that destroy disease-causing germs. If the immunized person is ever exposed to the real disease, the antibodies are there for protection. Sometimes additional doses of a vaccine have to be administered to boost immunity.

The vaccines included in the scheduler are those required between birth and six years of age: Hepatitis B, Rotavirus, Diphtheria/Tetanus/Pertussis, Haemophilus influenzae type b, Pneumococcal, Inactivated Poliovirus, Measles/Mumps/Rubella, Varicella, Hepatitis A and Meningococcal. Influenza is contained in the recommended schedule, but is not included in the scheduler. Each infant requires approximately 27 vaccine doses administered before two years of age for protection from 15 vaccine-preventable diseases.

A beta version of the tool was demonstrated at the AAP National Conference and Exhibition last October and presented to the Committee on Infectious Diseases as well as several pediatric clinics in Atlanta, including Children's Healthcare of Atlanta.

The scheduler follows the guidelines developed and revised each year by ACIP in collaboration with the AAP and the American Academy of Family Physicians. These guidelines include the feasible number, timing and spacing of doses of each vaccine based on the child's age, the number of doses and the age at which each dose was administered.

In addition, each dose of each vaccine has a minimum, maximum and recommended age for administration, and there are minimum and recommended gaps between doses. These gaps as well as future administrations of a particular vaccine may vary depending on the current age of the child and the age at which previous doses were administered.

If a child requires more than one live vaccine to be administered, there are two options: administer all live vaccines on the same day or wait 28 days between live vaccine shots. There also may be discretionary considerations such as limiting the number of simultaneous administrations a child receives or the number of visits required to complete the series for all vaccines.

To solve the complicated problem of developing a personalized catch-up vaccination schedule in just seconds, the researchers used a technique called dynamic programming. Dynamic programming means solving an optimization problem by efficiently sorting partial results.

For example, if two partial schedules are created for a child and they both administer the same number of doses, but one schedule administers them earlier than the other, then the partial schedule that administers the vaccines later is eliminated because a better option is already available.

The key to dynamic programming is to prove that one partial schedule is better than another without having to determine the entire schedule and without having to try every possible schedule.

“The benefit of dynamic programming is that it eliminates solutions or partial solutions that are not promising – those that won’t lead to the optimal solution,” said Keskinocak.

In providing such a tool, the researchers hope to improve the effectiveness of childhood vaccination programs by improving timely vaccination rates.

“In an ideal world, every child would receive their vaccines at the recommended times, but since this isn’t a perfect world, this tool developed at Georgia Tech allows children to correctly catch-up once they fall behind,” added Pickering.

Source: Georgia Institute of Technology

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