# Internet-based syndromic monitoring of acute respiratory illness in the general population of Germany, weeks 35/2011 to 34/2012

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In March 2011, the German sentinel surveillance system for influenza (Arbeitsgemeinschaft Influenza (AGI)) was complemented by an Internet-based syndromic monitoring system (GrippeWeb) for acute respiratory infections (ARI) and influenza-like-illness (ILI). To assess representativeness of GrippeWeb participants, key demographic variables and lifetime prevalence of asthma and diabetes were compared with data from the general population of Germany. To 'validate' GrippeWeb, we compared weekly ARI and medically attended ARI (MAARI) rates, generated between weeks 35/2011 and 34/2012, with AGI MAARI rates and overlaid GrippeWeb ILI rates with the number of positive influenza samples obtained by the AGI. GrippeWeb had high weekly participation rates (62% of participants reported in ≥90% of possible weeks). Although it varied by age group, participants reported a mean of between 1.3 and 6.0 ARI episodes and between 0.1 and 2.4 ILI episodes during the study year. Estimated GrippeWeb MAARI incidence was very similar to the AGI MAARI incidence and influenza circulation was reflected well in the GrippeWeb ILI rates. GrippeWeb became a reliable monitoring system shortly after implementation, capturing the burden of ARI and ILI at general population level. The high degree of agreement between GrippeWeb's and AGI's MAARI data lends support to the validity of both systems.

## Introduction

In Europe, surveillance for influenza is traditionally based on sentinel systems of primary care physicians who collect syndromic data on patients presenting with influenza-like illness (ILI) or acute respiratory infection (ARI) [1]. To this end, the Working Group for Influenza (Arbeitsgemeinschaft Influenza (AGI)) in Germany was founded in 1992 [2]. It is the German member of the European influenza surveillance network (EISN) coordinated by the European Centre for Disease Prevention and Control (ECDC) and the respective system of the World Health Organization Regional Office for Europe (EuroFlu) [3]. While most sentinel systems in Europe collect ILI data, the AGI collects ARI data. Because this type of surveillance focuses on illnesses of patients who seek healthcare, several countries have added Internet-based monitoring systems, in which data are collected from the population directly [4-10]. In March 2011, the Robert Koch Institute (RKI) launched an Internet-based syndromic monitoring system for ARI and ILI in Germany, named GrippeWeb [11]. Experiences from similar projects in other countries have shown that continuous participation of registered individuals is essential for data quality [4,5,7,10,12], but some systems have reported difficulties in achieving sustained participation [9,13]. Compared with the levels of ILI in the sentinel systems, the rise, peak and fall of ILI activity in the Internet-based and sentinel systems of Belgium, the Netherlands and Portugal, respectively, occurred at similar times [7-10]. However, a direct, quantitative comparison of medically attended illness rates of the two systems has not been published. Representativeness of the Internet-based systems has been reported to be good in terms of age and co-morbidity [7,8], but there were difficulties in reaching minors as well as elderly people [7-10].

GrippeWeb [14] runs throughout the year. Every person residing in Germany who is at least 14 years-old can register. Parents need to register separately, but one parent can report for their children aged 13 years or younger. Upon registration, participants answer 10 questions on demographic variables, lifetime physician-diagnosed chronic conditions, smoking, household size, daily occupation and main mode of transportation. Since the launch of the system in March 2011, participants have been recruited through paper-based or online media reports, during public events where GrippeWeb was presented and by word of mouth. In addition, public institutions, such as

county health departments, were provided with leaflets for further distribution to popularise GrippeWeb. GrippeWeb is carried out according to the German legislation on data protection. The GrippeWeb procedures were approved by the German Federal Commissioner for Data Protection and Freedom of Information.

Every Monday morning, participants receive an email summarising the GrippeWeb results published on the system's website and inviting them to complete their weekly questionnaire. In this questionnaire, participants are asked whether they have experienced the onset of a new respiratory illness during the previous week (Monday to Sunday). If the participant has had no respiratory illness with new symptom onset, no further questions need to be answered. In the alternative case, participants are asked to report date of onset, select symptoms from a short list (cough, sore throat, fever, runny nose), if they have consulted a physician because of the illness and whether they have been able to continue their usual daily occupation. Influenza vaccination is recorded weekly during the winter season as a separate item on the questionnaire. If a participant has missed filling in the questionnaire of a particular week, they can report weekly answers up to the previous four weeks. GrippeWeb defines an ARI as a subjectively reported respiratory illness with new onset of fever (subjective) or cough or sore throat. ILI is defined as a subjectively reported respiratory illness with a new onset of fever and cough or sore throat.

Individual results are fed back to each participant in a diary function; aggregated results are published in weekly reports on the website. To motivate participants aged 18 years or older to report as regularly as possible, they have the option to take part in a prize draw where a number of technical devices, such as a notebook or digital camera, can be won. The chance of winning can be increased by accumulating points with every report during a one-year period between August and July, after which winners are identified. Staff and family of the authoring institute (RKI) are excluded from participating in the draw.

Here we describe the characteristics of GrippeWeb and analyse the representativeness of its participants compared with the general population of Germany. We present ARI and ILI data from the first year of GrippeWeb, including the influenza season 2011/12, and compare these data with those generated by the AGI.

## Methods
We analysed GrippeWeb data collected from week 35/2011 to week 34/2012 (52 weeks). To calculate the proportion of weekly reports submitted after registration, we divided the participants in two groups: (i) those already registered at week 35/2011 (the beginning of the analysed period); and (ii) those who registered after the period of observation had started (for example, in week 40/2011). To determine the denominator of the maximum number of possible reports between

weeks 35/2011 and 34/2012 (the end of the period of analysis), we used as the denominator the total number of weeks between week 35/2011 and 34/2012 (first group) or the number of weeks from the beginning of registration until week 34/2012 (second group). For the numerator, we calculated for both groups the number of weekly reports submitted.

### Representativeness
We calculated the proportional age distribution of GrippeWeb participants as of week 34/2012 for six age groups (0–4, 5–14, 15–24, 25–34, 35–59 and >59 years), in alignment with the AGI age groups, the distribution by sex and the geographical distribution by federal state and compared these with the population of Germany as of 31 December 2011 using data provided by the German Federal Statistical Office (Destatis) [14]. In addition, we compared the age-adjusted lifetime prevalence of asthma and diabetes among GrippeWeb participants aged 18 years or above with those obtained in a representative survey of the population of Germany in 2010 (GEDA) [15,16].

### Impact of the prize draw
We investigated whether participants enrolled in the prize draw differed from those not enrolled and whether participation in the draw skewed responses. We compared the age and sex distribution, response rates and ARI/ILI rates in the two groups. Because the minimum age to take part in the prize draw was 18 years, we restricted these comparisons for participants aged at least 18 years.

### Calculation of ARI and ILI estimates
Weekly ARI/ILI rates were calculated by dividing the number of participants with ARI/ILI in a particular week by the total number of reporting participants in the same week. To calculate the mean number of ARI (ILI) during the one year study period, we used only the cohort of participants that were registered already on week 35/2011 and submitted a report in more than 46 (90%) of the 52 weeks in the following year. To estimate ARI/ILI rates for the general population of Germany, the sample was weighted according to the sex and age distribution based on the 2011 data of DESTATIS, the Federal Statistical Office [14]. We assigned each individual a weight according to the following formula [9]:

$$W_i = P_{i\ Germany} / P_{i\ GrippeWeb}$$

$W_i$ = weight of individual GrippeWeb participant

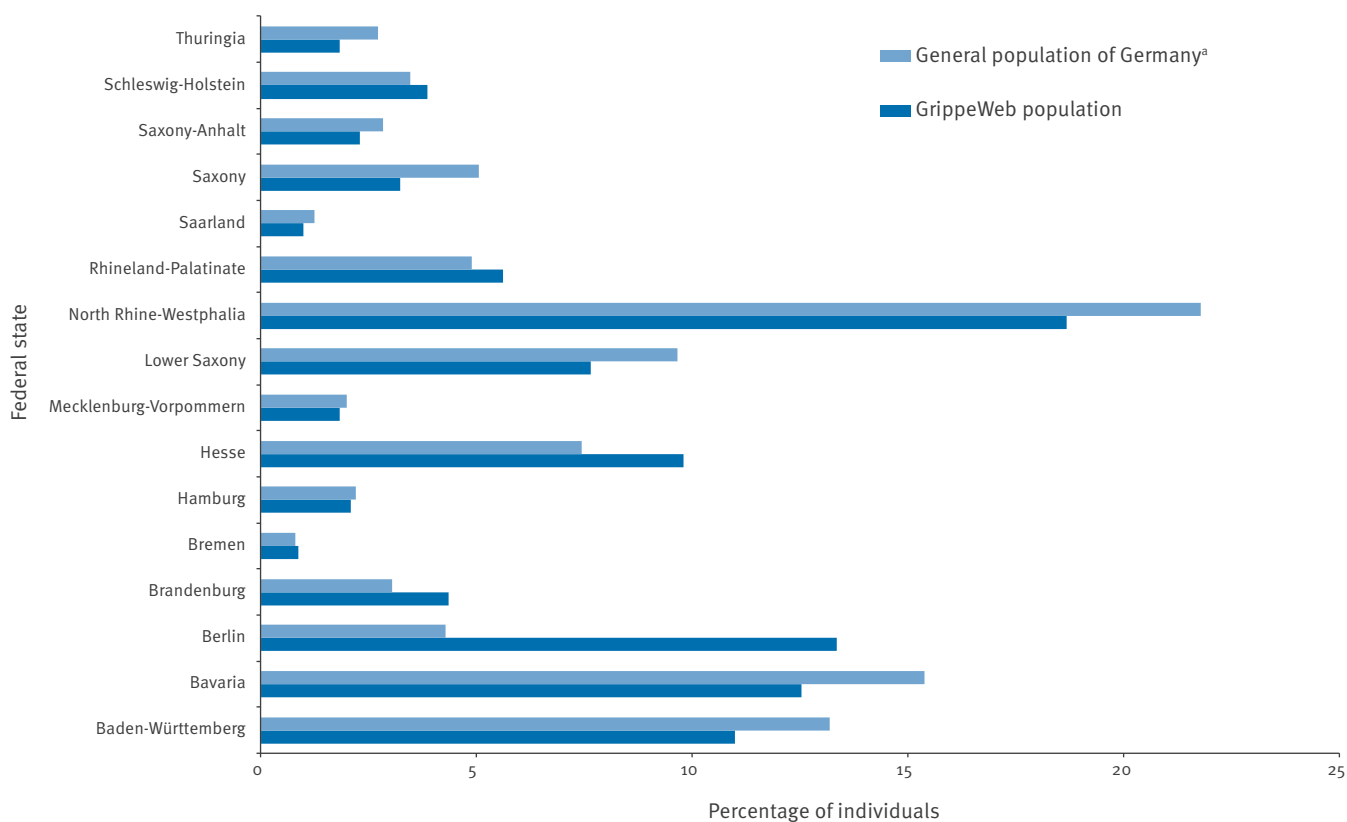$P_{i\ Germany}$ = proportion of the general population of Germany in the same age and sex group as the individual i

$P_{i\ GrippeWeb}$ = proportion of the GrippeWeb population in the same age and sex group as the individual i;

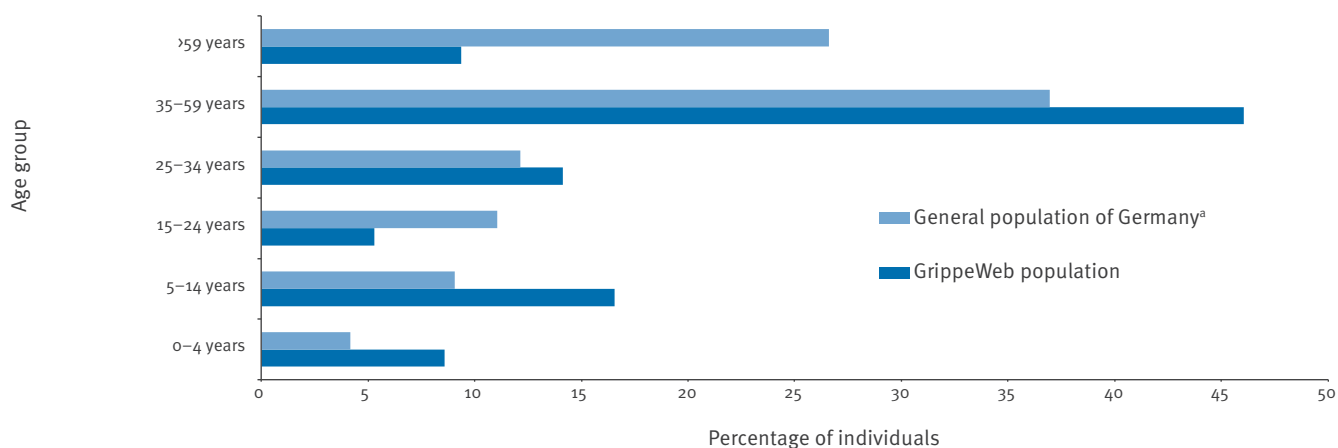To reduce the effect of individuals who register as a response to an acute illness and because participants

**FIGURE 1**

GrippeWeb participants (week 34/2011) and the general population of Germany (as of 31 December 2011) by federal state (A) and age group (B), Germany

A Participation by federal state



B Participation by age group



a Data from DESTATIS (Federal Statistical Office).

can report up to four weeks backwards, we restricted our dataset to participants' fifth and subsequent reports to calculate weekly ARI/ILI rates. Recurrent episodes of ARI and ILI of a participant were only counted if they did not report an ARI or ILI for at least one week after the last ARI/ILI.

## Comparison between ARI/ILI rates in GrippeWeb and the sentinel system of the AGI

The AGI defines ARI as a physician-diagnosed acute pharyngitis or bronchitis or pneumonia with or without fever [2]. To estimate the activity of medically attended ARI (MAARI), the AGI calculates the incidence of ARI in persons who consulted a physician because of it

(MAARI incidence) [17]. The AGI complements syndromic surveillance with virological data from samples taken by a subgroup of all sentinel physicians [18].

We conducted two 'validation' procedures of GrippeWeb data using AGI data. Firstly, to compare MAARI incidence of the AGI (AGI MAARI incidence) with data obtained by GrippeWeb (GrippeWeb MAARI incidence), we multiplied the weekly ARI rate with the weekly proportion of ARI patients who had indicated that they had consulted a physician due to their illness. Secondly, to investigate if the influenza wave of the 2011/12 season was reflected in GrippeWeb data, we overlaid ILI rates obtained by GrippeWeb (because ILI is more specific for influenza than ARI) with the number of samples positive for influenza A(H3N2) and B, the two circulating virus (sub)types in Germany during the 2011/12 season.

## Statistical analyses

Data analyses were performed using Stata version 12 (Stata Corporation, United States). For comparisons of two proportions, we used a chi-squared test, for comparisons of numerical values between two groups, we used the Mann–Whitney U test or Student's t-test. To compare the values of the GrippeWeb MAARI incidence and the GrippeWeb ARI incidence, respectively, with the AGI MAARI incidence and to compare ARI/ILI rates in GrippeWeb participants enrolled and not enrolled in the prize draw, we calculated the Pearson correlation coefficient r or Spearman's rho. To measure similarity of pairs of time series as a function of time lag, we calculated cross-correlations. All p values were calculated using two-sided tests. P values of less than 0.05 were considered statistically significant. Weekly GrippeWeb ARI/ILI incidences were calculated as a three-week moving average.

## Results

The number of registered participants rose from 1,385 in week 35/2011 to 3,803 in week 34/2012. The total cohort of participants who were registered at any time between week 35/2011 and week 34/2012 consisted of 4,102 participants. During the study period, 3,933 participants (96%) contributed reports. The major source that led participants to find out about GrippeWeb was the Internet (56%, 1,616 of 2,902 who answered the question). During the period analysed, participants contributed 125,393 reports to our dataset. For the analysis of ARI and ILI rates, 113,919 and 115,016 reports respectively were included, after exclusion of the first four reports submitted by participants and after exclusion of recurrent ARI and ILI episodes from one week to another.

During the period analysed, more than half of the participants (2,144/4,102) reported to GrippeWeb in more than 96% of the possible weeks, 62% (2,553/4,102) in at least 90% and 68% (2,805/4,102) of participants reported in at least 80%.

## Representativeness

Participants from all 16 German federal states registered for GrippeWeb. While the number of GrippeWeb participants by state correlated well overall with the number of residents of the respective state (rho = 0.90, p<0.001), there were differences between individual states. GrippeWeb participants were over-represented in several states (n=4, particularly the federal state of Berlin), and under-represented in Bavaria, Baden-Württemberg, Lower Saxony, North Rhine-Westphalia, Saxony and Thuringia (Figure 1A).

The age-adjusted proportion of female GrippeWeb participants was higher than in the general population of Germany (52% vs 51%, chi-squared test: p<0.001).

All age groups were represented in GrippeWeb. People aged 35–59 years constituted the largest portion in both GrippeWeb and the general population of Germany (Figure 1B). The proportion of 0–4, 5–14 and 35-59 year-old GrippeWeb participants was significantly higher, whereas the proportion of 15–24 and >59 year-old participants was significantly lower compared with the proportions in the general population of Germany.

The lifetime prevalence of asthma in GrippeWeb participants aged 18 and older was lower than the lifetime prevalence in the adult population of Germany (8.1% vs 9.7%, chi-squared test: p<0.001). GrippeWeb participants had also a lower lifetime prevalence of diabetes compared with that of the general population of Germany (5.3% vs 8.8%, chi-squared test: p<0.001).

## Impact of the prize draw

Among participants aged 18 and older, 80% (n=2,411) of 3,018 participants had signed up for the prize draw. Compared with GrippeWeb participants who had not enrolled in the draw, those who had enrolled did not differ by age (mean age 44.1 years vs 44.1 years, Mann–Whitney U test: p=0.70) and sex (chi-squared test: p=0.60). Weekly ARI and ILI rates were similar in both groups (for ARI, r= 0.90, p<0.001, 95% confidence interval (CI): 0.83–0.94 and for ILI, r= 0.42, p<0.002, 95% CI: 0.17–0.62) (Figure 2A).

Regarding the reporting rate, those enrolled in the draw reported more consistently throughout the study period. For example, 67% (1,607/2,411) of those enrolled vs 55% (332/607) of those not enrolled submitted at least 90% of the possible number of reports (Figure 2B; Mann–Whitney U test: p <0.001).
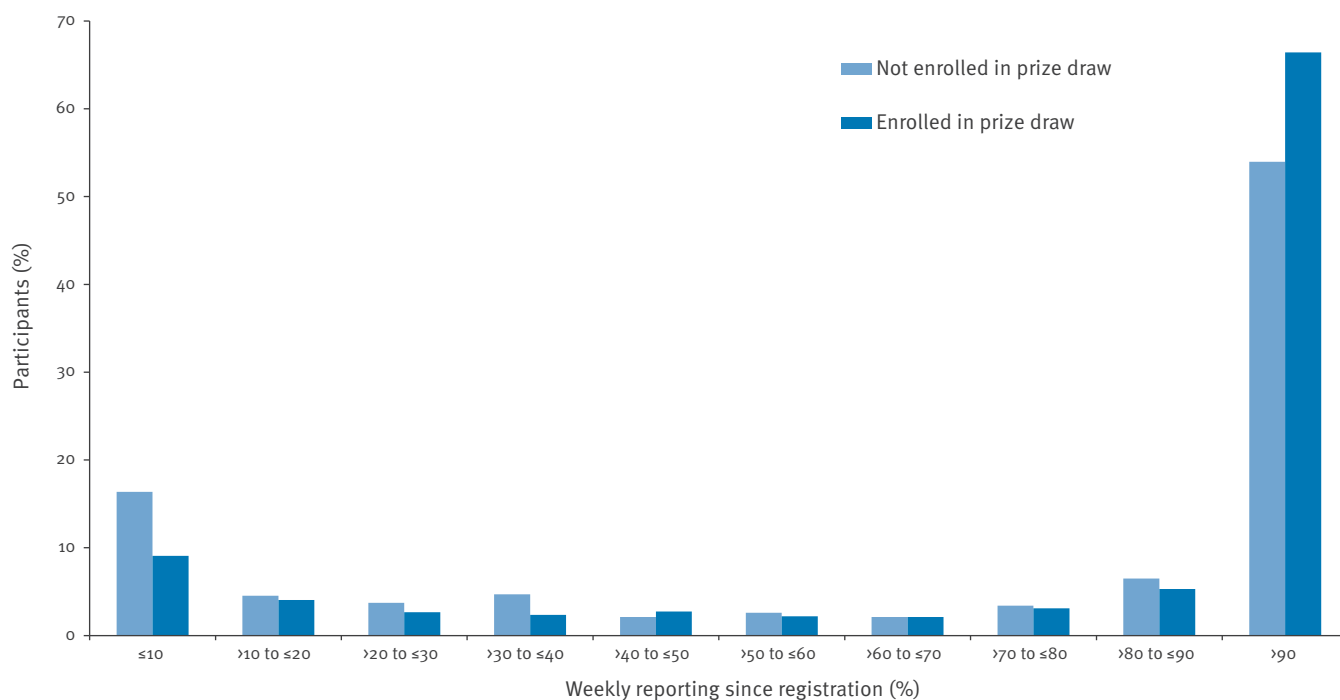
## Estimates of ARI and ILI among GrippeWeb participants

During the observed time period, estimated weekly ARI rates ranged between 3.0% (95% CI: 2.3–3.7) and 8.4% (95% CI: 6.7–10.1) for all ages, between 4.9% (95% CI: 3.2–6.7) and 14.1% (95% CI: 10.8–17.5) for children (aged 14 years or younger) and between 2.7% (95% CI: 1.9–3.5) and 8.2% (95% CI: 6.4–10.2) for participants
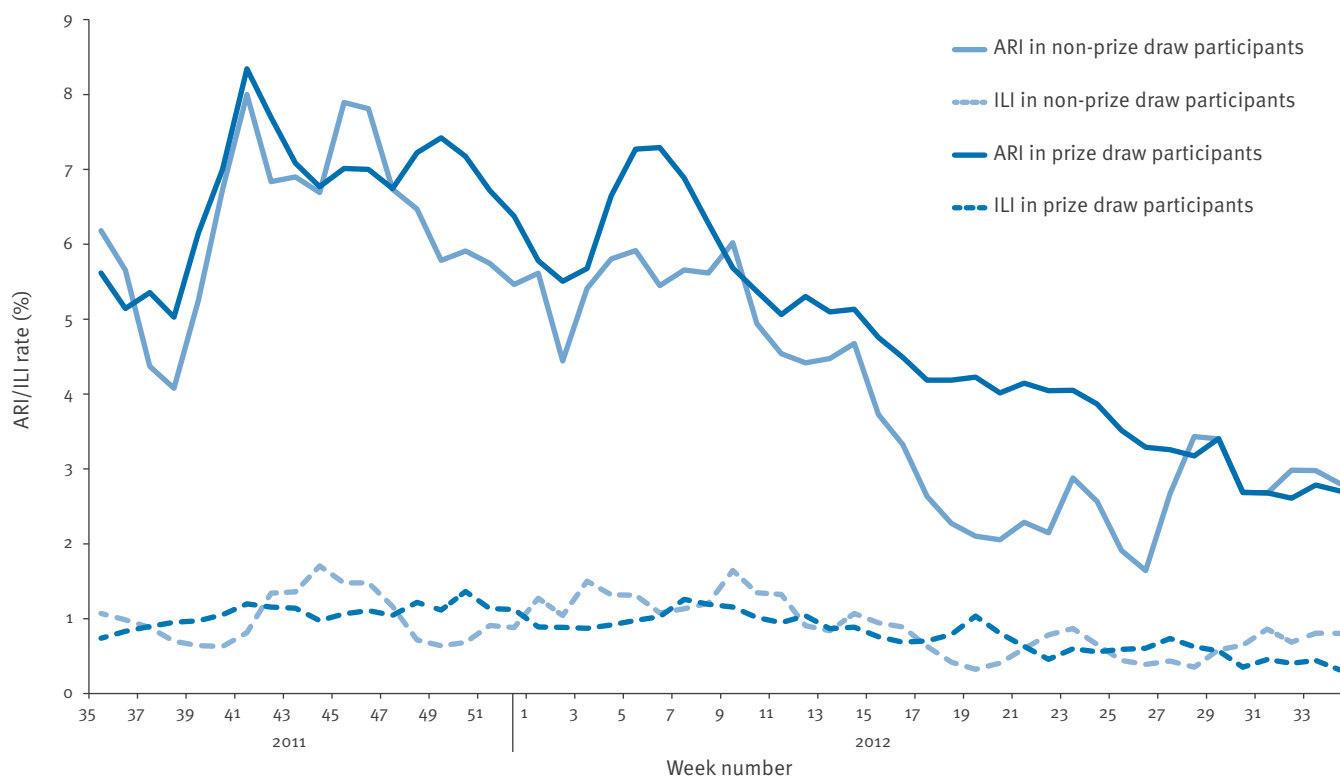
FIGURE 2

GrippeWeb participants enrolled and not enrolled in the prize draw: proportion of possible weekly reports after registration (A) and three-week moving average of reported acute respiratory illness and influenza-like illness (B), Germany, weeks 35/2011–34/2012

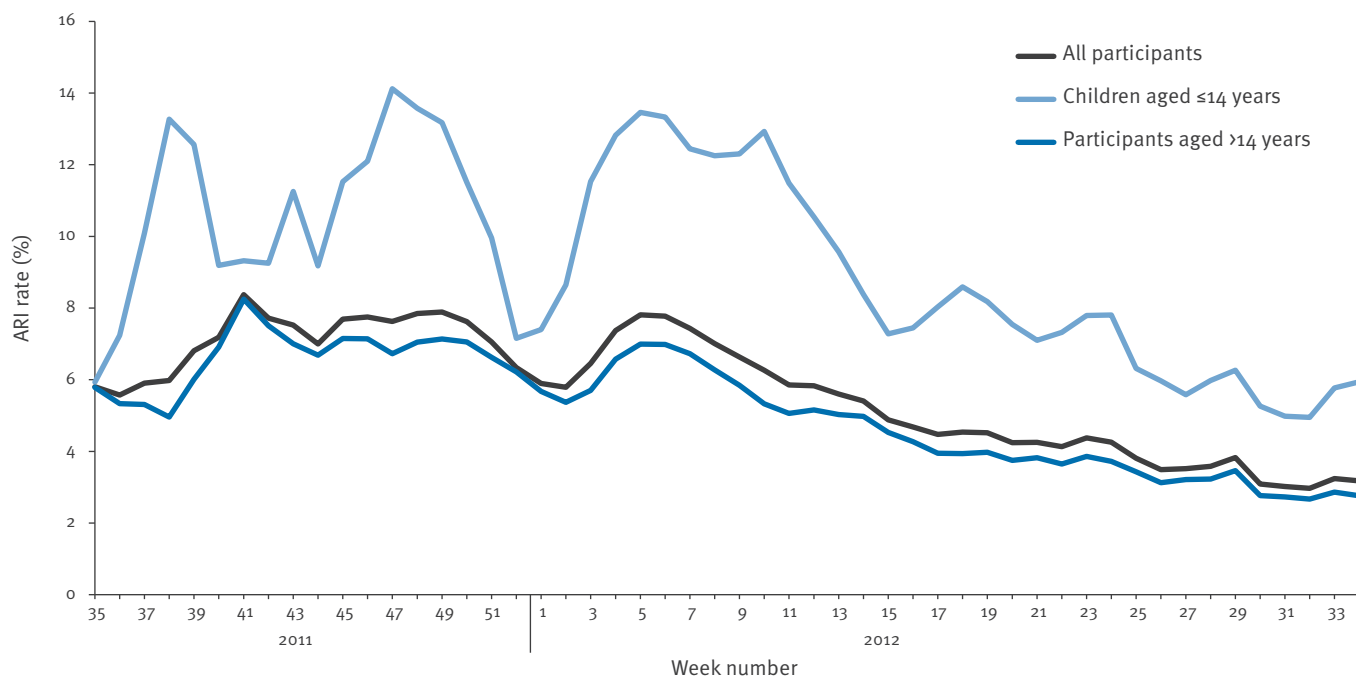A Weekly reporting

B ARI and ILI



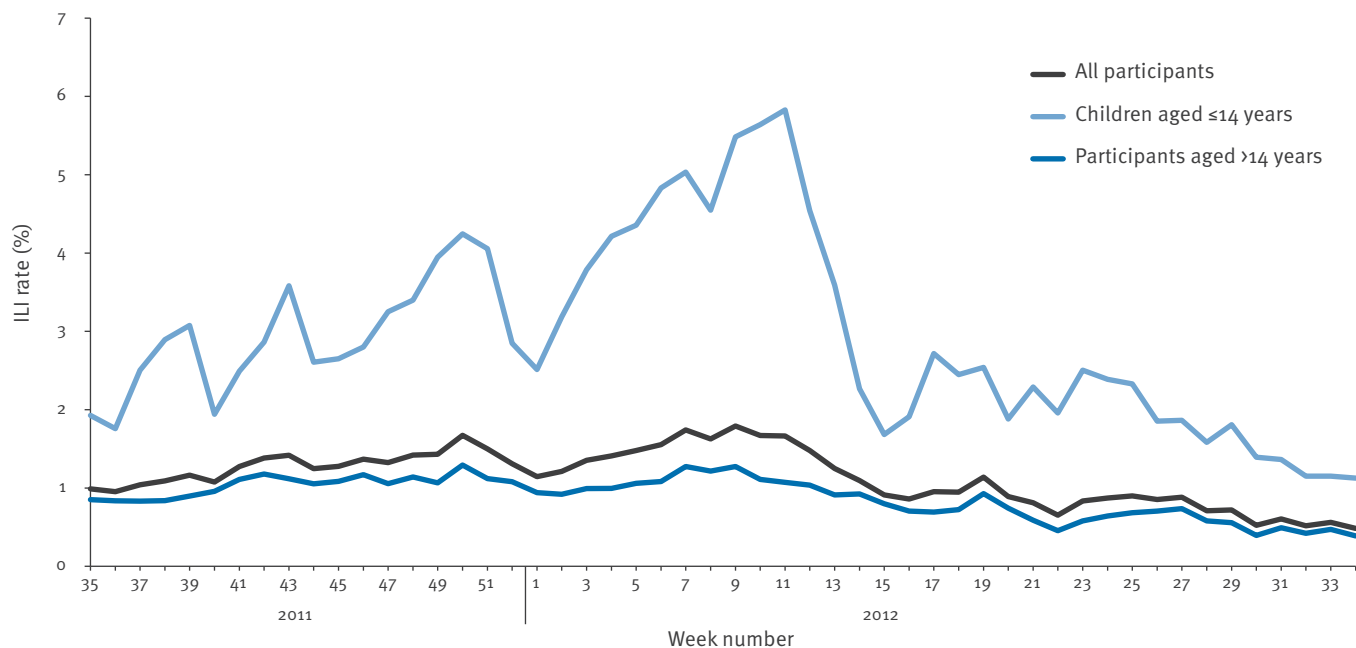ARI: acute respiratory illness; ILI: influenza-like illness.

**FIGURE 3**

Three-week moving average for children ≤14 years, participants >14 years and all age groups measured by GrippeWeb for acute respiratory illness (A) and influenza-like illness (B), Germany, weeks 35/2011–34/2012

A ARI



B ILI



ARI: acute respiratory illness; ILI: influenza-like illness.

Number of acute respiratory illness and influenza-like illness reports of GrippeWeb participants, Germany, during a one-year period (weeks 35/2011–34/2012)

| Age group in years[a] | Number of participants[b] | Number of ARI reports | | Number of ILI reports | |
|---|---|---|---|---|---|
| | | Mean | Median (25% percentile; 75% percentile) | Mean | Median (25% percentile; 75% percentile) |
| ≤4 | 38 | 6.0 | 6 (4; 8) | 2.4 | 2 (1; 3) |
| 5–14 | 115 | 3.4 | 3 (2; 4) | 0.9 | 1 (0; 1) |
| 15–34 | 125 | 3.2 | 3 (2; 4) | 0.5 | 0 (0; 1) |
| 35–59 | 438 | 2.3 | 2 (1; 3) | 0.4 | 0 (0; 1) |
| ≥60 | 64 | 1.3 | 1 (0; 2) | 0.1 | 0 (0; 0) |

ARI: acute respiratory illness; ILI: influenza-like-illness.

[a] Participants were included in the calculation only if they were already registered in week 35/2011 and reported to GrippeWeb a minimum 47 weeks out of the possible 52 weeks during weeks 35/2011 to 34/2012.

[b] One parent can report for children aged 13 years or younger.

aged >14 years (Figure 3A). ILI rates ranged between 0.5% (95% CI: 0.2–0.8) and 1.8% (95% CI: 1.3–2.3) for all ages, between 1.1% (95% CI: 0.3–2.0) and 5.8% (95% CI: 3.9–7.7) for children ≤14 years and between 0.4% (95% CI: 0.1–0.7) and 1.3% (95% CI: 0.7–1.9) for participants aged >14 years (Figure 3B). Rates of ARI and ILI reports dropped around weeks 40–42/2011, 01/2012 and 14/2012, particularly in children aged 0–14 years, coinciding with the autumn, Christmas and Easter holiday periods. ILI rates peaked in weeks 7–9/2012 in participants aged >14 years and in week 11/2012 in children aged ≤14 years. In an average week, GrippeWeb received 46 ARI and 15 ILI reports among children (aged 0–14 years) and 88 ARI and 16 ILI reports of participants aged >14 years. Mean weekly ARI rates in children were between 1.0 and 2.7 times higher than those in participants aged >14 years, while the mean weekly ILI rates in children were between 2.0 and 5.4 times higher.

During the period analysed, the mean number of ARI and ILI reports was strongly age dependent, varying from 6.0 in children aged 0–4 years to 1.3 in participants aged 60 years or older for ARI; for ILI, it varied from 2.4 in the 0–4 year-olds to 0.1 in those aged ≥60 years (Table).

Overall, participants consulted a physician in 18% and 42% of reported ARI and ILI episodes, respectively, due to their illness. After stratification by age, a physician was consulted most frequently for children aged 0–4 years (for ARI in 25% of episodes and for ILI in 49%) and participants aged 15–34 years consulted least frequently for ARI (15%) and adults aged 35–59 years least frequently for ILI (39%).

Regarding school or work absenteeism, participants reported in 30% of ARI and in 68% of ILI episodes that they refrained from their usual daily activity (day care, school, work, etc.) due to their illness.
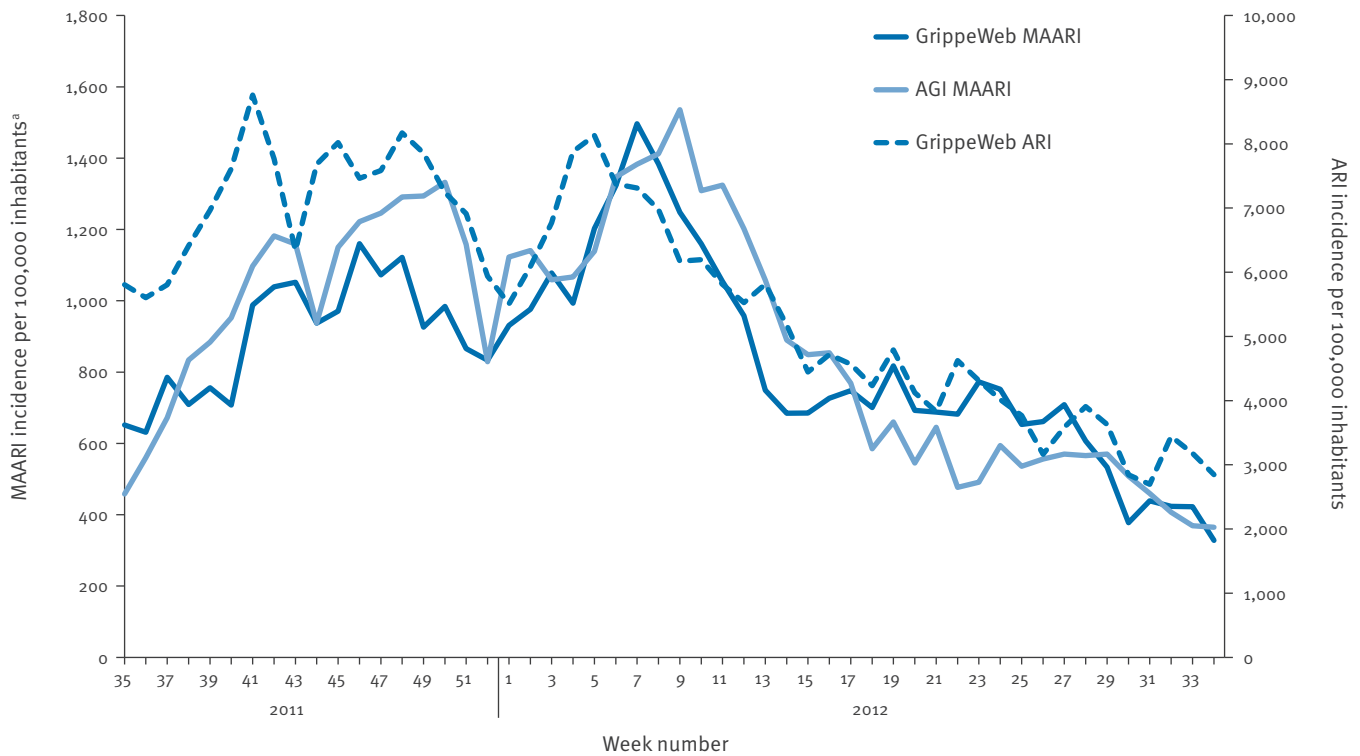
## Comparison of GrippeWeb ARI/ ILI rates with data from the AGI

The weekly GrippeWeb ARI incidence and MAARI incidence curves show the same trends as the AGI's consultation incidence curve (Figure 4). Peaks of incidence curves occurred a little earlier for GrippeWeb ARI (week 5/2012) and GrippeWeb MAARI (week 7/2012) compared with AGI MAARI (week 9/2012). The weekly GrippeWeb ARI incidences were about 4.8–10.8 times higher than the AGI MAARI incidence. Over the whole period analysed, the weekly GrippeWeb MAARI incidences differed by a factor 0.6–1.4 from the AGI MAARI incidences, and by a factor of only 0.9–1.4 (GrippeWeb MAARI/AGI MAARI) when considering only weeks 6–16/2012, which were retrospectively defined by the AGI as the time when the influenza epidemic occurred in Germany [2] (Figure 4). The GrippeWeb ARI incidence and MAARI incidence correlated significantly with the AGI MAARI incidence ($r = 0.80$ $p<0.001$, 95% CI: 0.68–0.88 (GrippeWeb ARI) and $r = 0.89$, $p<0.001$, 95% CI: 0.82–0.94 (GrippeWeb MAARI)). The correlation could be improved up to 0.89 by using a lag of two weeks for the correlation of GrippeWeb ARI incidence and AGI MAARI incidence.

Superimposing GrippeWeb ILI rates with the number of samples positive for influenza A(H3N2) and influenza B virus identified by the AGI demonstrated that the occurrence of the influenza wave was reflected in the ILI rates of children, but was less obvious among adults (Figure 5). Circulation of influenza A(H3N2) virus reached its peak in week 9/2012, preceding that of influenza B in week 12. During the period when influenza virus circulated most, ILI rates among adults peaked during weeks 7–9/2012, while among children they peaked during weeks 9–12/2012.

**FIGURE 4**

Incidence of acute respiratory illnesses and medically attended acute respiratory illness (MAARI) measured by GrippeWeb and MAARI incidence measured by the German sentinel surveillance system for influenza, weeks 35/2011–34/2012



AGI: Arbeitsgemeinschaft Influenza, German sentinel surveillance system for influenza; ARI: acute respiratory illnesses; MAARI: medically attended acute respiratory illness.
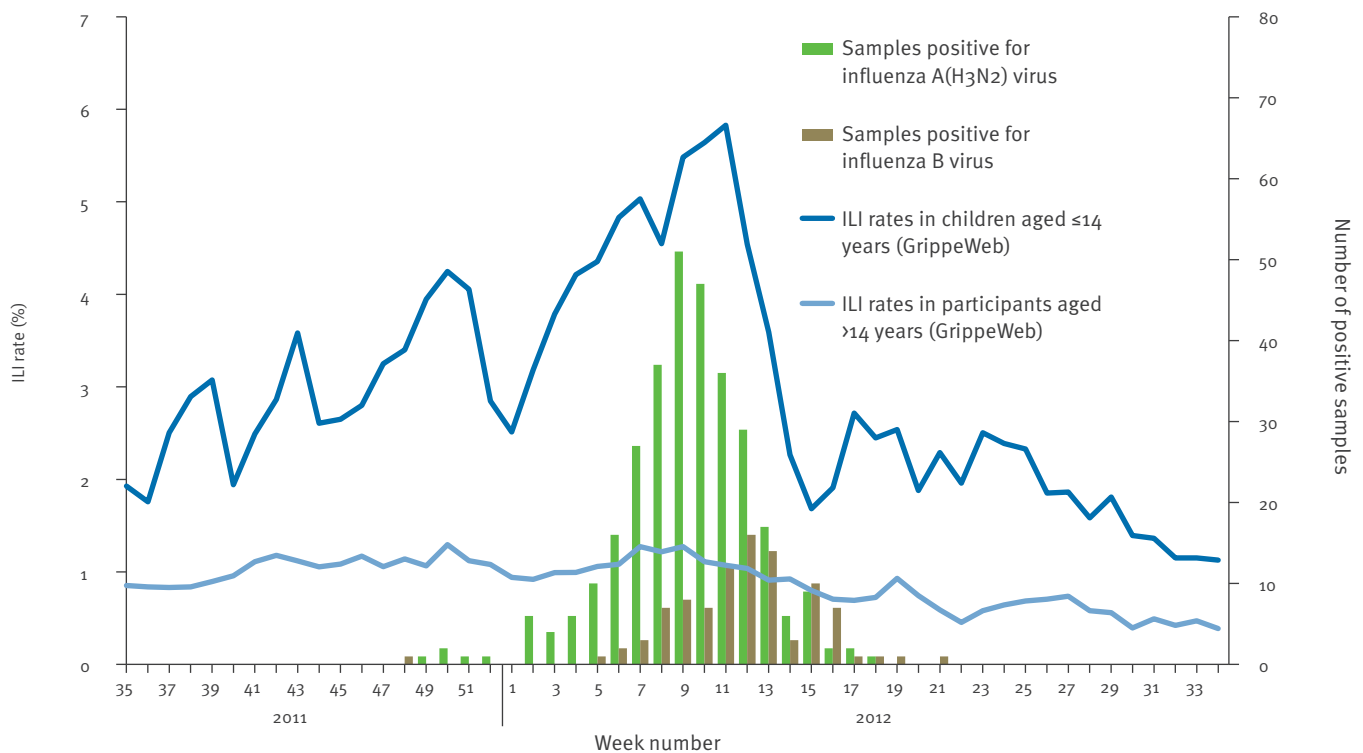[a] Three-week moving average.

## Discussion

During the one-year study period, at the start of GrippeWeb's existence, the system experienced a constantly growing number of participants, with very high weekly reporting rates throughout the year. Participants came from all German federal states and all age groups were represented. Signing up to the prize draw did not seem to affect validity of reporting, but enhanced reporting rates. Estimated GrippeWeb MAARI incidence was in the same range as the MAARI incidence measured by the physician-based AGI system and influenza circulation was reflected by the GrippeWeb ILI rates, particularly among children.

Start-up systems running with voluntary participation, such as GrippeWeb, always need to reach a minimum number of participants to be able to generate reasonably precise and reliable data [19]. During the period analysed, we were able to almost triple the number of GrippeWeb participants. Although statistically significant differences of the GrippeWeb participants existed when compared to the general population in Germany, these may have resulted because of the large numbers compared. Overall, the geographical (with the exception of Berlin in particular) and sex distribution

of participants were reasonably similar to that of the German population, but the age distribution could be improved. However, while other European Internet-based monitoring systems had reported under-representation of children [7,8,10], the two age groups of children in GrippeWeb (0–4 years and 5–14 years) were not under-represented, perhaps due to the simplicity and rapidity with which parents can report for their children. Nevertheless, similar to other Internet-based systems [7,8,10], the oldest age group (60 years and above) was under-represented in GrippeWeb, probably due to the lack of familiarity with the internet in this age group. In 2012, only 36% of persons living in Germany aged 65 years or older were Internet users [20]. One practical consequence of this under-representation is that other means of promoting the GrippeWeb system to elderly people need to be considered. The under-representation of the 15–24 year-old age group was at first surprising, but might be linked to the fact that parents can no longer report for their children when they turn 14 years. In addition, health-related topics might be of less interest to young people in this age group and might result in a lower willingness to sign up for GrippeWeb. Furthermore, this age group might tend to prefer the use of smartphone apps and social media such as Facebook instead of 'classic' Internet

**FIGURE 5**

GrippeWeb influenza-like illness rates for children aged ≤14 years and participants aged >14 years compared with the number of samples positive for influenza A(H3N2) and B viruses[a], Germany, weeks 35/2011–34/2012



ILI: influenza-like illness.

[a] Identified by the German sentinel surveillance system for influenza.

and email communication. Unavailability of GrippeWeb as a smartphone app and existing strict privacy regulations (prohibiting a link with Facebook) might lower the attractiveness of the system to those aged 15–24 years.

Another way to assess representativeness is to compare the proportion of participants with certain chronic diseases. We found a statistically significant difference between the proportion of GrippeWeb participants with asthma and diabetes compared to the proportion in the general population of Germany, with the participants having a lower prevalence. Data of the general population showed a negative association of diabetes mellitus lifetime prevalence and level of education [15]. Hence GrippeWeb might attract individuals with a higher educational background, who might have a more health-conscious behaviour and lower rates of diabetes in turn.

It is very encouraging to observe the good adherence of GrippeWeb participants, demonstrated by the fact that 62% of participants reported in at least 90% of all possible weeks during the period under study. This rate is very high considering that other Internet-based monitoring systems in Europe reported for the

2011/12 influenza season that at most 25% of participants reported at least 90% of weeks [19]. The very high participation rate in GrippeWeb might be related to the following: (i) the personal, individualised feedback that is automatically given to participants in the form of a diary whenever they log in; (ii) the fact that delivering the weekly report is simple and takes only a few seconds when reporting no new onset of an ARI and up to, at most, a couple of minutes when reporting a respiratory illness with new onset and answering the related questions;  and (iii) the prize draw might have attracted individuals who would otherwise not have participated. The way prizes are drawn (increased chance to win with continuous participation) may have fostered the willingness of those eligible to report frequently.

Because of the constancy of our participants, we were able to quantify the mean number of ARI and ILI people in different age groups had during one year of observation. While this number may differ to a certain extent from year to year, the magnitude and degree of difference between adults and children was interesting and declined steadily from the very young to the very old. Data like this are important and might be used for

calculations of burden of disease due to respiratory infections.

The proportion of participants sick with ARI or ILI consulting a physician is also an important parameter and we see clear differences by severity of disease (ARI vs ILI) and age (children vs adults), with highest proportions among 0–4 year-olds who have ILI (49%). In the same season, other European countries, such as France, Italy and Belgium, reported similar proportions between children and adults whereas the Netherlands and the United Kingdom reported rather lower proportions [21]. Data on physician consultations may be heavily influenced by societal factors, for example, at which point in time employees are required to present a medical certificate when they become ill.

Because the AGI system collects ARI data, we compared them with GrippeWeb ARI data. The two case definitions are similar: while the AGI defines an ARI as acute onset of pharyngitis, bronchitis or pneumonia with or without fever, an ARI in GrippeWeb is defined as a subjectively reported new onset of a respiratory illness with fever or cough or sore throat. It was reassuring that the course of GrippeWeb ARI rates was similar in its dynamic compared with the AGI MAARI rates, where the difference in magnitude reflects the rate at which patients seek professional medical advice. This concurs with the experience from other European systems [7-10]. The improved correlation coefficient (of 0.80 to 0.89, when a lag of two weeks is allowed for) suggests that GrippeWeb ARI rates might detect substantial changes in the population perhaps one or two weeks earlier than the AGI system.

It is novel to compare directly and quantitatively MAARI rates of a sentinel-based surveillance system (that of AGI) with those estimated by an Internet-based monitoring system (GrippeWeb). It is remarkable that the two, entirely independent systems with different data sources, sampling schemes, geographical distribution and extrapolation procedures to the whole population agree not only in their weekly patterns throughout the year, but also estimate very similar numerical values (illustrated by the large correlation coefficient of 0.89). This agreement even holds, albeit to a lesser degree, after stratification into age groups (data not shown). We regard this as a sort of 'mutual validation' of the two systems. We were also pleased to see that the actual influenza circulation, as measured by the virological surveillance of the AGI, was also reflected in our ILI data. However, it also shows that syndromic data must always be interpreted in the context of virological surveillance. It would be even more helpful to have virological information (on a broader range of agents) from samples coming directly from participants in the GrippeWeb system, for example, as done in [22].

Strengths of GrippeWeb are that the system could be relatively easily extended or adapted according to, for example, acute needs in an epidemic or even pandemic

and it could include other symptoms, such as diarrhoea/nausea/vomiting. Data are gathered in a timely manner: individual (not aggregated) data on demographic variables, lifestyle and underlying health conditions of participants might allow the identification of risk factors to an extent that is hardly possible by physician-based sentinel systems. The data allow us to assess influenza vaccination uptake and estimate influenza vaccination effectiveness (to protect from ILI). The costs of GrippeWeb are limited when compared with those of a sentinel surveillance network: after gathering data from further seasons, modelling should be capable of estimating the burden of disease in the population due to influenza (or other viruses, if data become available).

GrippeWeb has the following limitations. Participants are Internet-users and may have an interest in health topics, which may result in a cohort with a behaviour that is more health conscious than that of the general population. We do not believe, however, that this specifically affects ARI and ILI rates, otherwise the comparison with AGI data would be substantially worse. The number of participants during the reported period was small, resulting sometimes in very small numbers, for example when examining age or other strata. Lastly self-reporting may lead to a tendency to report only when illness occurs. However, by including data of all participants only after they have reported four times for calculation of ARI, ILI and MAARI rates, we have controlled for the 'starter bias'; moreover, because GrippeWeb participants reported very regularly, we feel that it is justified to have a high degree of confidence in the data. Nevertheless, as GrippeWeb is a very young system, it is possible that participants' motivation will decrease over time and participation rate will drop.

## Conclusion

Already in its second year after implementation, GrippeWeb has become a reliable tool to estimate ARI and ILI in the general population. It proved to be a valuable complement to the physician-based sentinel system of the AGI. Both systems report their data in parallel. The constant increase of registered participants in GrippeWeb, adequate representativeness, remarkably high continuity of participation and excellent agreement with an independent data source (AGI) provide good and an increasing amount of data. The inclusion of an incentive system for regular participation has shown to be effective. Future strategic steps include a further increase of GrippeWeb subscribers and the collection of samples directly from GrippeWeb participants, for example, by using a self-swabbing approach.

## Conflict of interest

None declared.


## Authors' contributions

UB, CR, SK, SB and WH developed the design of the study; UB, CB, CR, MH, KT, SK and MH were involved in data management and analyses; CB drafted the manuscript; all co-authors reviewed and assisted in the editing of the final version of the manuscript.

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