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SHORT REPORT

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Development and preliminary data on the use of a mobile app specifically designed to increase community awareness of invasive pneumococcal disease and its prevention

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ABSTRACT

Given the growing use and great potential of mobile apps, this project aimed to develop and implement a user-friendly app to increase laypeople's knowledge and awareness of invasive pneumococcal disease (IPD). Despite the heavy burden of IPD, the documented low awareness of IPD among both laypeople and healthcare professionals and far from optimal pneumococcal vaccination coverage, no app specifically targeting IPD has been developed so far. The app was designed to be maximally functional and conceived in accordance with user-centered design. Its content, layout and usability were discussed and formally tested during several workshops that involved the principal stakeholders, including experts in IPD and information technology and potential end-users. Following several workshops, it was decided that, in order to make the app more interactive, its core should be a personal "checker" of the risk of contracting IPD and a user-friendly risk-communication strategy. The checker was populated with risk factors identified through both Italian and international official guidelines. Formal evaluation of the app revealed its good readability and usability properties. A sister web site with the same content was created to achieve higher population exposure. Seven months after being launched in a price- and registration-free modality, the app, named "Pneumo Rischio," averaged 20.9 new users/day and 1.3 sessions/user. The first in-field results suggest that "Pneumo Rischio" is a promising tool for increasing the population's awareness of IPD and its prevention through a user-friendly risk checker.

Invasive pneumococcal disease (IPD) refers to severe conditions occurring in the event of pneumococcal diffusion in normally sterile sites, such as cerebrospinal fluid or blood, and includes e.g. bacteremia, meningitis and bacteremic pneumonia. IPD carries a significant burden (especially in the elderly and specific risk groups): 20,785 cases were notified in 2012 in Europe – a notification rate of 5.2 per 100,000 inhabitants.[1] Furthermore, among vaccine-preventable bacterial infections, IPD has the highest mortality.[2]

Despite its heavy burden and the availability of safe and effective vaccines, pneumococcal vaccination coverage remains suboptimal in most industrialized countries.[2] A large European survey[3] has established that people's main reasons for not being vaccinated are lack of recommendation by general practitioners (GPs), scant awareness of vaccination availability and inadequate perception of the risk of contracting pneumococcal disease. Moreover, awareness of the disease is relatively low among medical doctors; indeed, only 50% and 71% of GPs and specialists, respectively, know the term "IPD."[3]

Today, the use of smartphones and mobile apps is increasingly common. The potential of apps is well-documented; for instance, they are able to provide information on disease-specific topics,[4] thereby raising community awareness. As yet, however, no app specifically targeting IPD has been developed. The objective of this project was to develop and implement a user-friendly mobile app to increase laypeople's knowledge, awareness and personal risk perception of IPD and motivate app users to request further information on IPD and its prevention from their doctors.

Development of the app involved several steps: after verification of the public health need for the app, its design, content and target group were conceptualized and established; pilot versions were created and formally tested; the final version was drawn up and launched, and its usage was assessed.

The need for an evidence-based online resource on IPD was evaluated from the perspective of supply-based infodemiology techniques[5] by assessing the prevalence of IPD information (by quantifying the absolute number of web pages on IPD and synonyms retrieved from www.google.it).

The app was designed to be maximally functional and simple to use. The design of the app was conceived in the fashion of a user-centered approach. Its content, layout and user-friendliness were discussed during several workshops held either face-to-face or via voice/video conferences. The team was composed

of the principal stakeholders, including experts in IPD and its prevention (DP, RG, PB, GI, DA, AB and SB), information technology (IT) (an IT company contracted to develop the app) and potential end-users (residents and technical staff of the Department of Health Sciences, University of Genoa).

The content of the app was drafted by IPD experts and reviewed by the whole research team. In order to make the app more interactive and introduce some concepts of gamification, it was decided that a simple checker on single risk factors should be adopted. Since the app was primarily intended for use in Italy, the 2012–2014 Italian National Vaccine Prevention Plan (NVPP)[6] was used as a reference document for the identification of risk factors. Additionally, other international guidelines were considered.[7]

The general adult population in Italy was set as the app target group.

Once reviewed, the content of the questionnaire was checked for text readability by means of the GulpEase index (ranging from 0 to 100; the higher the score, the better the readability), which is specific to the Italian language; appropriate text modifications were made if necessary. Following discussion of several on-paper drafts of the app and of stakeholders' comments, an app prototype was created. This underwent both expert- and user-based evaluation of its usability. The latter was assessed through the performance of 10 tasks and measured in terms of technical effectiveness (task completion outcome), and a relative user-efficiency score (average time taken to complete a task by end-users divided by the time taken by the app expert) was assigned, as reported by O'Malley et al.[8]

Google Analytics was used to quantify online data traffic and to determine users' characteristics and interaction with the app and the website. Users were aware of which data were collected and how these would be used (an extensive explanation of these issues was provided in the mandatory section on privacy policy).

Crude Google hits of the term "IPD" and its various synonyms and spellings yielded approximately 9,000 results, without taking duplicate web pages into account; this was well below the number of enquiries regarding other infectious diseases with lower incidence rates. The observed gap between the pool of information on IPD and its burden indicated the presence of information disparities[5] and is in line with the findings of previous research.[3]

The idea of incorporating a risk checker into the app was approved by all team members. The checker was populated with the following risk factors, identified through the NVPP: chronic cardiac, pulmonary (excluding asthma), renal and liver diseases, alcoholism, diabetes, hereditary hemoglobinopathies, asplenia, primary and secondary immuno-deficiencies, including iatrogenic ones, HIV/AIDS, hematological and non-hematological malignancies, and presence of a cochlear implant. Additionally, as the Centers for Disease Control and Prevention recommend[7] immunization with 23-valent pneumococcal vaccine for adult smokers and asthmatics, these 2 risk factors (current smoking and presence of asthma) were also included. In sum, the final version of the questionnaire consisted of 16 items; most of these were yes/no questions. One of the polar questions about cancer had an extension (in the case of affirmative response) concerning the type of malignancy, classified according to a 4-option item (leukemia, lymphoma, multiple myeloma and "any other type of cancer"). Another item, on

alcohol consumption, had an easily manageable scrollbar indicating the mean number of drinks consumed per week. Preliminary linguistic analysis of the checker raised several concerns and revealed a suboptimal readability level; several language modifications were therefore made in order to facilitate comprehension. In particular, highly technical terms and loanwords were avoided as much as possible and more difficult terms (such as drink, asplenia or cochlear implant) were defined. To prevent self-diagnosis, most questions were worded in the third person (e.g., "*Has your doctor ever told you…?*" rather than "*Do you suffer from…?*"). The final version of the questionnaire displayed good readability properties, the GulpEase index being 61.0, which means it would be easily understood by subjects with a middle-school education.

The overall risk of contracting IPD was categorized as low (healthy adults), medium (healthy elderly and immuno-competent subjects of any age with any chronic condition) and high [immuno-compromised (including any type of cancer, disorders of the blood forming organs, primary and secondary immuno-deficiencies) subjects of any age].[9] In order to facilitate comprehension, the final result was displayed on a graded scale ranging from yellow (low risk) to red (high risk). Risks concerning single conditions were also reported as supplementary information, which could be consulted. Possible combinations of single risk factors were not considered, owing to the lack of data. In sum, the final result was qualitative (risk category) rather than quantitative since no prediction formulas were applied. Once the checker had been completed, users were given the option of sending the results of the risk evaluation to their GPs via email.

Background referenced information on pneumococcus, IPD and risk factors was limited to essential information that IPD experts believed end-users needed to know. The text was edited several times following comments made during the workshops.

Consecutive reviews allowed us to identify and address several criticalities of the app prototype in terms of its usability. Navigation was improved by enlarging the main icons and simplifying the hierarchical structure of the menu, which was reduced to 2 navigation levels; necessary shortcuts were provided. Coherence of the gesture commands was ensured and easily intelligible symbols were assigned to all buttons. Click-sensitive areas were made more distinguishable by improving color contrast combinations; when a button was clicked, its background color changed. If erroneous data were entered or if data were missing, the user was immediately alerted by an error message. Once the above criticalities had been addressed, the second prototype was formally tested by both experts and potential end-users (N = 8, age 25–48 years). The computational algorithms were tested in order to detect any bugs. Technical effectiveness and relative efficiency were judged acceptable: all tasks were accomplished by all testers, with a mean relative user-efficiency score of 2.1 per task. Questionnaire completion time ranged from 2.5 to 4.5 min. A short video tutorial on the functioning of the app was also provided. During the last meeting, it was decided that the app should be available in the main app stores (Apple Store, Google Play and Windows Store) and that a sister website with the same functionalities should be created, in order to ensure maximum coverage.

The app "*Pneumo Rischio*" and the website www.pneumorischio.it have been publicly available to the adult population in
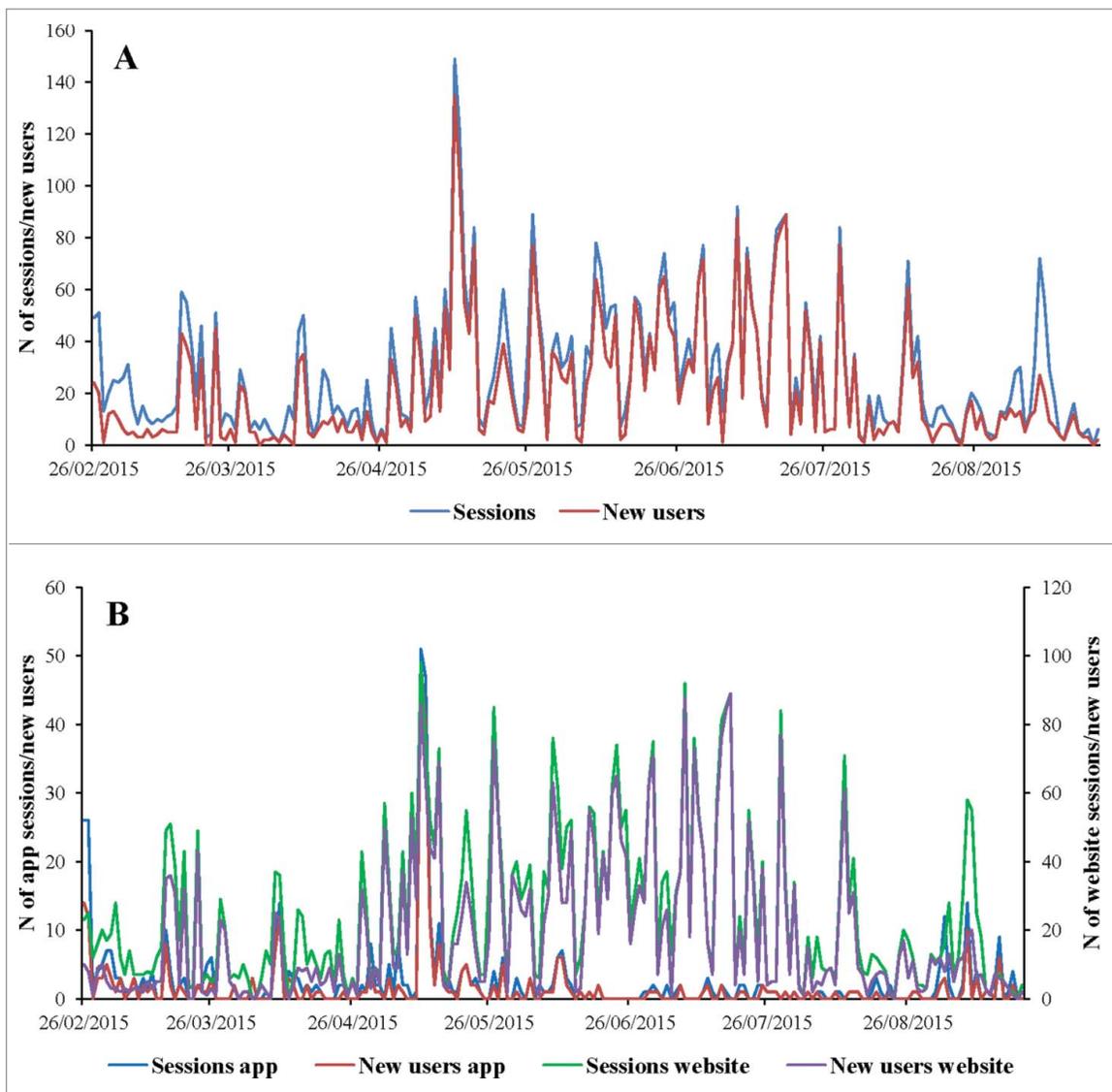
Figure 1. Time-series of daily number of new users and sessions of both app and website (A) and separate number of app and website new users and sessions (B).

a registration- and price-free modality since February 2015. The app's mandatory privacy policy complies with all aspects of local laws and recommendations. Approximately 7 months (207 days) after being launched, "*Pneumo Rischio*" (both app and website) had, on average, 20.9 new users/day and 1.3 sessions/new user (cumulative number). Most of these were website users (N = 3,994), while single downloads of the app accounted for 340. Notably, on average, mobile users engaged in more sessions (1.5 sessions/new user) than website users (1.3 sessions/new user); this difference was statistically significant ($p < .01$).

Figure 1A shows 2 time-series indicating the daily number of new users and sessions undertaken with regard to both the app and the website. As expected, the mean number of both parameters was significantly higher on working days than at weekends [new users: 23.5 vs 14.9, $t = 2.45$, $p = .015$; sessions: 31.3 vs 18.5, $t = 3.46$, $p < .001$]. This partially explains the saw-tooth pattern observed in both time-series. When the time-series of new users and sessions were further subdivided in terms of app and website use (Fig. 1B), only modest, though still statistically significant ($p \leq .001$), correlation

coefficients were recorded between app and website new users ($r = .27$) and between app and website sessions ($r = .26$). This could indicate different profiles of "*Pneumo Rischio*" users.

Demographic data were gathered from approximately 800 users and reported in Table 1. Female users prevailed significantly ($z = 8.70$, $p < .001$) over males. Most sessions were undertaken by 45–54- and 25–34-year-olds,

Table 1. Distribution of user sessions, by sex and age.

Parameter	Level	%
Sex[*]	Male	34.7
	Female	65.3
Age-class, years[**]	18–24	5.6
	25–34	29.5
	35–44	21.7
	45–54	30.1
	55–64	8.7
	≥65	4.4

Notes: [*]N = 809 [**]N = 793
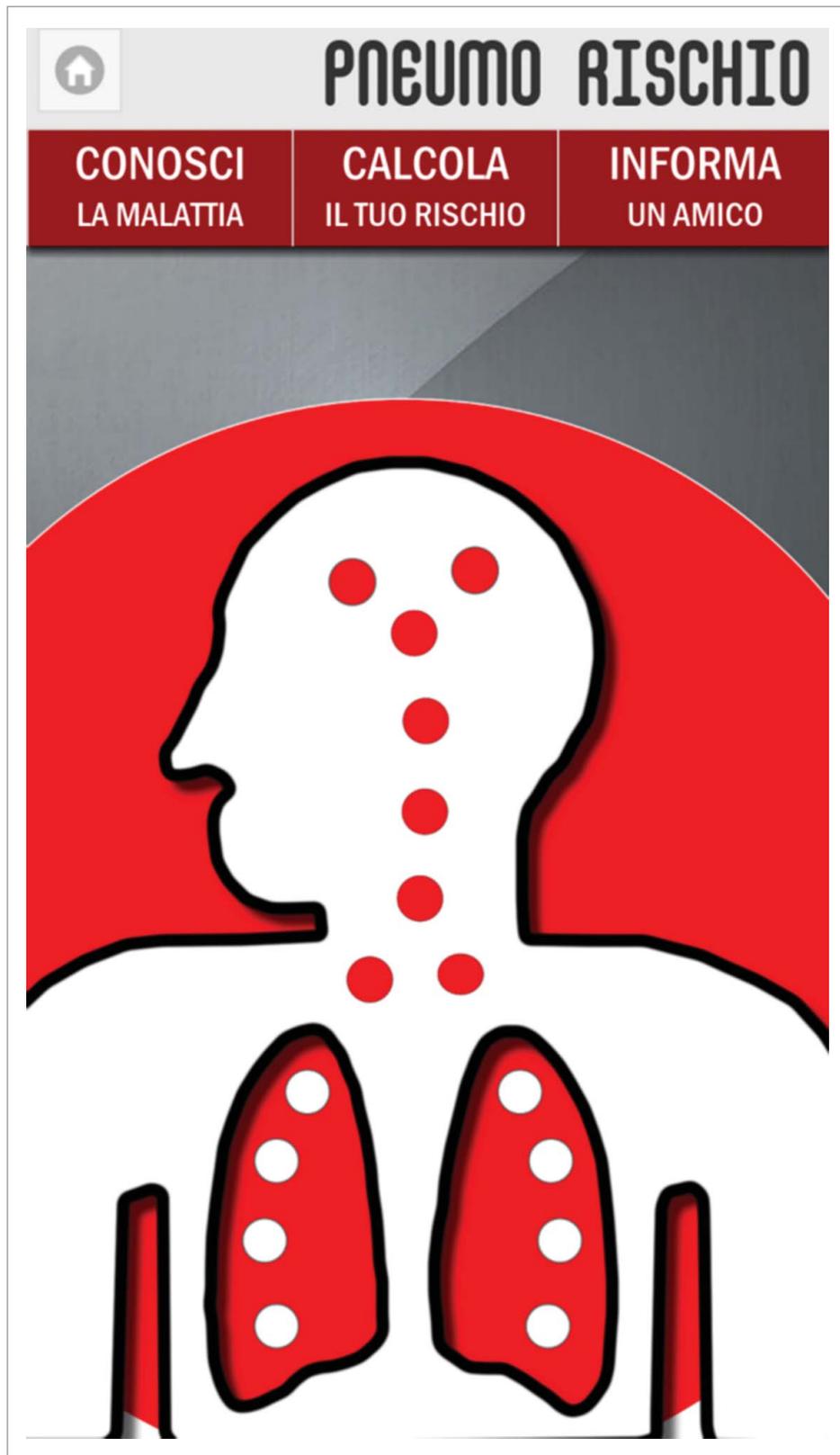
Figure 2. *"Pneumo Rischio"* home page.

while the 18–24 and over-65 age-classes were under-represented.

As shown in Figure 2, the header menu of the homepage features 3 key elements: "learn about the disease," "check your risk" and "inform a friend." As expected, the option "check your risk" was the most popular first choice (53.4%), while the sections "learn about the disease" and "inform a friend" were first-clicked less frequently (36.9% and 9.8%, respectively). The

drop-out rate from the checker was low (12.7%), while 53.7% of users who successfully finished the risk evaluation went on navigating the app.

The "*Pneumo Rischio*" website appears within the first 30 Google search results of queries regarding "pneumococcus," "IPD" and synonyms. To ensure a higher "findability," a banner with a direct link to "*Pneumo Rischio*" was posted on the corresponding page of the partner website www.vaccinarsi.org, which is the largest top-ranked vaccination-related HONcode (Health on the Internet)-certified site in Italy.

The first in-field results suggest that "*Pneumo Rischio*" is a promising tool for increasing the population's awareness of IPD and its prevention through a user-friendly risk checker. Moreover, it is well known[3,10-13] that scant awareness and perception of the personal risk of contracting a vaccine-preventable disease are associated with low levels of immunization and intention to be immunized in the future. For instance, in their study on factors influencing pneumococcal vaccination levels, Schneeberg et al.[11] found that, in comparison with unvaccinated people, a significantly higher proportion of vaccinated subjects acknowledged that they were at high risk of pneumonia.

It is also encouraging that most of our users visited the information section "learn about the disease," and many people used the app/website more than once. Moreover, we believe that "*Pneumo Rischio*" has the potential to improve the relatively low awareness of IPD among healthcare professionals, which may hold down vaccination levels among their patients.[3] For this purpose, "*Pneumo Rischio*" is now being promoted among Italian GPs and presented at conferences and congresses; we hope that health professionals will subsequently recommend the app and website to their patients as a high-quality resource.

Our future work will focus on evaluating user satisfaction, identifying social marketing strategies to increase community exposure (especially among males and the elderly) and proxies of app effectiveness, as well the feasibility of internationalizing the app. Moreover, since in our usability study only few participants, which cannot be considered representative of the target population, were involved, "*Pneumo Rischio*" will be tested for both usability and perceived usefulness in a larger sample of users.

Abbreviations

GP	general practitioner
HONcode	Health on the Internet code
IPD	invasive pneumococcal disease
IT	information technology
NVPP	National Vaccine Prevention Plan

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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