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Abstract: The authors aimed to evaluate the web and an Interactive Voice Response (IVR) phone service as vehicles in population-based infectious disease surveillance. Fourteen thousand subjects were randomly selected from the Swedish population register and asked to prospectively report all respiratory tract infections, including Influenza-like Illness (ILI), immediately as they occurred during a 36-week period starting October 2007. Participants were classified as belonging to the web or IVR group based on their choice of technology for initial registration. In all, 1,297 individuals registered via IVR while 2,044 chose the web. The latter were more often young and well-educated than those registered via IVR. Overall, 52% of the participants reported at least one infection episode. The risk of an infectious disease report was 14% (95% CI: 6, 22%) higher in the web group than in the IVR group. For ILI the excess was 27% (95% CI: 11, 47%). After adjustments for socio-demographic factors, statistically non-significant excesses of 1% and 8% remained, indicating trivial differences potentially attributable to the two reporting techniques. With attention to confounding, it should be possible to combine the web and IVR for simple reporting of infectious disease symptoms.

Interactive Voice Response and web-based questionnaires for population-based infectious disease reporting

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ORIGINAL ARTICLE

Interactive Voice Response and web-based questionnaires for population-based infectious disease reporting

ABSTRACT

The authors aimed to evaluate the web and an Interactive Voice Response (IVR) phone service as vehicles in population-based infectious disease surveillance. Fourteen thousand subjects were randomly selected from the Swedish population register and asked to prospectively report all respiratory tract infections, including Influenza-like Illness (ILI), immediately as they occurred during a 36-week period starting October 2007. Participants were classified as belonging to the web or IVR group based on their choice of technology for initial registration. In all, 1,297 individuals registered via IVR while 2,044 chose the web. The latter were more often young and well-educated than those registered via IVR. Overall, 52% of the participants reported at least one infection episode. The risk of an infectious disease report was 14% (95% CI: 6, 22%) higher in the web group than in the IVR group. For ILI the excess was 27% (95% CI: 11, 47%). After adjustments for socio-demographic factors, statistically non-significant excesses of 1% and 8% remained, indicating trivial differences potentially attributable to the two reporting techniques. With attention to confounding, it should be possible to combine the web and IVR for simple reporting of infectious disease symptoms.

Word count: 190

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ABBREVATIONS

CI	-	Confidence Intervals
ILI	-	Influenza-like Illness
IVR	-	Interactive Voice Response
NRN	-	National Registration Numbers
RR	-	Relative Risk

Global surveillance of influenza utilizes national systems (1, 2) that are typically based on reports from sentinel physicians and/or on data from routine testing at virology laboratories (3, 4). Although invaluable components in complete influenza surveillance schemes, particularly in the early identification of outbreaks of new strains, these data collection mechanisms often lack anchorage in the underlying population. Uncertain denominator data and possible selection forces behind health-care consultations limit the interpretability of resulting rates and complicate epidemic forecasting. Moreover, overtaxing of health care during pandemics may severely bias such surveillance data. Therefore, there is a need to supplement these mechanisms with robust, population-based data collection with short time-delay (5).

The Internet is already an important component in many of the existing surveillance systems as electronic reporting decreases time-delay (3, 6). Along with the Netherlands, the Nordic countries have the world's highest general Internet penetration (7) and web-based data collection directly from the public is technically feasible in a growing number of countries including Sweden (8, 9). But since the Internet is not available to the entire population, supplementary technologies could potentially be used to improve population coverage and response rates. Interactive Voice Response (IVR), available through both landline and mobile telephones, can be used for short questionnaires (10-12). Availability of telephone-based interviews as a supplement to the web has been shown to boost response rates (13).

In this cohort study, randomly selected subjects were asked to immediately report all occurrences of respiratory tract infection during a 36-week period from September 2007 to May 2008. At entry, they were given the option to respond to the invitation via a study-specific web site or via IVR. During the follow-up period with participant-initiated reporting they were allowed to alternate between these two contact modes. This study aims to investigate the degree to which the reporting method *per se* might influence incoming self-reports by comparing participants who initially chose the web with those who chose to use IVR; of interest were possible socio-demographic selection forces, patterns of switch-over between the contact modes, and proportions reporting infections.

METHOD

Subjects and recruitment

A random sample of 14,000 Stockholm county residents, aged 0 to 95 years, was drawn from the continuously updated Swedish population register at Statistics Sweden (14). Mailed invitation letters were sent to all selected individuals. For children under the age of 16 years, the parents were contacted as proxy reporters in lieu of the child. Elderly people with impediments that hindered self-reporting could ask a deputy to act as a substitute. Before start of the infectious disease reporting, participants were required to first register by entering their National Registration Numbers (NRNs) at the study web site or via IVR. Either action was considered informed consent. The participants' choices of technology for this initial registration were used to categorize them as belonging to either the web group or the IVR group.

Follow-up

Registered participants were asked to report all new occurrences of upper respiratory tract infection (influenza-like illness [ILI] or "common cold") during the 36-week follow-up period. In the event of such an infection they were to contact the study via the website or IVR. Answering a short questionnaire about specified symptoms and time since onset was an integrated part of the reporting. Both the website and the IVR platform presented the same branched set of questions and they were connected to the same database. Participants were allowed to freely alternate between the two technologies. Postcards were sent to all registered participants at Christmas (study week 12) and around Easter (study week 25) to remind them about the ongoing study. At the end of the study, all individuals included in the total sample received a final questionnaire including questions about registration and influenza vaccination.

Record linkage

After data collection was completed, a dataset including all registered participants was linked to the Longitudinal Integration Database for Sick Leave and Labour Market Studies at Statistics Sweden to obtain individual information on gender, year and month of birth, marital status, country of birth, highest completed education, occupation, household size, total household income, and place of residence. The NRNs insured a high degree of accuracy in the record linkages. After completion of all linkages, the NRNs were replaced with internal IDs before delivery to the investigators, thus preserving the integrity of each participant. For children under the age of 18 parental data was received on highest completed education, occupation and marital status. Corresponding data (excluding parental data) on the total sample was received on an aggregated level.

Statistical analyses

Cross-tabulations of chosen reporting technology and socio-demographic variables (age group, gender, highest degree of education, marital status, size of household and household income) enabling to compare the web and IVR groups. Data on a continuous or ordered categorical scale were compared with the Wilcoxon rank-sum test while data on a nominal scale (proportions) were compared by chi-square tests.

To evaluate differences between reporting patterns over the study period and techniques, reports were separated into reports of any infection (stating infection in response to the portal question of the reporting questionnaire with onset of symptoms within seven days of the report) and reports of ILI (ILI – i.e., a symptom pattern conforming with the case definition proposed by the European Centre for Disease Prevention and Control [ecdc.europa.eu]). As some participants reported symptoms on more than one occasion, only the first individual report was used. Week by week, the proportions who reported the occurrence of a new infection out of all participants in the web and IVR groups respectively, were plotted in visual graphs for comparison. Reports were onset of symptoms occurred more than seven days prior the report was not used in the analysis. To assess the effects of choice of reporting technology and other measured background factors on the risk of reporting at least one infection, log-binomial regression models were fitted. First, crude relative risk (RR) of ever reporting an infection (yes/no) during the follow-up period was calculated for the web group, relative to the IVR group in a univariable analysis. The model was then multivariably adjusted for age group, gender, level of education, household size and family income. As marital status was highly correlated with size of household, marital status variable was not included in the regression models. For children under the age of 18 socio-economic data on their parents were obtained and used in Table 2 and in the regression models (Tables 3 and 4).

The goodness of fit of the models was evaluated by using the model deviance. Likelihood ratio tests were used to assess the relative importance of the model covariates. All statistical tests were done on the two-sided 5% level of significance. All analyses were performed with the SAS 9.1.3 statistical software program. The study was reviewed and approved by the Regional Ethics Review Board in Stockholm in 2007.

RESULTS

Response rate

After two reminders, 436 (3%) of the originally invited 14,000 individuals had declined participation and 3,341 (24% of total sample) were registered as participants, of whom 1,297 (9% of total sample) registered via IVR and 2,044 (15% of total sample) registered via the web. At the end of the study, 13,366 (96% of total sample) received the final questionnaire out of which 6,742 (49% of total sample) answered.

Socio-demographic distribution

Participants vs. total sample

Distributions of socio-demographic characteristics for the participants and for the total sample are described in Table 1. Women were over-represented among participants (56%), compared to the total sample (51%). There was a shift toward older ages among participants compared with the total sample, and there was a noteworthy under-representation of participants in the age group 18-39 (20% versus 30%). Moreover, participants had, on average, a higher level of education, higher household income, somewhat higher representation of two-person household and a lower representation of individuals who had never been married.

Web vs. IVR participants

The distributions of socio-demographic characteristics among web and IVR participants are shown in Table 2. When comparing socio-demographic characteristics between the participants registered via the web and those who registered through IVR, statistically significant differences emerged in regard to age, gender, education, size of household, marital status and family income. Women, older individuals, and individuals with a lower level of education were over-represented in the IVR group, while participants younger than 65 years and those with a higher level of education were over-represented in the web group. The web also attracted individuals from larger households, individuals with higher family income, and individuals who had never been married.

Distribution of reports

During the 36-week study season, 617 (48% of 1,297) participants in the IVR group submitted 1,035 reports of infections. Of these reports, 283 were identified as ILI, coming from 229 (18% of 1297) IVR participants. During the same period, 2032 reports of infections were received from 1,107 (54% of 2,044) web participants. Of these, 695 were ILI episodes, reported by 460 (23% of 2,044) web participants. When looking at the transfer between the two technologies, 103 (8% out of 1,297) IVR registered participants reported through the web and 129 (6% out of 2,044) of those who registered through the web had reported through IVR, indicating that most participants used the same technology for reports as for initial registration.

Figure 1 illustrates, for each of the 36 studied weeks, the proportions reporting any infection with an onset within seven days by contact mode, defined in terms of the technology chosen for the initial registration. The corresponding data pertaining to influenza-like illness (ILI) is shown in Figure 2. Although slightly more infections (both all infections and ILI) were self-reported via the web than via IVR, the reports obtained from the two groups were on the whole remarkably consistent. Both figures demonstrate obviously artificial peaks immediately following the receipt of the two postcard reminders, especially the first one that was sent out before Christmas. This peak was particularly conspicuous in the web group.

In stratified analyses, the lower report frequency in the IVR group compared to the web group was confirmed in both men and women. The proportions reporting infections and ILI by 5-year age groups are plotted in Figures 3 and 4. These proportions were generally higher in the younger age groups than in the older, and the lowest proportions were seen in the oldest age group for both technologies.

Crude and adjusted RRs for reporting at least one infection by technology, estimated in log-binomial regression models, are shown in Table 3. The unadjusted RR in the web group, relative to the IVR group, was 1.14 (95% CI: 1.06, 1.22). When adjusting for gender, the RR increased slightly. After including gender, age group, education, family size and income, the RR shifted to 1.01 (95% CI: 0.94, 1.09), indicating that the difference in reporting frequency between the two techniques was mostly due to other factors, and especially age group (Table 3). Crude and adjusted RRs for reported ILI by reporting technology are shown in Table 4. The crude RR was estimated to 1.27 (95% CI: 1.11, 1.47). After adjustment for available background factors the RR shifted to 1.08 (95% CI: 0.94, 1.25) (Table 4). No statistical interaction was found.

DISCUSSION

In this study of population-based influenza surveillance, participants were given the opportunity – after having received invitation letters by regular mail – to choose between the web and IVR through telephones for participant-initiated self-reporting of new upper respiratory tract infections during a 36-week follow-up period. More than 60% of participating individuals chose the web. Differences between socio-demographic strata with regard to preference for communication technology were found, in line with the results of other studies which have compared web- and telephone-based interviews (12, 15). More women, elderly, and less educated participants preferred IVR, while individuals younger than 65 years, with a higher level of education, living in larger households, and having a high family income were over-represented in the web group. This socio-demographic distribution among the web group is comparable to other web-based studies (16, 17). Interestingly, most participants remained faithful to their initial choice of technology and the proportion that switched over was small (less than 10%) and similar regardless of the initial choice. Although the week-to-week variation in disease reporting was remarkably similar in the web and IVR groups, the overall proportion that reported at least one disease episode was 14% (any infection) and 27% (ILI) higher in the web group than in the IVR group. This excess, however, was inflated by confounding from socio-demographic factors, notably age. After adjustments for these factors, statistically non-significant excesses of no more than 1-8% remained.

The major limitation of this study is the uncertain generalizability. Out of 14,000 invitations to the representative population sample, 3,341 (24%) registered to participate in the study. On average, the participants were older, had a higher degree of education and were more represented by women than the total sample. This distribution of socio-demographic characteristics among responders vs. non-responders has been demonstrated in other epidemiological studies (18-21) and seems to be a growing methodological problem (19, 22, 23). However, in view of the rather heavy commitment expected from the participants in the present study, participation rate in the lower range of what is presently seen in epidemiological studies with active participation of healthy people was foreseen.

While the validity of the self-reports in this investigation is subject for a separate study, some counter-intuitive findings deserve to be highlighted. In view of the over-representation of people with high socio-economic status in the web group, it might be expected that the members of this group would, on average, be healthier (12, 18), but they were, in fact, slightly more likely to report new infections. Though there seem to be no association between socio-economic status and common cold among adults (24), there are some evidence of increased susceptibility to upper respiratory tract infections if living under low socio-economic conditions during childhoods (25). However, the web group contained more participants with large families, and children are notorious vectors of infections (26). It might also seem counter-intuitive that the lowest average report frequency was observed among the oldest participants. However, the oldest were more likely to live in small households and are probably less often interacting with children. In spite of a general tendency for the immune system to become somewhat less efficient in elderly people, the spectrum of immunity acquired over a long life is likely to confer considerable protection. In regard to influenza, the oldest age group is the only one that has been subject to systematic vaccination (27, 28). Among the participants who answered the final questionnaire, 57% in the oldest age group were vaccinated compared to less than 10% in the other age groups.

The dramatic effect of the first reminder suggests that some participants may have misunderstood the instructions and were waiting for a contact from the study secretariat. When the first reminder arrived, some telescoping (29) (but also some false positive reports) may have occurred, thus inflating the rates. Interestingly, the phenomenon was expressed in an almost identical way in the web and IVR groups.

The studied technologies require access to the Internet or a telephone. This is probably a minor problem, as in 2008, 84% of the Swedish population had used the Internet regularly (14), and most individuals have access to a landline or a mobile phone

(30). Hence, as the system is dependent on a mixed-mode of two techniques, the low response rate is probably not due to lack of accessibility to the technique.

In conclusion, information and communication technologies, such as the web and IVR, have the potential to logistically implement a population-based influenza surveillance system where reports can be registered with short time-delay. Although some socio-demographic factors that determine the preference for registration technology were also linked to the propensity for reporting infections (and presumably to the incidence of such infections) thus confounding the comparison of disease rates in the web and IVR groups, it appears that the technology per se does not have any important effect on the quality of the resulting data. With proper attention to possible confounding, it should be possible to use web and IVR interchangeably for simple reporting of infectious disease symptoms.

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Conflicts of interest: None declared

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Table 1. Distribution of Socio-demographic Characteristics Among Participants and the Total Sample in a Study Where Participants Were Randomly Selected and Asked to Report all Occurrences of Respiratory Tract Infection Either through the Web of through Interactive Voice Response (IVR) During a 36-week Period From September 2007 to May 2008 in Stockholm, Sweden[a]

	Participants n=3,341 n	(%)	Total n=14,000 n	(%)
Age Group				
0-17	727	(22%)	3,089	(22%)
18-39	665	(20%)	4,220	(30%)
40-64	1,247	(37%)	4,639	(33%)
≥65	702	(21%)	2,052	(15%)
Gender				
Men	1,473	(44%)	6,882	(49%)
Women	1,868	(56%)	7,118	(51%)
Education				
≤ 9 years	232	(7%)	1,985	(14%)
10-12 years	875	(26%)	4,078	(29%)
13-15 years	433	(13%)	1,461	(10%)
>15 years	805	(24%)	2,487	(18%)
Missing[b]	996	(30%)	3,989	(28%)
Household size				
1	916	(27%)	4,205	(30%)
2	835	(25%)	2,827	(20%)
3	536	(16%)	2,337	(17%)
4	713	(21%)	2,958	(21%)
5	279	(8%)	1,192	(9%)
≥6	62	(2%)	378	(3%)
Missing			103	(1%)
Marital Status				
Never married	1,552	(45%)	7,361	(53%)
Married	1,297	(39%)	4,841	(35%)
Divorced	340	(10%)	1,466	(10%)
Widow/widower	139	(4%)	574	(4%)
Missing	13	(0%)		
Household income[c]				
Low	239	(7%)	1,924	(14%)
Low/middle	296	(9%)	1,676	(12%)
Middle	556	(17%)	2,372	(17%)
High/middle	561	(17%)	2,166	(15%)
High	1,645	(49%)	5,627	(40%)
Missing	44	(1%)	235	(2%)

[a] All data compared on aggregated level

[b] Including children in the age group 0-17 years

[c] Household income categorized as low (<14,915€/year), middle/low (14,916-24,129€/year), middle (24,130-36,220€/years) middle/high (36,221-50,415€/year), high (≥50,416€/year), and unknown

Table 2. Distributions of Socio-demographic Characteristics Among Participants who, Respectively, Used the Web and Interactive Voice Response (IVR) via telephone for Initial Registration to Participate in a Study Where Participants Were Randomly Selected and Asked to Report all Occurrences of Respiratory Tract Infection Either through the Web of through IVR During a 36-week Period From September 2007 to May 2008 in Stockholm, Sweden

	Web n=2,044 n (%)	IVR n=1,297 n (%)	P-Value
Age group			
0-17	498 (24%)	229 (18%)	<0.0001*
18-39	480 (23%)	185 (14%)	
40-64	817 (40%)	430 (33%)	
≥65	249 (12%)	453 (35%)	
Gender			
Men	987 (48%)	486 (37%)	<0.0001**
Women	1,057 (52%)	811 (63%)	
Education[a]			
≤9 years	179 (9%)	130 (10%)	<0.0001*
10-12 years	689 (34%)	444 (34%)	
13-15 years	379 (19%)	184 (14%)	
>15 years	734 (36%)	329 (25%)	
Missing	63 (3%)	210 (16%)	
Household size			
1	499 (24%)	417 (32%)	<0.0001*
2	442 (22%)	393 (30%)	
3	386 (19%)	150 (12%)	
4	495 (24%)	218 (17%)	
5	183 (9%)	96 (7%)	
≥6	39 (2%)	23 (2%)	
Marital status[a]			
Never married	700 (34%)	343 (27%)	0.0001**
Married	1,081 (53%)	660 (51%)	
Divorced	214 (11%)	183 (14%)	
Widow/widower	44 (2%)	101 (8%)	
Missing	5 (0%)	10 (1%)	
Household income[b]			
Low	123 (6%)	116 (9%)	<0.0001**
Low/middle	125 (6%)	171 (13%)	
Middle	288 (14%)	268 (21%)	
High/middle	337 (16%)	224 (17%)	
High	1,137 (56%)	508 (39%)	
Missing	34 (2%)	10 (1%)	

* Wilcoxon rank-sum test

** Chi-2 test

[a]Children under the age of 17 were represented by the parent who reported in lieu of the child.

[b]Household income categorized as low (<14,915€/year), middle/low (14,916-24,129€/year), middle (24,130-36,220€/years) middle/high (36,221-50,415€/year), high (≥50,416€/year), and unknown

Table 3. Relative Risk (RR) and 95% Confidence Intervals (CI) for Reports of any Upper Respiratory Tract Infection, Obtained Using Log-binomial Regression Modelling in a Study Where Participants Were Randomly Selected and Asked to Report all Occurrences of Respiratory Tract Infection Either through the Web of through Interactive Voice Response (IVR) During a 36-week Period From September 2007 to May 2008 in Stockholm, Sweden. Results of Univariable and Multivariable Models (the Latter Including all Variables in the Table).

	Univariable		Multivariable	
	RR	95% CI	RR	95% CI
Technique				
IVR	ref		ref	
Web	1.14	1.06, 1.22	1.01	0.94, 1.09
Age group				
0-17			1.36	1.18, 1.57
18-39			1.23	1.08, 1.41
40-64			1.06	0.94, 1.20
≥65			ref	
Gender				
Women			1.24	1.61, 1.33
Men			ref	
Education[a]				
≤ 9 years			0.91	0.80, 1.04
10-12 years			0.94	0.87, 1.02
13-15 years			1.12	1.03, 1.21
>15 years			ref	
Household size				
1			ref	
2			1.04	0.93, 1.16
3			1.00	0.89, 1.12
4			0.97	0.86, 1.09
5			1.00	0.87, 1.14
≥6			1.03	0.81, 1.32
Household income[b]				
Low			0.93	0.81, 1.08
Middle/Low			0.89	0.77, 1.02
Middle			0.91	0.82, 1.02
Middle/high			0.98	0.89, 1.08
High			ref	

[a] Children under the age of 17 represented by the parent who reported in lieu of the child.

[b] Household income categorized as low (<14,915€/year), middle/low (14,916-24,129€/year), middle (24,130-36,220€/years) middle/high (36,221-50,415€/year), high (≥50,416€/year), and unknown

Table 4. Relative Risk (RR) and 95% Confidence Intervals (CI) for Reports of Influenza Like Illness (ILI), Obtained Using Log-binomial Regression Modelling in a Study Where Participants Were Randomly Selected and Asked to Report all Occurrences of Respiratory Tract Infection Either through the Web of through Interactive Voice Response (IVR) During a 36-week Period From September 2007 to May 2008 in Stockholm, Sweden. Results of Univariable and Multivariable Models (the Latter Including all Variables in the Table).

	Univariable		Multivariable	
	RR	95% CI	RR	95% CI
Technique				
IVR	ref		ref	
Web	1.27	1.11, 1.47	1.08	0.94, 1.25
Age group				
0-17			1.87	1.38, 2.52
18-39			1.57	1.18, 2.09
40-64			1.24	0.95, 1.61
≥65			ref	
Gender				
Women			1.47	1.28, 1.70
Men			ref	
Education[a]				
≤ 9 years			1.12	0.88, 1.41
10-12 years			0.98	0.84, 1.16
13-15 years			1.14	0.95, 1.37
>15 years			ref	
Household size				
1			ref	
2			1.16	0-92, 1-46
3			1.17	0.92, 1.49
4			1.02	0.81, 1.30
5			0.89	0.55, 1.42
≥6			1.12	0.84, 1.50
Household income[b]				
Low			0.67	0.48, 0.94
Middle/Low			1.00	0.76, 1.31
Middle			0.81	0.55, 1.02
Middle/high			1.04	0.86, 1.26
High			ref	

[a] Children under the age of 17 represented by the parent who reported in lieu of the child.

[b] Household income categorized as low (<14,915€/year), middle/low (14,916-24,129€/year), middle (24,130-36,220€/years) middle/high (36,221-50,415€/year), high (≥50,416€/year), and unknown

Figure 1. Proportions in the web and IVR groups that self-reported any infection during the influenza season 2007/2008, by week and reporting technology

Figure 2. Proportions in the web and IVR groups that self-reported influenza-like illness (ILI) during the influenza season 2007/2008, by week and reporting technology

Figure 3. Proportions in the web and IVR groups that self-reported any infection during the influenza season 2007/2008, by 5-year age group and reporting technology

Figure 4. Proportions in the web and IVR groups that self-reported influenza-like illness (ILI) during the influenza season 2007/2008, by 5-year age group and reporting technology

Figue 1
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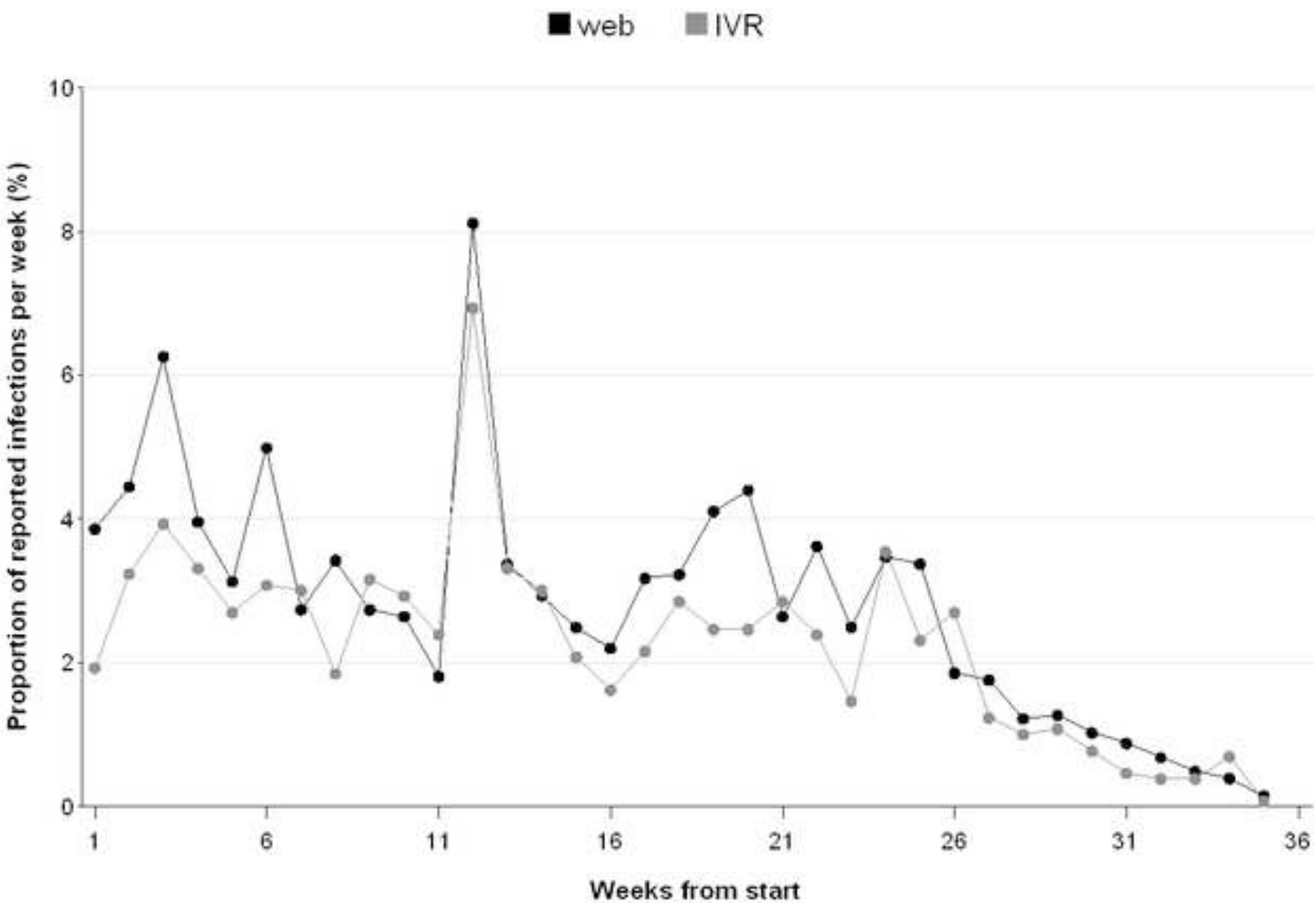

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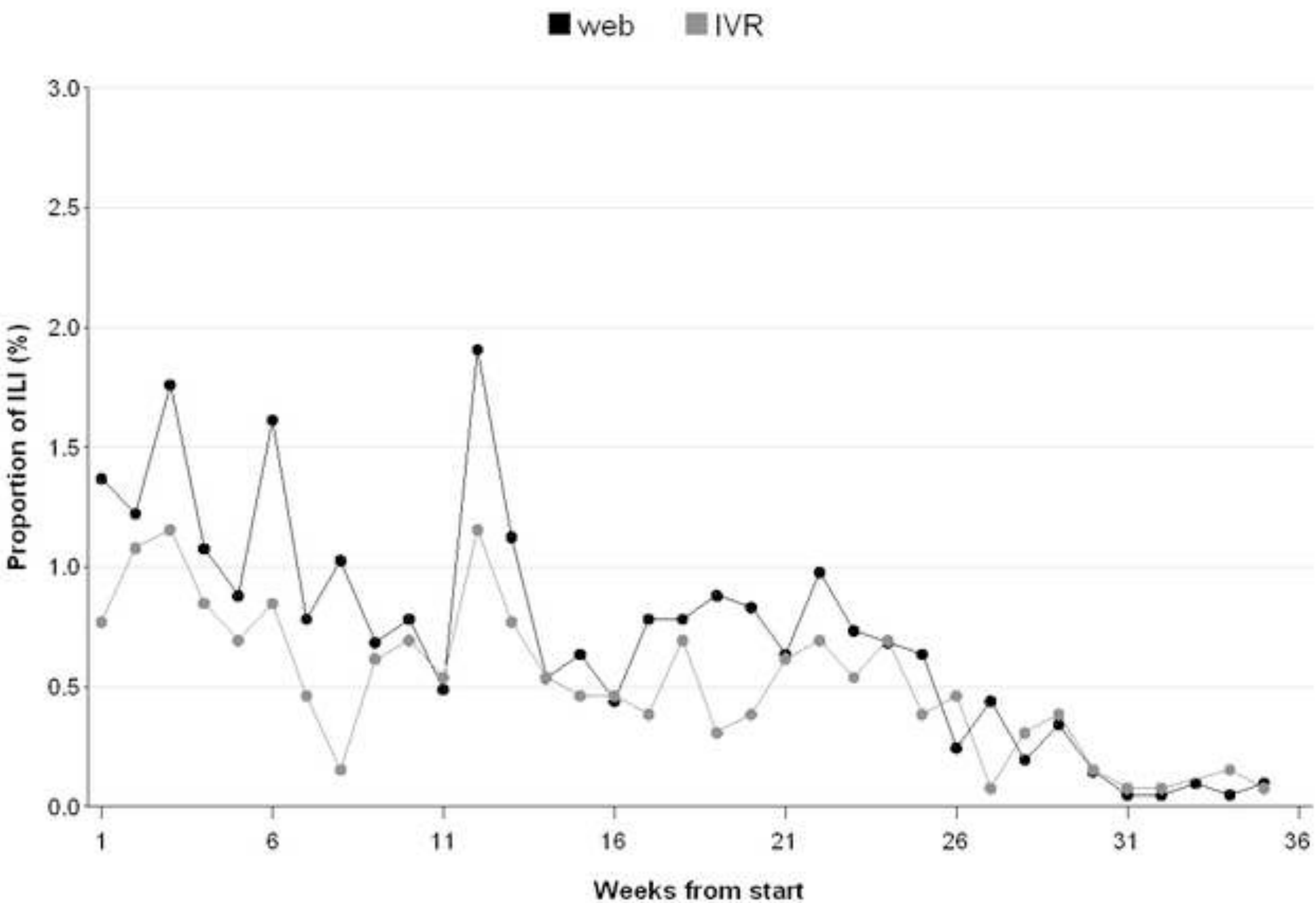

Figue 3

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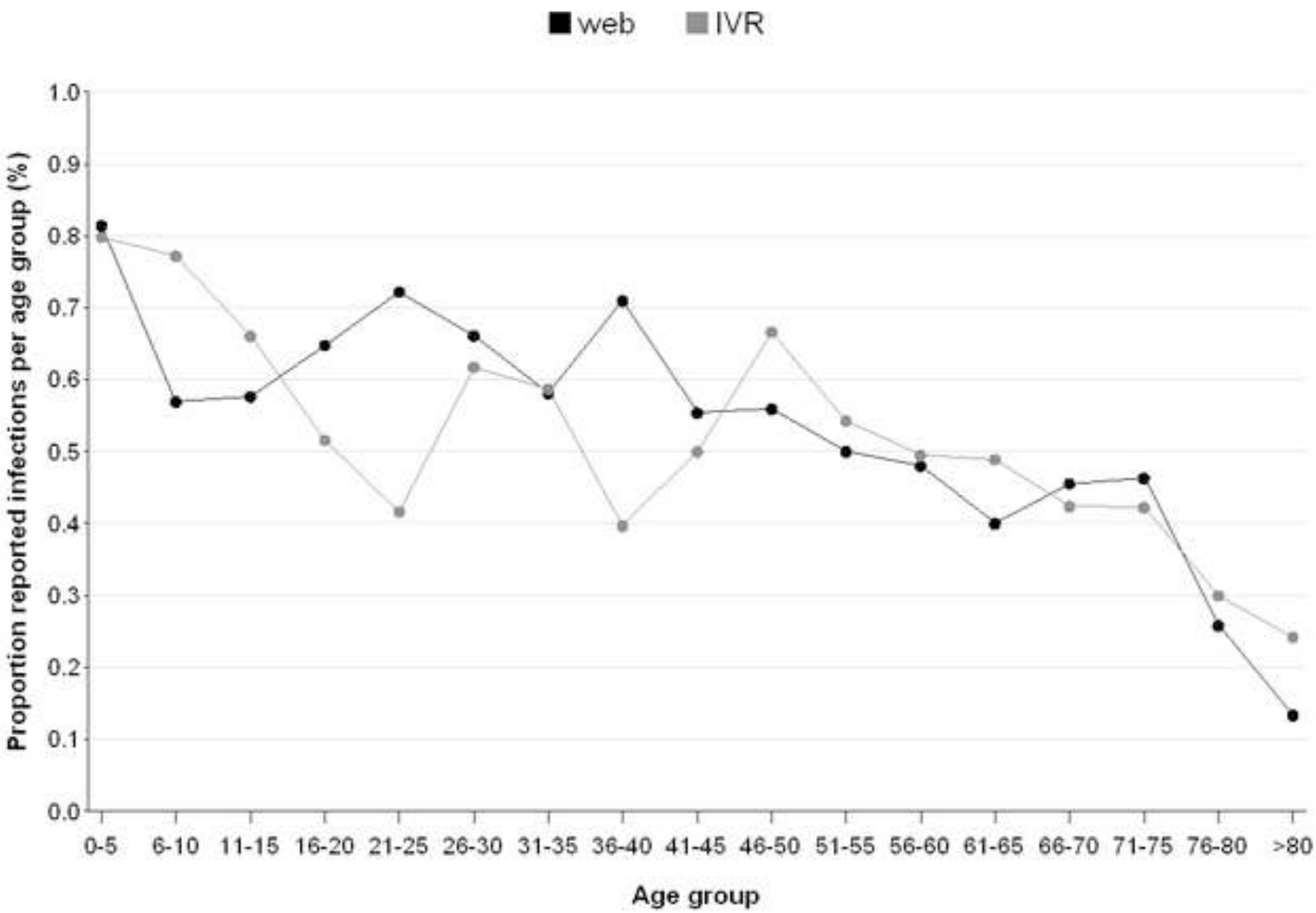

Figue 4
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