



# Knowledge and practices regarding infant vaccination: results of a survey of French physicians

Pierre Bakhache<sup>1,2</sup> · Brigitte Virey<sup>1,2</sup> · Christina Bienenfeld<sup>3</sup>

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## Abstract

A prospective, observational, survey of pediatricians and general practitioners (GPs) was conducted to assess pediatric vaccination knowledge and practices. The survey was distributed by email to 1069 pediatricians and 1700 GPs and completed by 151 pediatricians (14.1%) and 201 GPs (11.8%). Knowledge of the vaccination calendar was very good (99% overall). Of the respondents, 98% were confident in vaccine efficacy. Eight-one percent of pediatricians and 62% of GPs agreed that recommended vaccinations should become obligatory; all prescribed hexavalent vaccines often or always. More pediatricians (88%) than GPs (75%) used anti-pyretics; the use of anesthetic cream/patches was similar in each group (79% and 75%, respectively). The ambience at vaccination was considered to be important by both groups, and was disturbed in 37% of cases. Seventy percent of pediatricians and 57% of GPs agreed that vaccine reconstitution (e.g., Hib pellet) is a complicating factor: overall, 28% reported occasionally omitting to reconstitute a pentavalent or hexavalent vaccine in error, and 60% reported having not fully reconstituted the vaccine. Almost all (93%) considered non-reconstitution as an important error.

**Conclusion:** Overall, adherence to good vaccination practices was good, although errors in reconstitution were reported by physicians. These problems would be minimized by wider use of fully liquid vaccines.

## What is Known:

- Pediatric vaccination schedules are crowded.
- Good vaccination practices and the use of multivalent vaccines are essential to maintain good compliance to pediatric vaccination recommendations.

## What is New:

- Overall good compliance to good vaccination practices by both pediatricians and GPs in France.
- Omission of pentavalent or hexavalent vaccine reconstitution of Hib pellet and incomplete reconstitution reported by pediatricians/GPs. Awareness of pediatricians/GPs that omission and incomplete reconstitution are important errors.

**Keywords** Fully liquid vaccine · General practitioner · Hexavalent vaccine · Pediatrician vaccine reconstitution

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✉ Pierre Bakhache  
pbak@club-internet.fr

Brigitte Virey  
bvirey@wanadoo.fr

Christina Bienenfeld  
Christina.Bienenfeld@ifop.com

## Abbreviations

aP	Acellular pertussis
D	Diphtheria
GP	General practitioner
Hib	<i>Haemophilus influenzae</i> type b
HB	Hepatitis B
IPV	Inactivated poliovirus
PRP~T	Hib polysaccharide conjugated to tetanus protein
T	Tetanus
USA	United States of America

<sup>1</sup> AFPA, Association Française de Pédiatrie Ambulatoire, 3 Ter Boulevard Richelieu, 02100 St-Quentin, France

<sup>2</sup> INFOVAC, 27 rue Inkermann, 94100 Saint-Maur-des-Fossés, France

<sup>3</sup> IFOP Healthcare, 78 rue Championnet, 75018 Paris, France

## Introduction

Good vaccination practices are essential for the safe, timely, and efficacious delivery of antigens in an increasingly crowded calendar of recommended vaccines, particularly in the first few months of life [8]. In the United States of America (USA), the vaccination calendar includes around 30 vaccinations by 6 years of age [3], which equates to over 100 million opportunities for errors related to pediatric vaccination each year in the USA alone.

Multivalent, combination pediatric vaccines are increasingly the standard of care and their use has helped to significantly reduce global disparities and vaccination errors and improve coverage [10] against a range of childhood infectious diseases as well as improving the timeliness of vaccination [7]. Additionally, their use can alleviate concern over the number of injections that are required to comply with vaccination recommendations in young infants [12, 17]. Modern combination pediatric vaccines are often comprised of five or six disease antigens (e.g., diphtheria [D], tetanus [T], acellular pertussis [aP], inactivated poliovirus [IPV], *Haemophilus influenzae* type b [Hib], polysaccharide conjugated to tetanus protein [PRP-T], and/or hepatitis B [HB]). These can be supplied and administered in various ways, e.g., a reconstitutable pentavalent DTaP-IPV//PRP~T vaccine (e.g., Pentaxim™/Pentavac™) [13] and a standalone HB vaccine, a reconstituted DTaP-IPV-HB//PRP~T hexavalent vaccine (e.g., Infanrix™ hexa) [18]), and most recently a fully liquid DTaP-IPV-HB//PRP~T hexavalent vaccine requiring no reconstitution (Hexaxim™, Hexyon™, or Hexacima™, depending on the country where licensed) [9, 11]. The availability of a ready-to-use, fully liquid vaccine means that the possibility of handling errors that can occur during the reconstitution process [2] is eliminated. Such vaccines are usually administered in a two or three vaccination primary series in the first few months of life followed by a booster vaccination early in the second year.

Also important in maximizing good vaccination practices are a good level of knowledge and acceptance of vaccination schedules by the healthcare provider, the use of the correct vaccination site, and, particularly for small infants, a conducive ambience during the consultation and vaccination process to minimize any distress to the infant that could in turn lead to distress to the parent(s).

This study was conducted using a questionnaire to evaluate the adherence to good vaccination practices by pediatricians and general practitioners (GPs) in France. The objective was to describe vaccination practices in infants by pediatricians and GPs, including an assessment of the vaccines prescribed and the adherence to the vaccination calendar, aspects of the vaccination process, the use of any distraction methods during the vaccination, and the perception of errors of vaccine manipulation (e.g., reconstitution).

## Materials and methods

### Study design and participants

This study comprised a survey of pediatricians and GPs that included a total of 38 questions (including 10 questions related to patient load and screening purposes) and was conducted in France. No patients were involved in the survey and so the patient-physician relationship was not affected. All data were collected using an electronic declarative questionnaire. The questionnaire was developed using the software Conformat. IFOP Healthcare tested and validated the questionnaire in conjunction with a partner (SERMO) by performing a review of spelling and typographical errors, routine logic checks (including numeric ranges, single- or multiple-choice responses and response choice order, mutual exclusivity for conflicting responses [such as “None of the above”/“Do not know”/“None”], free-text area associated with response of “Other (specify)”), and conducted a soft launch in 10% of the target sample that was validated prior to conducting a full launch to all potential participants. The survey was distributed by email to 1069 pediatricians and 1700 GPs between 31 October 2016 and 29 November 2016.

Pediatricians and GPs who spent  $\geq 20\%$  of their time in the provision of pediatric care, who prescribed or administered, on average, at least one hexavalent or pentavalent vaccine per week to infants aged 0–2 years, and who prescribed or administered hexavalent vaccines with a frequency  $\geq 50\%$  compared to pentavalent vaccines were eligible for the survey.

### Study assessments

The following data were provided by each survey participant: sex, specialty and type of employment (e.g., hospital), years of medical practice experience, location, number of patients aged 0 to < 18 years examined per week, adherence to the recommended vaccination calendar, the usual vaccination site used (e.g., deltoid, thigh), the prescription of anti-pyretics associated with vaccination, the usual order of vaccine administration for multiple administrations during a single visit (e.g., the least or most painful administered first or last), the use of topical anesthetic (and if so, for which vaccines), and distraction methods (e.g., toys, music) used during the vaccination (if any).

### Statistical analyses

All data are reported as incidences (%) and all analyses were descriptive.

There was no formal planned sample size and the largest possible number of completed surveys was collected in the time period described earlier.

The statistical analyses were done using Cosi 4.1.

## Results

### Characteristics of participants

A total of 352 surveys were completed, including 201 GPs and 151 pediatricians, representing a response rate of 12.7% (11.8% for GPs and 14.1% for pediatricians). Overall, 99% (100% of pediatricians and 98% of GPs) declared being involved or very involved in the vaccination of infants aged 0–2 months.

All regions of France were well represented with respectively 18%, 17%, 27%, 10%, and 28% of pediatricians and 20%, 24%, 15%, 12%, and 29% of GPs from the north-west, north-east, Parisian, south-west, and south-east regions. There were more female (60%) than male (40%) pediatricians, but more male (73%) than female (27%) GPs. Most respondents were full-time workers (79% of pediatricians and 95% of GPs).

For pediatricians, the most common patient age group was 0–2 years (average of 53 patients/week), with fewer patients aged 3–6 years (25 patients/week), 7–12 years (12 patients/week), and 13–< 18 years (6 patients/week). For GPs, the following number of patients was seen for each patient age group: 18 patients/week aged 0–2 years, 19 patients/week aged 3–6 years, 17 patients/week aged 7–12 years, and 15 patients/week aged 13–< 18 years.

### Knowledge and opinion of vaccination recommendations

Most pediatricians and GPs had good or very good knowledge of the vaccination calendar and of mandatory compared to recommended vaccines (100% and 95% of pediatricians and 98% and 97% of GPs, respectively; Fig. 1a). Pediatricians were more aware of the prevalence of infectious diseases in France than GPs (good or very good knowledge for 90% of pediatricians and 81% of GPs). Similarly, pediatricians were more aware of vaccines currently available and in development (good or very good knowledge for 87% of pediatricians and for 79% of GPs). The knowledge of the public debate around vaccination that was ongoing at the time of the survey was slightly lower in both groups (good or very good for 71% of pediatricians and 61% of GPs).

Regarding vaccination recommendations, most pediatricians and GPs (99% and 98%, respectively) had confidence in the ability of vaccination to protect against infectious diseases. A much greater number of GPs (81%) than pediatricians (62%) agreed that vaccines included in the vaccination calendar should be obligatory; conversely, significantly more pediatricians (59%) than GPs (45%) agreed that these vaccines should remain as recommendations rather than obligations.

Most pediatricians and GPs obtained their information from articles in the medical literature (89% and 80%, respectively). A similarly high number of pediatricians used expert information and conferences as sources of information (80% and 85%, respectively) with slightly fewer relying on medical representatives (66%). For GPs each of these was less important as an information source than for pediatricians (59%, 48%, and 57%, respectively). For both groups, the use of web sites was less important (42% for pediatricians and 38% for GPs).

### Vaccines prescribed and use of anti-pyretics and anesthetics

Pediatricians prescribed more vaccines than GPs, with  $\geq 93\%$  prescribing hepatitis A, HB, pentavalent (D, T, aP, IPV, Hib), meningococcal C conjugate, pneumococcal conjugate, measles/mumps, rubella, and hexavalent (D, T, aP, IPV, HB, Hib) vaccines often or always; for GPs, this was  $\geq 78\%$ , although notably 100% prescribed measles/mumps, rubella, and hexavalent (D, T, aP, IPV, HB, Hib) vaccines. For rotavirus, chicken pox, meningococcal B, meningococcal ACWY, and BCG vaccines, prescription was made often or always by 75–87% of pediatricians and 39–72% of GPs.

Most pediatricians (88% and 79%, respectively) and GPs (75% and 75%, respectively) used anti-pyretics and anesthetic cream/patch sometimes, often, or always for primary vaccination series (Fig. 2), with significantly higher use of anti-pyretics by pediatricians but no difference in the use of anesthetic cream/patch between pediatricians and GPs.

### Vaccination sites used

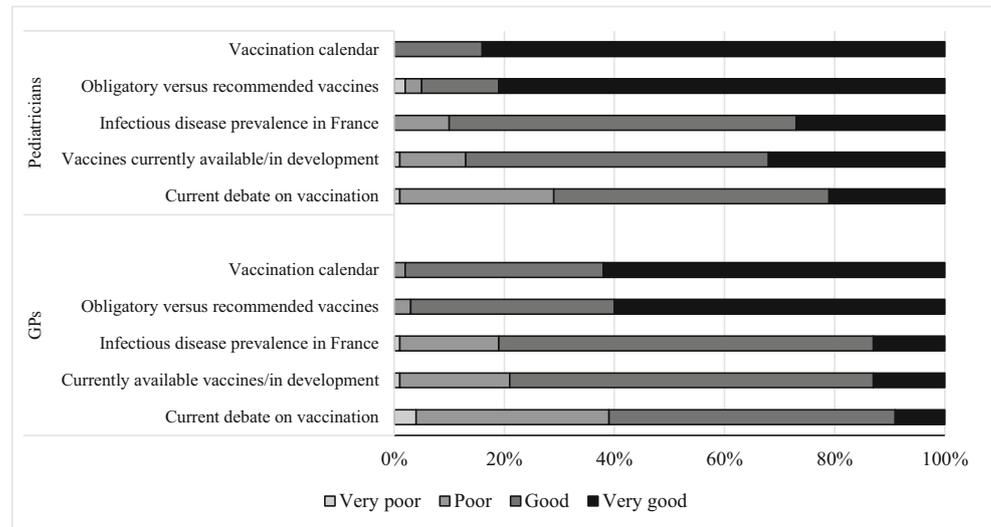
For primary series and infant booster vaccinations ( $\leq 24$  months of age), the thigh was the most common site of vaccination for both pediatricians and GPs, but was used more by pediatricians (ranging from 89% at 2 months to 73% at 13–24 months) than by GPs (74% at 2 months to 53% and 13–24 months) and decreased with age for both pediatricians and GPs (Fig. 3). The buttocks, although strictly not indicated in children, were used to a similar extent for each age, and this site was used more by GPs (28–32%) than by pediatricians (8–9%). The use of the deltoid increased with age to a similar extent for both pediatricians (3% at 2 months to 30% at 13–24 months) and GPs (3% at 2 months to 33% at 13–24 months).

### Vaccination process/environment and risk of errors

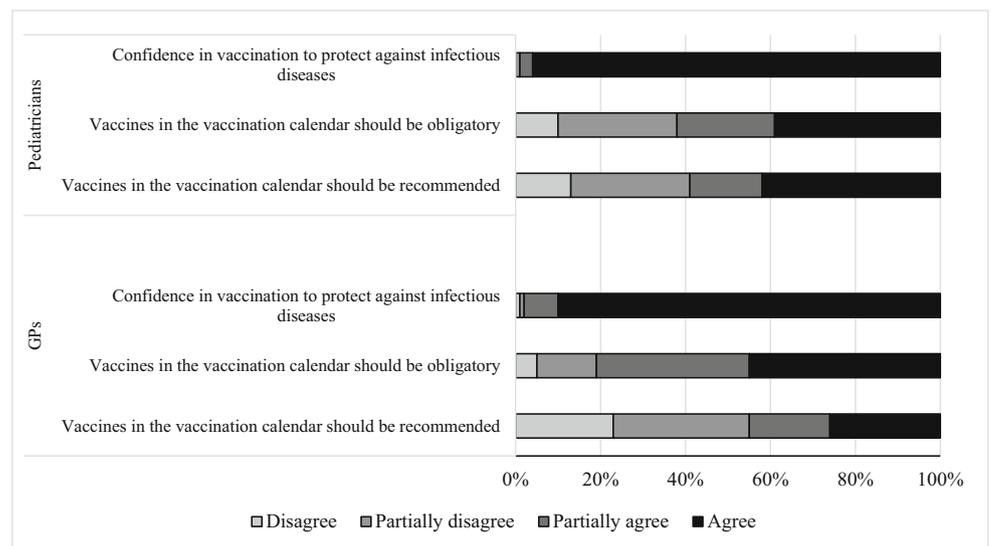
The general ambience during the vaccination consultation was considered to be very important or extremely important by most pediatricians (87%) and GPs (87%) for primary series and infant booster vaccinations (Fig. 4a). Overall, both pediatricians (46%) and GPs (49%) reported that the vaccination

**Fig. 1** Knowledge and opinion of vaccination recommendations. **a** Knowledge of vaccination recommendations. **b** Opinion of vaccination recommendations

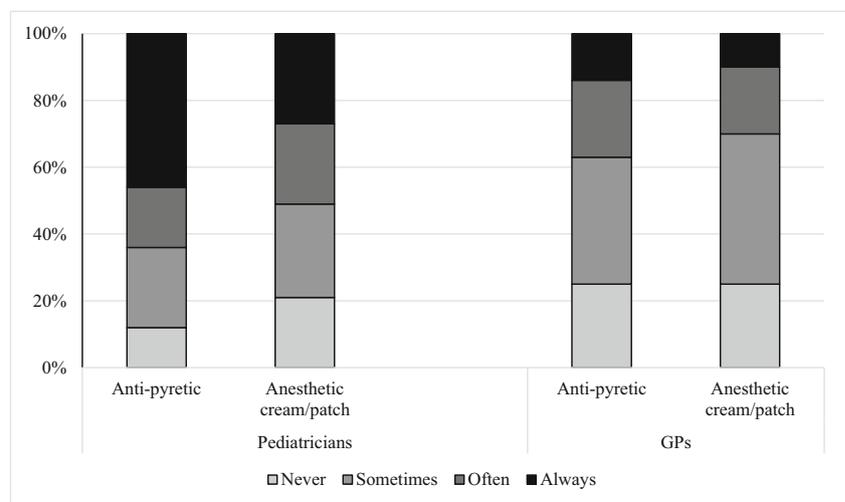
**a Knowledge of vaccination recommendations**

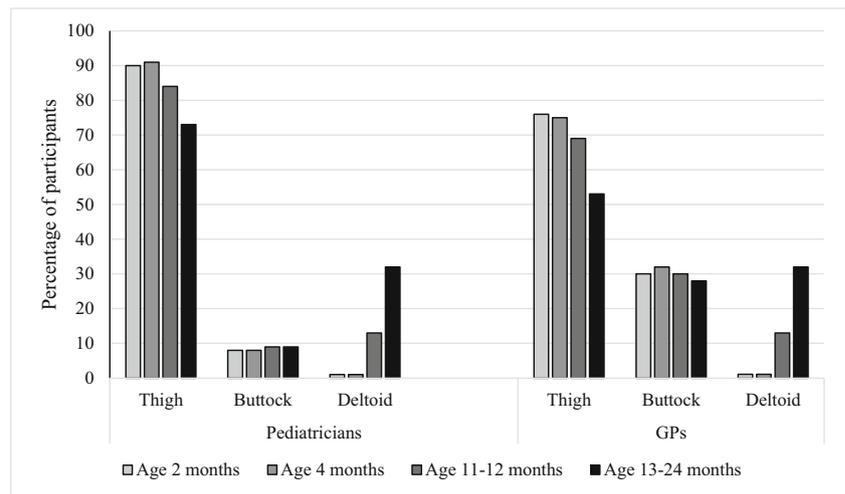


**b Opinion of vaccination recommendations**



**Fig. 2** Use of antipyretics and anesthetic cream/patch for primary vaccination



**Fig. 3** Vaccination sites used by age

Note: more than one site could be selected, so totals for an age range can exceed 100%

process is disturbed sometimes (e.g., interruptions due to the infant crying or the infant or parents becoming agitated), although 37% of pediatricians and 37% of GPs reported that the vaccination process such disturbances occur often or very often (Fig. 4b). To counter such disturbances, most participants (54–91%) used one or more means of distraction at each primary series or infant booster vaccination (Fig. 4c), with this being more common for pediatricians (79–91%) than GPs (54–77%). This was most commonly ( $\geq 85\%$ ) by the parent(s) holding or talking to the child, and toys or dummies were also used often.

Regarding the opinions of pediatricians and GPs on vaccine reconstitution (Fig. 5), pediatricians were more aware than GPs of the potential complications and increased possibility of errors introduced by the necessity to reconstitute a vaccine immediately prior to administration. A total of 70% of pediatricians agreed that the reconstitution of a vaccine is a complicating factor (57% for GPs), and 64% of pediatricians agreed that the steps involved in the reconstitution introduce a risk of error (48% for GPs). Both pediatricians and GPs agreed that vaccine reconstitution allowed more time to talk to and/or distract the infant but also that the reconstitution steps represented time lost that could have been spent with the infant and/or the parent(s). Overall, 28% of participants reported that the omission of reconstitution of a pentavalent or hexavalent vaccine with the separate Hib pellet had previously occurred in their practice, 31% of participants reported that accidentally touching the sterile part of the syringe used for the reconstitution or injection had occurred in their practice, and 60% of participants reported incomplete reconstitution of the Hib pellet. A total of 93%, 80%, and 64% of participants considered such errors of manipulation in each of these respective steps of vaccine reconstitution to be of importance in the vaccination process.

## Discussion

A large number of pediatricians and GPs participated in the survey (over 350 participants in total), with good representation from all regions of France. As such, these results can be considered to be fairly representative of pediatric vaccination practice throughout France.

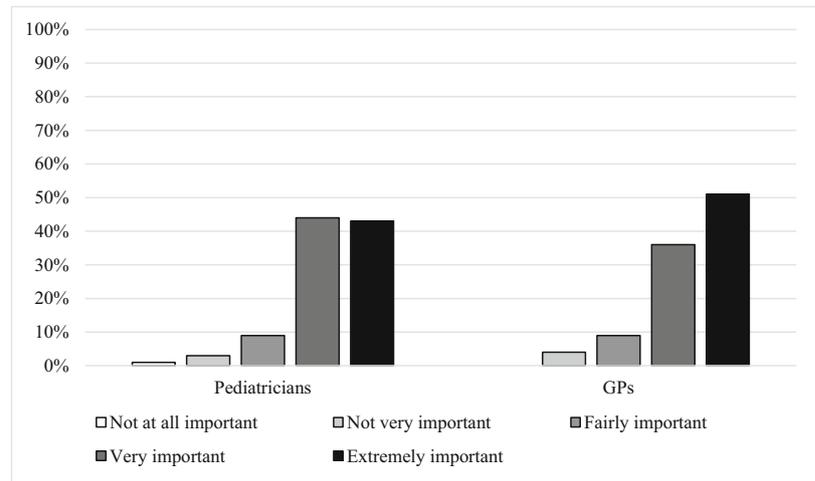
Most participants in each group relied mainly on the medical literature for their information, with the internet being used much less in this respect. There was a good level of knowledge of vaccination recommendations and good acceptance of the importance and utility of vaccines in general that was similar for both pediatricians and GPs. However, a recent survey in France showed that although vaccination levels had increased in 2016 from a low point in 2010, vaccine coverage has not yet recovered to the levels of over 90% that were attained at the end of the 1990s [14].

Most pediatricians and GPs agreed that the administration of recommended vaccines should be obligatory, and public health data suggest that if vaccination is not obligatory, 13% of parents are unlikely to have their children vaccinated [14], suggesting that more obligatory vaccination would be accepted by healthcare professionals and would favor better coverage. Since the time of this survey, 11 pediatric vaccinations became obligatory in France from 2018 (diphtheria, tetanus, polio, pertussis, measles, mumps; rubella, hepatitis B, influenza, pneumonia, and meningitis C), a decision that reflects the views of both pediatricians and GPs observed in this survey and also supported by 200 senior doctors in France [1].

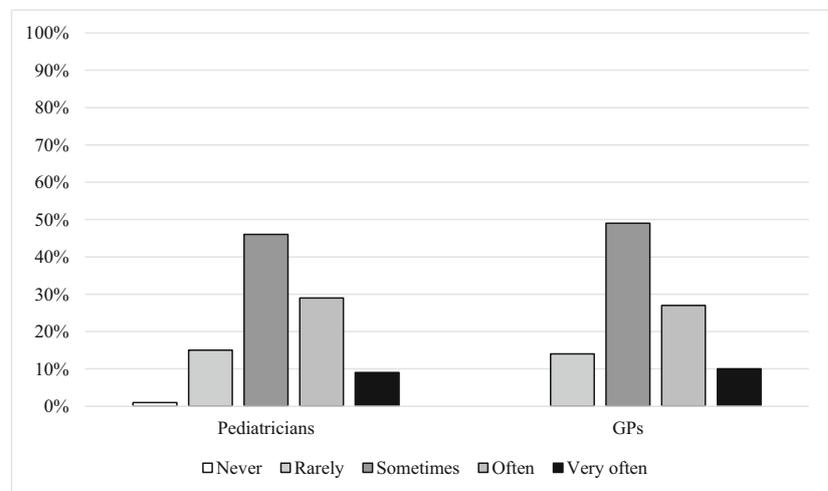
The significantly better knowledge by pediatricians of the prevalence of infectious diseases in France and of vaccines currently available and in development may reflect their increased specialization in this area compared to GPs. Perhaps related to this is the higher rate of vaccine prescription by pediatricians, e.g., rotavirus and chicken pox vaccines,

**Fig. 4** Importance of general ambience, frequency with which the vaccination process is disturbed, and use of distractions for primary series and infant booster vaccinations. **a** Importance of general ambience. **b** Frequency of disturbance. **c** Incidence of the use of  $\geq 1$  means of distraction by age

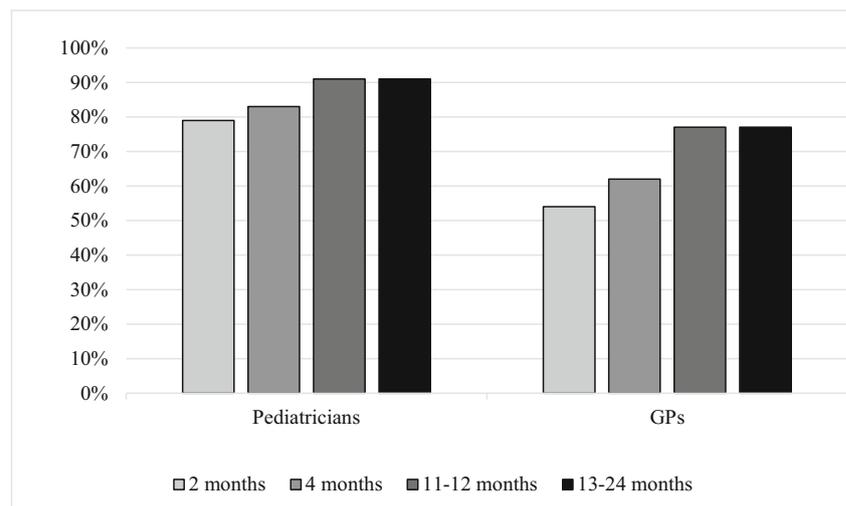
#### a Importance of general ambience



#### b Frequency of disturbance

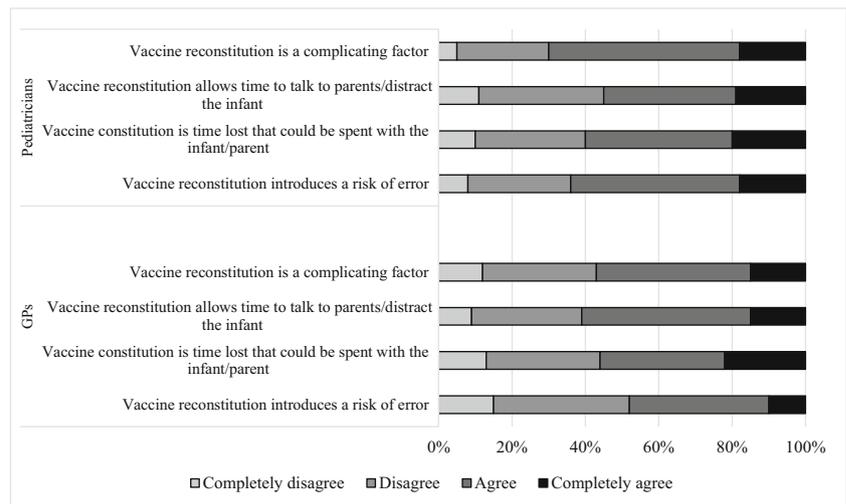


#### c Incidence of the use of $\geq 1$ means of distraction by age



although the high level of prescription of hexavalent vaccines was similar for pediatricians and GPs.

In a recent systematic review, prophylactic anti-pyretics have been shown to be effective in reducing febrile reactions

**Fig. 5** Opinions on vaccine reconstitution

post-vaccination in children [4]. In the present study these were administered frequently prior to vaccination, particularly by pediatricians, which may be related to a better knowledge of the relevant medical literature as well as a wider clinical experience in pediatric vaccination. Similarly, anesthetic cream/patch was used frequently, and the use of such products is considered to be effective in reducing vaccination-related distress in infants [15, 16].

For primary series and booster vaccination, the thigh, due to its greater muscle mass, was the most commonly used site of vaccination by both pediatricians and GPs. This practice reflects Advisory Committee on Immunization Practices guidance [8]. However, a larger number of GPs than pediatricians still used the buttocks for vaccine administration, which is not advised for infants and toddlers but can be used in certain circumstances [8].

Most pediatricians and GPs considered the general ambience to be very or extremely important for the vaccination to proceed without interruption and to minimize distress to the child. With disturbance during the vaccination process being common, most pediatricians and GPs favored interventions such as holding or talking to the infant, or using toys for distraction, to facilitate the process.

A very important aspect of good vaccination practices is the correct reconstitution of combination vaccines. Such errors do happen [6] and more pediatricians are aware of the risks involved in vaccine reconstitution in terms of complicating the vaccination process and introducing the risk of an error in the composition of the vaccine to be administered. Furthermore, reconstitution has been shown to double the time needed for vaccination compared to using a fully liquid vaccine [5]. Importantly, a marked number of participants reported having already experienced in their practice either omission to reconstitute, or not fully reconstituting the Hib pellet of pentavalent and hexavalent vaccines, or having accidentally touched the sterile part of the syringe during the reconstitution process. Most participants recognized each of these events as important errors. These reconstitution errors are

of significant concern in the context of the very large number of vaccinations now performed in the first 6 years of life, as described earlier. However, encouragingly, most areas of good vaccination practice were reflected in the real-life situation described in this study for both pediatricians and GPs.

The results of this survey showed overall good compliance to good vaccination practices. The use of fully liquid vaccines, if available, eliminates the numerous problems associated with vaccine reconstitution, and significantly improves and simplifies the vaccination process. Their wider use therefore would be an important step to ensuring optimal levels of coverage for each antigen.

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**Authors' contributions** PK acted as coordinators for the study participants and were involved in the design of the survey, data collection, data interpretation, and review and approval of the manuscript.

BV acted as coordinators for the study participants and were involved in the design of the survey, data collection, data interpretation, and review and approval of the manuscript.

CB was involved in the design of the survey, data interpretation, and review and approval of the manuscript.

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## Compliance with ethical standards

**Conflict of interest** PB and BV are members of some advisory groups on vaccination practices; invited participant to medical congresses by Sanofi and Merck Sharp & Dohme; and invited participant to continuing medical education congresses and symposia by Pfizer, GlaxoSmithKline, Sanofi, and Merck Sharp & Dohme. CB is an employee of IFOP, a polling and market research institute that conducts projects on behalf of various stakeholders, including life science companies. This particular project was funded by Sanofi Pasteur.

**Informed consent** Informed consent is not applicable as patients were not included in the study, which was a survey of general practitioners and pediatricians.

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