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Global assessment of national mandatory vaccination policies and consequences of non-compliance

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Abstract

Background: Declining vaccination coverage and increasing hesitancy is a worldwide concern. Many countries have implemented mandatory vaccination policies to promote vaccination. However, mandatory vaccination policies differ significantly by country. Beyond case studies, no comprehensive study has compared these policies or the penalties for non-compliance on a global scale.

Methods: We conducted extensive keyword, policy, and literature searches to identify mandatory national vaccination policies globally and develop a comprehensive database. A mandatory national vaccination policy was defined as a policy from a national authority that requires

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Katie Gravagna: Conceptualization, Investigation, Data curation, Validation, Formal analysis, Writing - original draft, Writing - review & editing, Funding acquisition. **Andy Becker:** Data curation, Formal analysis, Visualization, Writing - review & editing.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2020.09.063>.

individuals to receive at least one vaccination based on age or to access a service. Two reviewers independently evaluated evidence for a mandate and whether non-compliance penalties were incorporated. We categorized penalties into four types, based on the nature of the penalty. These penalties impact an individual's financial, parental rights, educational (i.e., child's school entry and access), and liberty status. We rated the severity within each category.

Results: Of 193 countries investigated, 54% (n = 105) had evidence of a nationwide mandate as of December 2018. The frequency, types, and severity of penalties varied widely across all regions. We found that 59% (n = 62) of countries with national mandates defined at least one penalty for non-compliance with a vaccine mandate. Among those, educational penalties (i.e., limiting a child's entry or ongoing access to school) were the most common (69%; n = 43), with most countries with educational penalties refusing school enrollment until vaccination requirements are met (81%; n = 35).

Conclusion: We undertook a comprehensive assessment of national mandatory vaccination policies and identified a diversity of penalties in place to promote compliance. Our results highlight the need to critically evaluate the implementation of non-compliance penalties in order to determine their effectiveness and to define best practices for sustaining high vaccination uptake worldwide.

Keywords

Vaccines; Vaccination; Policy; Mandatory; Penalties; Compliance; Vaccine hesitancy

1. Introduction

Vaccination programs are one of the most successful and cost-effective public health interventions ever developed. Vaccination against four diseases (diphtheria, tetanus, whooping cough, and measles) prevents an estimated two to three million deaths among children under five years of age worldwide each year [1]. In the United States, comparisons of case reports prior to national vaccination recommendations and in 2006 found cases declined 99% for diseases including diphtheria, measles, and rubella [2]. Similarly, in Italy, more than 4 million cases of vaccine-preventable diseases may have been prevented by the implementation of vaccination programs between 1900 and 2015 [3]. While vaccines can currently prevent more than 26 diseases, an estimated one and a half million children still die of vaccine-preventable diseases each year, and many millions of individuals of all ages suffer significant morbidity [1,4]. Achieving and maintaining high vaccination coverage in diverse settings is an important public health priority.

However, previous evidence has indicated that perceptions that vaccines are of low importance, as well as concerns about vaccine safety, vaccine effectiveness, and the perceived religious compatibility of vaccination, are some of the most common reasons for vaccine hesitancy and refusal globally [5]. The increasing proportion of vaccine-hesitant individuals who refuse or delay vaccination for themselves and their children creates challenges for communities and countries aiming to prevent and reduce the burden of vaccine-preventable diseases. It also creates challenges at the global scale as efforts to

prevent disease outbreaks from spreading across borders rely heavily on high vaccination coverage.

Despite concerns about vaccine hesitancy, vaccines and vaccination programs have significantly reduced the morbidity and mortality caused by infectious diseases. For example in the U.S. alone, over the past century, vaccines against seven previously common childhood diseases have prevented an estimated 103 million cases [6]. Given the global importance and impact of vaccines and vaccination programs and the significant challenge to public health prevention that the rise in vaccine hesitancy and refusal presents, the World Health Organization (WHO) named vaccine hesitancy as one of the top ten global health threats of 2019 [7].

Declining vaccination rates due to both hesitancy and access issues over the past several years have led to numerous outbreaks of vaccine-preventable diseases in both high-burden and low-burden settings, including outbreaks of deadly diseases such as measles and pertussis [8,9]. A hallmark of many of these outbreaks is that the cases consist of a substantial proportion of unvaccinated or under-vaccinated individuals. For example, an analysis of five recent pertussis outbreaks in the U.S. found that an estimated 24–45% of cases had not been fully vaccinated according to recommended schedules [9].

An individual's decision to be vaccinated has important community-wide implications. Many vaccines benefit individuals directly by reducing the risk of disease, and benefit communities indirectly by reducing the risk of transmission and outbreaks. In addition, some individuals cannot be vaccinated (often due to other health conditions that make them vulnerable to infectious disease), and must rely on the indirect benefits of vaccination. Therefore, maintaining high vaccination coverage is critically important. National authorities have adopted a variety of strategies to promote and maintain vaccination coverage among their populations, including but not limited to mandatory vaccination.

Mandatory vaccination policies, whereby individuals either in totality or as part of designated groups are legally required to be vaccinated or have their children vaccinated, are one strategy that has been implemented in multiple countries and sub-national jurisdictions both routinely and during the course of public health emergencies [10,11]. Historically, numerous policies designed for the public good have been incentivized or disincentivized in order to increase compliance [12]. In the case of mandatory vaccination policies, many countries have included in their policy documentation provisions for levying penalties against those who do not comply. Case studies have indicated that these disincentives span a wide range of one-time and ongoing penalties of varying degrees of severity, including denial of educational enrollment, fines, jail time, and loss of parental rights [13].

Recently, comparative analyses have begun to examine the prevalence and variability of mandatory vaccination policies, though the focus has primarily been on European countries [11,13]. Yet, no comprehensive global review of mandatory vaccination policies has been undertaken. Furthermore, no systematic evaluation and assessment of the nature and degree of penalties for non-compliance with mandatory vaccination policies has been conducted. Research across other policy fields has highlighted the importance of evaluating whether

a policy exists, how those policies vary across jurisdictions in ways that can substantially influence effectiveness, and how policies and related penalties aim to maintain compliance.

In this study, we conducted a global country-by-country assessment to address these gaps in describing and categorizing existing national-level mandatory vaccination policies. Specifically, we aimed to: (1) identify, on a global scale, which countries have enacted national-level mandatory vaccination policies and (2) assess and categorize the defined penalties for non-compliance described as part of these mandatory vaccination policies. Our study is the first step towards a global assessment of the effectiveness of mandatory vaccination policies and the diversity of approaches that national authorities use to ensure compliance.

2. Methods

2.1. Defining national mandatory vaccination policies

Mandatory vaccination policies vary significantly with respect to many factors including which individuals are required to comply under the guidelines of the policy, what the policy encompasses, how the policy is implemented, how the requirements of the policy are enforced and by whom, and what penalties apply to those who fail to comply with the policy. In this study, we defined a national mandatory vaccination policy as a policy that meets the following criteria: (1) a policy established by a national authority that requires that eligible individuals, including all or some subgroup of those over whom the authority has jurisdiction, receive at least one vaccination and (2) a policy that establishes a requirement that an individual be vaccinated based on the age of the individual, their status in school or enrollment in educational services, or their eligibility to access societal or governmental benefits. We used this definition to define national mandatory vaccination policies broadly and capture as many as possible.

2.2. Identification of national mandatory vaccination policies

No comprehensive, global database of national mandatory vaccination policies exists at present. Therefore, we undertook extensive efforts over an approximately two-year time period to both identify and to verify the existence of national mandatory vaccination policies for all countries by conducting research using multiple search strategies and using multiple sources of information. Beginning with the list of countries identified as having at least one mandatory childhood vaccination according to the 2010 Vaccine European New Integrated Collaboration Effort (VENICE) study survey and then expanding to all UN-member countries (in total 193 countries), we conducted online searches following a detailed process, as shown in Fig. 1, to obtain the most comprehensive, publicly available information as possible describing each country's vaccination policy and whether it included a national mandate.

Our primary aim was to identify which countries had national mandatory vaccination policies. We classified a country as having evidence of a national vaccination policy if an official mandatory vaccination policy legal document was obtained (which we defined as the gold standard for identifying the existence of a policy) or if detailed information about

the policy was obtained from a reputable source such as a nationally- or internationally-recognized organization. In order to confirm whether a country had a national mandatory vaccination policy in place, a primary reviewer determined the mandate status of each country based on the comprehensive information obtained via the searches described in Fig. 1. If the existence of a mandate was unclear or uncertain or if the evidence suggested that a mandate existed but no specific information about the policy itself could be obtained, an independent second reviewer repeated the search process to identify additional evidence and determine whether a policy existed. All countries were assigned to one of three categories: (1) no evidence of a national mandatory vaccination policy was obtained, (2) evidence of a national mandatory vaccination policy was confirmed but with limited information about the policy itself, or (3) evidence of a national mandatory vaccination policy was confirmed and with detailed information about the policy itself. In order to ensure that our determinations about the existence of a national vaccination policy were as robust as possible, both primary and secondary reviewers reviewed all of the data collected for all countries with mandates, conducted additional searches, and ensured that the identification and categorization of the status of the national mandatory vaccination policy were well-documented and reproducible. All discrepancies between reviewers were reviewed again and adjudicated.

Our secondary aim was to identify whether penalties were described for non-compliance with the policy in countries with documentation of a national mandatory vaccination policy and, if so, the nature, extent, and degree of severity of the penalties described. To do this, we undertook the same process detailed above and shown in Fig. 1. A primary reviewer implemented the process described in Fig. 1 to identify and categorize all evidence about penalties obtained including the type and degree of the penalty described. A secondary reviewer independently assessed the information obtained for each country and conducted additional research to also categorize the type and degree of penalties imposed, if any. Both the primary and secondary reviewers determined the categorization of penalties independently and in a blinded fashion. These categorizations were compared and all differences adjudicated.

We developed a database (see supplementary files) identifying, categorizing, and assessing the components of each national mandatory vaccination policy and the corresponding penalties identified. The database contained data for each country, including: (1) whether a national mandatory vaccination policy has been enacted, and (2) what type(s) of penalties for non-compliance with the policy had been described. We focused this analysis on national policies only. Only those countries with national policies (i.e. mandates that apply to the entire country) are included in our analysis of national mandatory vaccination policies. Due to the complexity of individual categorization and the unclear legislative impact, reviewing sub-national, regional, state-level or other mandates was beyond the scope of our research; countries without national mandates are categorized as not having a national mandate, even if all or some sub-regions within the country have implemented individual mandates. For example, individual US states each have their own mandates, but there is no mandate at the national level to qualify this country for inclusion in our study. Policy components related to mandate enforcement, such as types of exemptions or regulatory bodies, were also outside the scope of this study. The database was initially created using Microsoft Excel and

all database management and analyses were undertaken and visualizations created using R (version 3.5.1).

2.3. Analysis of national mandatory vaccination policy penalties

For each country with a national mandatory vaccination policy and evidence of at least one penalty for non-compliance, we assessed the type and severity of the penalty that was described and we compared and contrasted the nature and severity of these penalties within and between countries to understand the range of approaches countries are using to deter non-compliance. We categorized penalties into four types: (1) financial penalties (those designed to impact an individual's finances, i.e. fines), (2) parental rights penalties (those designed to impact parental status, referring to children under parental legal care, i.e., loss of custody), (3) educational penalties (those designed to impact a child's access to education, e.g. denial of enrollment), and (4) liberty penalties (those designed to impact an individual's freedom, i.e. jail time). Within each of these types, we then classified each penalty based on the severity of the penalty imposed, as shown in Fig. 2. As noted above, the assessments of two independent reviewers for each penalty were compared for concordance. After the primary and secondary reviewer comparison, there were 20 discrepancies identified among countries with educational penalties, 11 discrepancies identified among countries with financial penalties, one discrepancy among countries with liberty penalties, and no discrepancies among countries with parental penalties. All discrepancies between reviewers were adjudicated and a final penalty classification reflecting the degree of severity of the penalty imposed was assigned.

3. Results

We identified 105 (54%) out of a total of 193 countries that had evidence of a national vaccination mandate requiring at least one vaccine as of December 2018: 35 in Asia, 29 in the Americas, 23 in Europe, 11 in Africa, and 7 in Oceania. Thus, for 88 countries (46%) we found no evidence of a national mandate based on publicly available information to which we had access.

Fig. 3 shows that 62 (59%) countries were determined by the available data both to have robust evidence of a national mandatory vaccination policy and to have robust evidence that allowed us to identify at least one type of penalty; 34 (32%) had evidence of a national mandate but no penalties were identified out of the 105 countries with evidence of a national mandate. In addition, nine countries (9%) had evidence of a national mandatory vaccination policy but no additional information about penalties was identified. In the comparisons of penalty types, all 105 countries with national mandates are included; those with "no additional information" and those with "no penalty identified" are categorized together as having "no evidence of a penalty" available.

Of the countries with evidence of a national mandate ($n = 105$), the distribution globally and by region of the 59% ($n = 62$) that specified at least one type of penalty for non-compliance is shown in Figs. 4 and 5, respectively. Of these countries, educational penalties were the most common, found in 69% ($n = 43$) of countries with at least one penalty type. Fifty-two

percent (n = 32) had financial penalties, 19% (n = 12) had penalties that resulted in loss of liberty, and 2% (n = 1) had a penalty that resulted in loss of parental rights (Fig. 5).

3.1. Financial penalties

Of the 32 countries with financial penalties (Fig. 5a), 53% (n = 17) specified a one-time fine of less than 1000 USD, while 25% (n = 8) specified a one-time fine of at least 1000 USD. Repeated fines were less common with only 16% (n = 5) specifying a repeating fine of less than 1000 USD, and only 6% (n = 2) specified a repeating fine of at least 1000 USD.

3.2. Parental penalties

One country (Italy) described a penalty that potentially results in loss of parental rights (Fig. 5b). For this country, procedures are in place for parents to temporarily lose custody during parental evaluation following non-compliance with the mandate.

3.3. Educational penalties

Of the 43 countries with educational penalties (Fig. 5c), routine grounds for enrollment refusal or enforced absences were the most common subtype (81% (n = 35) of countries with educational penalties imposed it), making routine enrollment refusal or enforced absences the most common penalty subtype overall. Five percent (n = 2) used educational penalties situationally only. Situational penalties refer to penalties that are only implemented in certain contexts, such as during an outbreak. In addition to these subtypes of penalties affecting education, 6 additional countries recorded documentation of vaccination status, but did not indicate the implications for no documented vaccination status.

3.4. Liberty penalties

Of the 12 countries that had penalties that entailed loss of liberty (Fig. 5d), 58% (n = 7) had immediate jail time of less than six months, 17% (n = 2) had waived jail time of less than six months, 8% (n = 1) had waived jail time of at least six months, and 17% (n = 2) had immediate jail time of at least six months.

3.5. Regional variation

Within each geographic region, we observed significant variation between continents and regions and country-by-country within regions (Fig. 5). European countries use financial penalties more frequently than any other region (56% of European countries with evidence of a national mandate). Additionally, Italy is the only country to list temporary loss of child custody as a penalty for non-compliance.

At least a third of countries with national mandates in all regions include at least one type of educational penalty, though these types of penalties are most prevalent in the Americas. The prevalence of countries with other penalty subcategories varies widely. Asia is the only region where countries have implemented a national policy with situational educational penalties (such as barring unvaccinated children from attending school during an outbreak). Grounds for routine enrollment refusal as a penalty for lack of vaccination is much less common than routine automatic enforced absences, which are used to address non-compliance by at least one country in all regions of the world. Penalties that entail

loss of liberty were only described in 12 countries, and they are most common in Africa, with three of the countries with liberty penalties (25%) allowing waived jail time and an opportunity to comply before penalties are imposed. However, immediate jail time is used as a penalty for non-compliance by at least one country in all regions, with countries in Asia and the Americas having policies that describe the longest sentences imposed immediately. Penalty category and subcategory severity for each country with a national mandate is given in Figs. S1–S5.

Of the 105 countries with evidence of a national mandate, 41 (39%) described only one type of penalty for non-compliance with the mandate. Of the 21 (20%) countries with two or more types of penalties, all implemented financial penalties as one of the penalty types. Among these 21 countries, 67% (n = 14) also included educational penalties, 52% (11) also included liberty penalties, and 5% (1) also included a parental penalty as well as a financial penalty.

4. Discussion

In our analysis, we found evidence that more than 100 countries around the world have national mandatory vaccination policies. The majority of countries with national mandatory vaccination policies specified at least one penalty associated with failing to comply with the policy and most of those only specified one type of penalty for failing to comply. The most severe and extreme penalties – loss of child custody for failure to vaccinate and loss of liberty – are relatively rare. In addition to the relatively common use of financial penalties, the high prevalence of educational penalties demonstrates the key role of educational systems both in reporting and supporting high vaccine uptake in diverse settings. Educational penalties for non-compliance with national mandates are both the most common type of penalty and the category with the highest proportion of the most-severe penalty subtype with many countries describing routine enrollment refusal or enforced absences as a consequence of non-compliance.

We limited our analysis to national mandatory vaccination policies and we found that national mandates are the norm in this global comparison. However, of note, there are multiple countries with robust regional mandates and several of these have generated substantial evidence about the effectiveness of the mandate on increasing vaccination rates. For example, the United States has no national mandate, but each state and the District of Columbia mandates one or more vaccines and state-based policies include a diversity of penalties for non-compliance related to school enrollment, though there is great variation in these policies and the penalties imposed state-to-state [14]. Similarly, while Nigeria has a national mandatory vaccination policy, the country also has extensive local variations that were not considered in our analysis since they did not meet the definition of a national policy [15]. Several countries, for example Canada, have multiple regional mandates with various requirements and penalties, though these mandates only apply to certain geographic regions of the country rather than to the country as a whole [16].

Despite the variation in the nature of national mandates implemented by different national authorities, evidence has suggested that penalties have increased vaccination uptake in some

cases. For example, in Europe, one study found that increases in the amount of monetary fines were associated with increases in vaccination [17,18]. In addition, this same study found that European countries that implemented a financial penalty had a lower incidence of measles and pertussis [17,18]. In the United States, state-based mandatory vaccination policies have been associated with maintaining high childhood vaccination rates despite the variation in the number of vaccines required and the availability of exemptions [19]. A further study identified an additional benefit of the mandates, which allow for the ability to estimate the number of vaccinated children through consistent school-based checks of vaccination records, which may lead to higher rates of vaccination [20].

However, mandates may also lead to distrust of authorities and fuel anti-vaccination sentiment [17]. Mandating vaccination for children of vaccine-hesitant parents can increase public outcry; the difficulty in mandating vaccination while moderating public response is that the majority of the population must already be willing to comply for mandates to be implemented successfully [12]. Concerns have been raised that mandates may further polarize opinions about vaccination and decrease support for vaccines [21,22]. After Serbia implemented stricter mandates following a measles outbreak without significant improvements in communication, the public response was increased anti-vaccination support, negative media coverage, and low confidence in the program [23].

An important consideration that complicated our assessment of national mandates and penalties and that will make efforts to assess mandate effectiveness globally more challenging is that national mandates are policies that are often changing and evolving. Italy in 2017 and France in 2018 both significantly broadened the scope of their mandates after measles outbreaks, adding 6 and 8 mandatory vaccines, respectively [24]. Additionally, following the March 2018 elections, the Italian government attempted to revise the mandate once more to allow vaccination self-certification again [25]. Italy and France also saw an increase in vaccination against diseases that were *not* mandatory. These countries also saw a corresponding decrease in vaccine hesitancy: the percentage of vaccine-hesitant parents dropped 4% in Italy in 2016. There was also a 17.3% decrease in those who disagreed that vaccines were safe in France from 2015 to 2018 [25,26]. France, in particular, is an interesting case study of modern vaccine mandate adoption because estimates suggest that it has had some of the highest rates of vaccine hesitancy worldwide for the last 5 years [27]. In France, the decision to use a more robust mandate was motivated by three factors: widespread vaccination uncertainty, the confusion that non-mandatory vaccines caused, and the infectious disease morbidity and mortality owing to low levels of vaccination [26].

While case studies can provide a very nuanced assessment of the impact of specific components of vaccine mandates, our assessment is intended to go beyond case studies and present a comprehensive overview of the diversity of strategies in use globally to ensure high vaccination coverage nation-wide. Countries face increasing challenges which makes determining the optimal policy for ensuring and maintaining high vaccine uptake difficult. Our analysis serves as a resource that describes the breadth of approaches currently in use with respect to their penalties for non-compliance.

While vaccination mandates have many benefits, they can also exacerbate inequalities, as penalties (such as financial repercussions for non-compliance) may disproportionately affect disadvantaged groups. After Australia passed the No Jab, No Pay and No Jab, No Play legislation, both economically disadvantaged and migrant families reported being negatively impacted, as vaccination-linked payments and inability to access childcare had a greater impact on lower-income families [23]. These families also cited barriers to vaccine access and difficulty updating vaccination registers to reflect immunization as primary reasons for lack of compliance, not vaccination hesitancy [23]. The use of penalties for non-compliance may be counter-productive in cases where they further prevent access to vaccination, especially among groups already facing barriers to vaccine access.

There are many reasons that an individual may not be in compliance with vaccination mandates. Vaccine hesitancy is not the only motivating force for non-vaccination in many contexts, in which barriers to access of vaccines play a significant role. For example, a study conducted in the rural district of Uganda, a country where non-compliance with the national vaccination mandate can be penalized by jail time, vaccine stock-outs are frequent, and transportation and language barriers make outreach campaigns difficult [28]. Access barriers in Zambia and Uganda were found to be the primary factors that influenced vaccination initiation, while issues of vaccine demand determined the ability of individuals to complete the series of recommended vaccinations [29]. Individuals may also be unaware of vaccination recommendations and requirements in their country. In a systematic overview of studies examining vaccination barriers in Europe, Oceania, and North America, information gaps including poor communication or lack of awareness of the vaccination schedule were also cited as reasons for non-vaccination [30]. Germany, which recently started requiring evidence of vaccination for school enrollment and may fine parents for failure to provide these records, has found lower rates of immunization among children who immigrated compared with children born in Germany [31]. Rigorous and comprehensive studies that can evaluate which aspects of vaccine mandates, if any, and which types of penalties, if any, are effective at increasing vaccination coverage in multiple contexts are needed.

Another important factor that may decrease mandate effectiveness is the prevalence of non-medical exemptions, which can provide a type of loophole to mandatory vaccination. In the U.S., states that made it easy to obtain non-medical exemptions had nearly twice the rate of non-medical exemptions than states that did not [32,33]. In addition, European countries with a vaccination mandate and no non-medical exemptions were found to have a lower incidence of measles [18]. However, when California (U.S.) removed non-medical exemptions, higher rates of medical exemptions followed, which appeared to indicate that parents had simply changed exemption types instead of deciding to vaccinate their children, which was the intended outcome [32]. Other regions and countries that have eliminated non-medical exemptions include Ontario (Canada), France, and Australia [34].

In our study, we undertook extensive and robust searches to assess the prevalence of national vaccination policies across every country of the world. However, our effort is limited in that complete information about the national vaccination policy of every country of the world may not necessarily be publicly available for review. Our primary limitations were that we

only reviewed documentation available online in English, Spanish, or French and that we were limited to information available electronically online, which was sometimes limited in scope, detail, completeness and/or contradictory. Whenever possible, we accessed primary source documents describing national mandates for a given country, but these were not routinely available for most countries. We used a robust process to verify the information obtained and to ensure that multiple, independent reviewers assessed the information for consistency; however, it is possible that the national mandatory vaccination policy information we report here is incomplete, contradicted by other sources, or has already changed. We conducted our research between September 2017 and December 2018; thus, mandates that came into effect after December 2018 were not included. The authors invite readers to contact them with information and references that could be used to update any of the categorizations presented here.

In addition, our study focused on identifying and categorizing national mandatory vaccination policies and related penalties. Further research is needed to assess implementation of policies, as well as the inclusion of specific policy components such as number of vaccines. Whether mandatory vaccination policies are effective and whether incentives or disincentives promote compliance is a major topic of debate. The degree of communication, financial support, and monitoring for compliance may vary across countries, as well. Furthermore, while potential penalties may be described within policies, how consistently those policies are applied in practice may also vary. Future studies are needed to determine which policy initiatives have the greatest impact on vaccination rates and whether penalties are an effective legislative lever. Conducting a future study of sub-national mandates on a global scale would provide an even more nuanced understanding of the methods that countries are using to improve vaccination rates. In addition, future studies should evaluate the implementation of vaccination incentives, in addition to penalties, to determine whether and to what degree incentivizing vaccination, or the combination of both incentivizing and disincentivizing, may lead to higher vaccination coverage and greater trust in vaccines. The evidence we have generated can be used to guide future research.

5. Conclusion

This study assessed current use of national mandatory vaccination policies and penalties for non-compliance across the world. This is the first step towards a global evaluation of the effectiveness of mandatory vaccination policies. Penalty-based national vaccination mandates have been enacted widely on a global scale. The high prevalence of educational and financial penalties highlights international efforts to prevent and control infectious disease outbreaks. Further research is needed to identify additional elements of these policies and these penalties and assess whether they contribute to increased vaccination uptake and confidence in vaccines.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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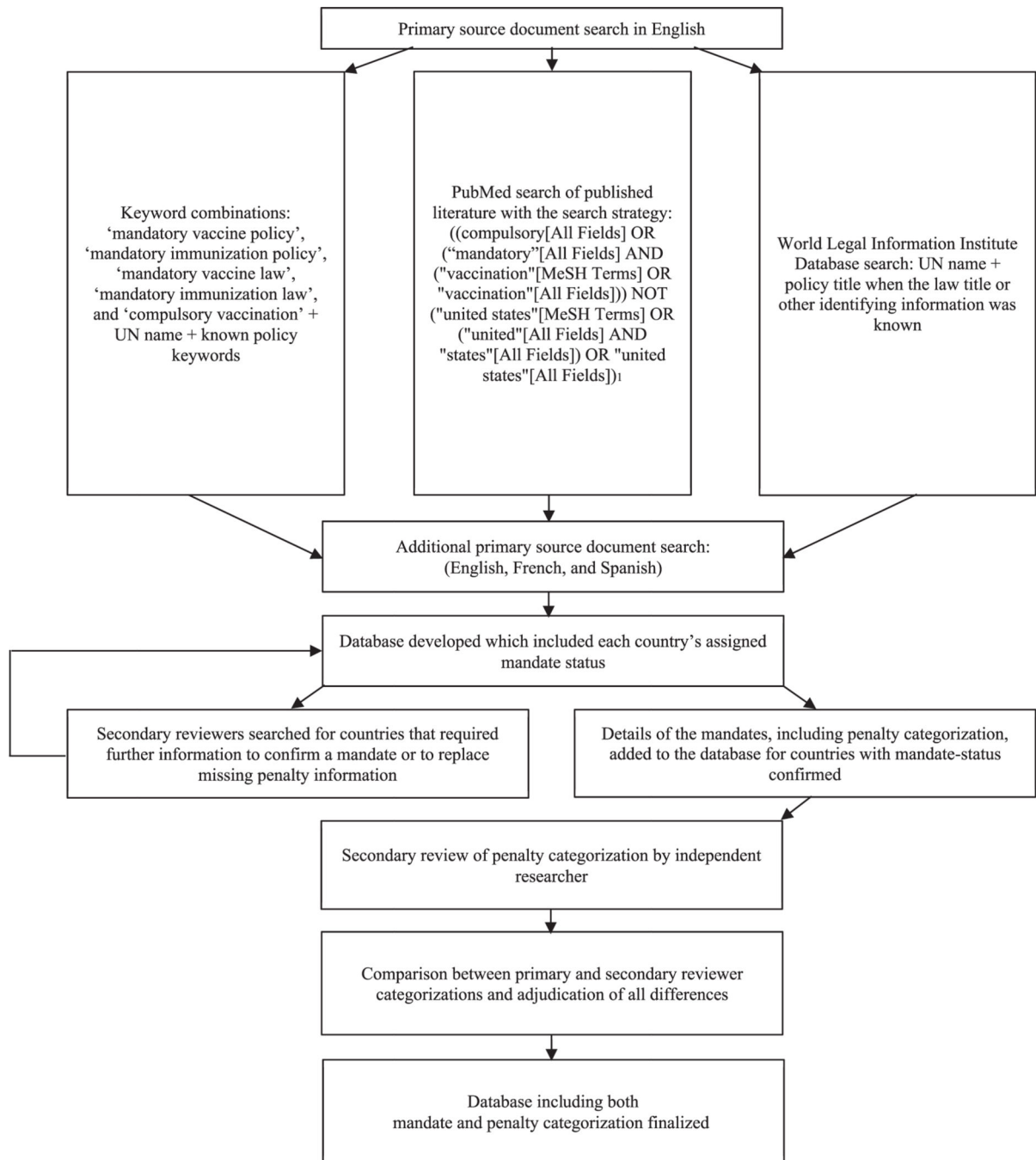


Fig. 1. Research process for identifying and categorizing national mandatory vaccination policies and associated penalties for non-compliance.

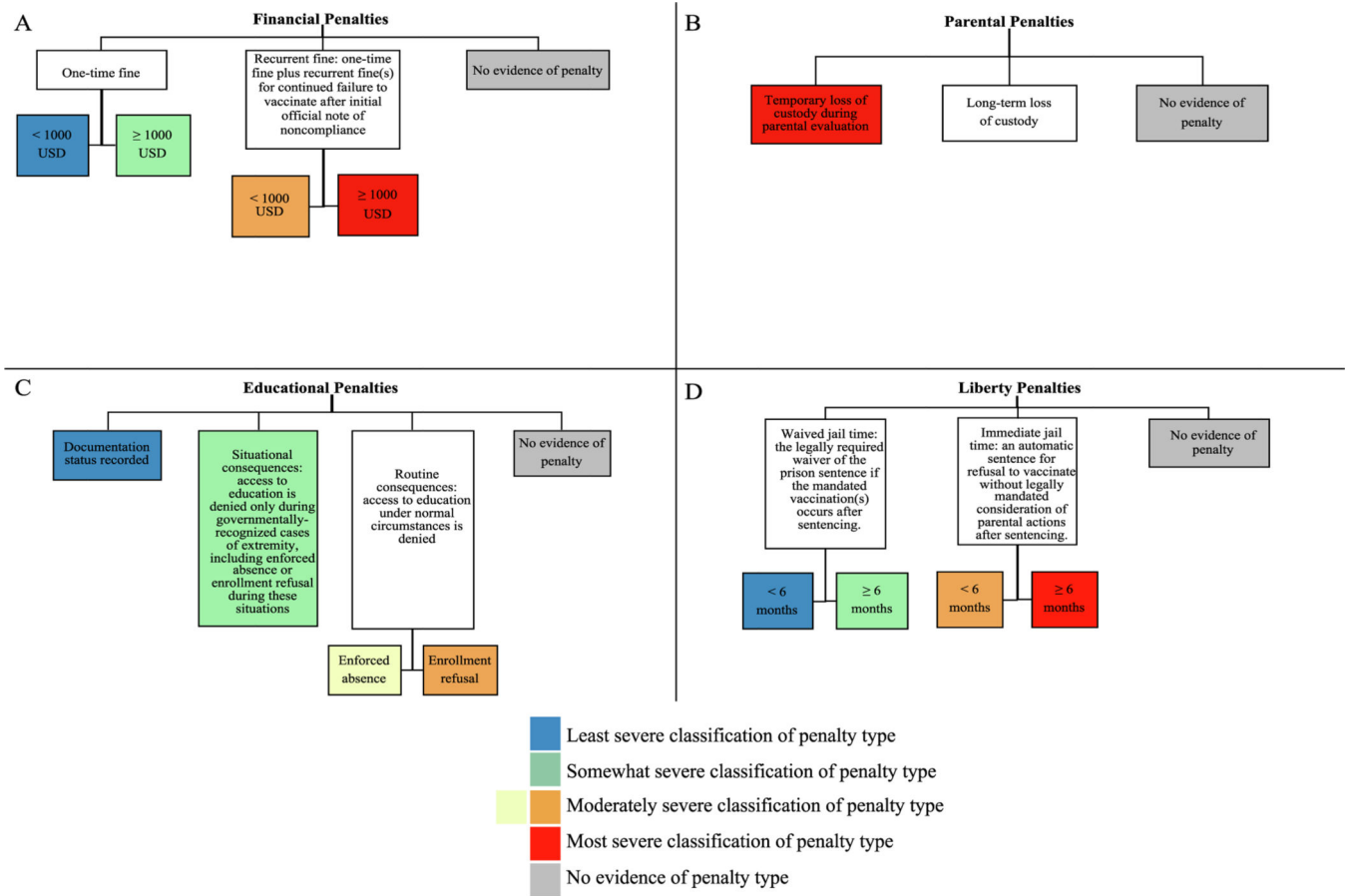


Fig. 2. Classification scheme used in this global analysis of national mandatory vaccination policies to categorize the severity of each penalty type for: (a) financial penalties; (b) parental penalties; (c) educational penalties; (d) liberty penalties.

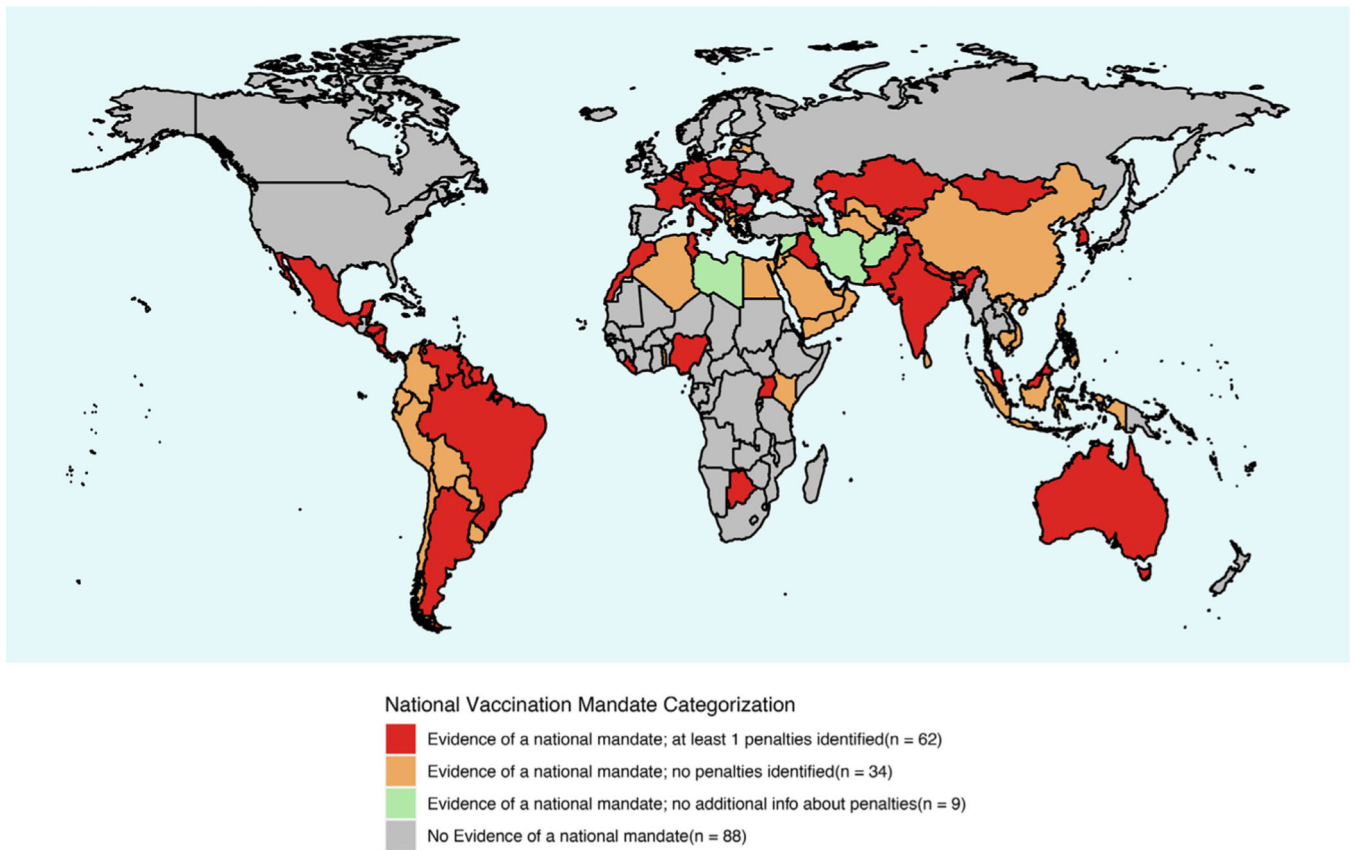


Fig. 3. Distribution of national mandatory vaccination policies globally, further categorized based on whether evidence was obtained that the policy includes penalties for non-compliance.

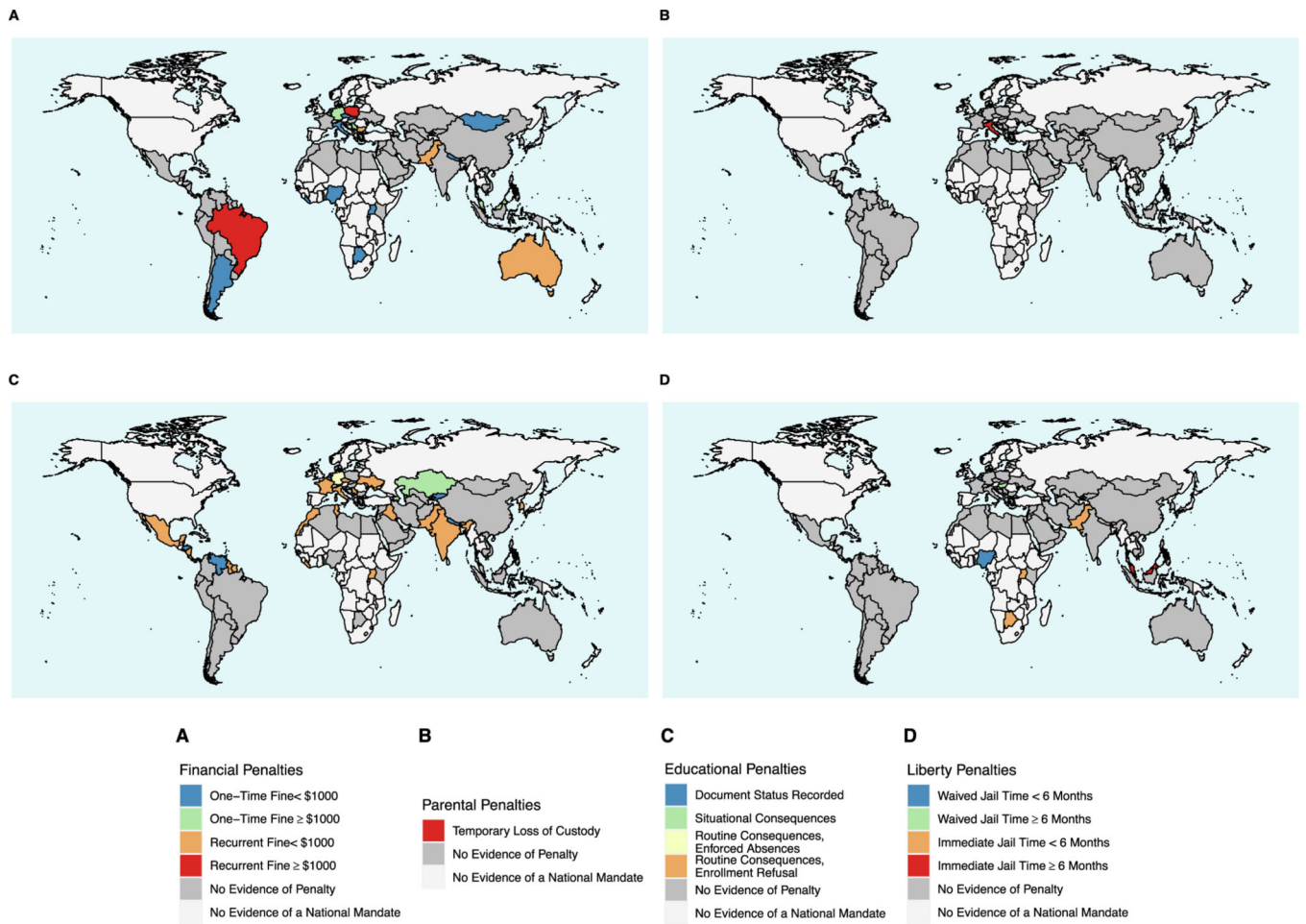


Fig. 4. Global distribution of the types of penalties in countries with national mandatory vaccination policies for: (a) financial penalties; (b) parental penalties; (c) educational penalties; (d) liberty penalties.

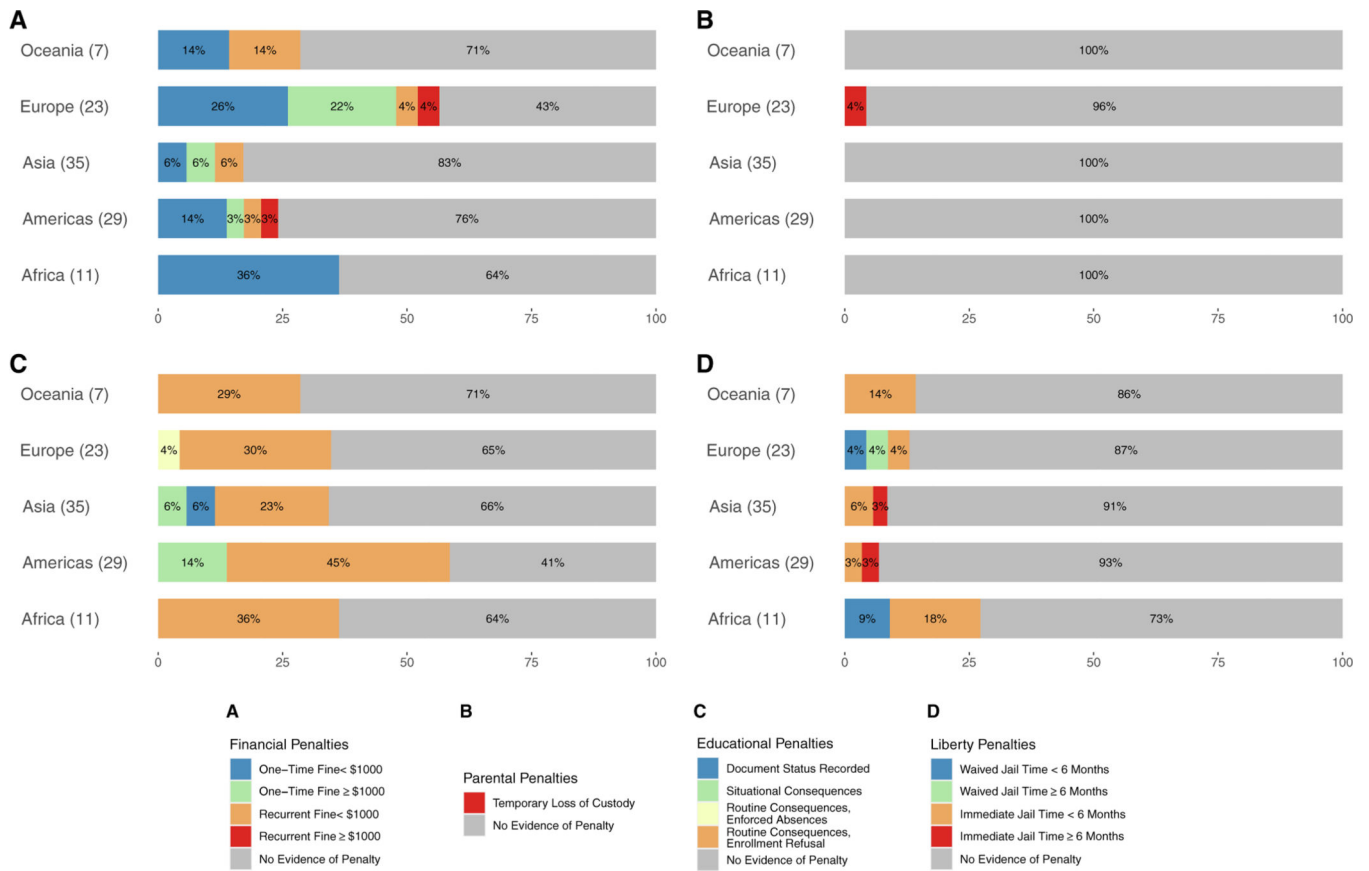


Fig. 5. Regional distribution of penalty types and severity within those types identified in countries with evidence of a national mandatory vaccination policy; (A) financial penalties; (B) parental penalties; (C) educational penalties; (D) liberty penalties.