Since the 2003 heat wave, the Department of Epidemiology of the National Institute of Health Dr. Ricardo Jorge (INSA) in Portugal has been developing a daily mortality monitoring system (VDM), which came fully operational in 2007. During health-related events, like influenza epidemics or occurrence of extreme weather events, such as heat waves or cold spells, the observed “all causes” mortality increases above the expected, presenting excess deaths of 20-40%. Previous studies have showed that 95% of the deaths that occurred in a specific day are registered up to 6 days after, with an average and median delay of 8 and 2 days respectively. Given that the detection of the impact of the events are dependent on these delays, it would be very important to have, on a daily basis, the estimate of the number of deaths occurred but not yet registered in the system.

OBJECTIVES
Development of a method to predict (nowcast) on a daily basis the number of deaths occurred but not yet reported to the system. Early detection of the impact of health-related events using the proposed method.

METHODS
The VDM system receives electronically, on a daily basis, all deaths registered in the previous day at the Conservatories of the Civil Registry. The database comprised a total of 583,659 observations regarding data received between May 2007 and January 2014. The reporting delay was measured as time, in days, between occurrence of death and its notification to the VDM system. The real number of deaths on day $t$ using the registered number of deaths up to the current day $t+i$, $N_{t,i}$, is estimated by $\hat{N}_{t,i} = \sum_{j=1}^{i} n_{t-j}$, where $n_j$ is the number of deaths on day $j$ registered up to day $t$ and $\hat{p}_j$ is the probability that a death occurred on day $j$ is reported until day $t$. Logistic regression models, adjusted for overdispersion, were used to estimate each $\hat{p}_j$ using as covariates the binary variables indicating the weekday of death, the occurrence of public holiday on the day of death, the occurrence of nowcast day on the day of death, and the occurrence of nowcast day and up to four days before death. Performance of the developed method was evaluated in two phases: Phase 1 adjusting the model to mortality using data from 2008 to 2011 and nowcasting mortality for 2012; Phase 2 adjusting the model to mortality using data from 2008 to 2012 and nowcasting mortality for 2013, using the measures: median percentual relative error of predictions, sensitivity, positive predictive value and timeliness in the detection of excess mortality.

RESULTS
The minimum delay is 1 day which corresponds to deaths that are registered on the day of death and reported to the VDM system the next day. The relative median error of nowcasts were always ≤10% for all moments of prediction (e.g. $t+1, t+2, t+3$). The first detection of excess mortality is more likely (sensitivity>75%) at $t+2$ with 2 or 1 day of information. The more reliable detection of excess mortality (positive predictive value>80%) are at $t+2$ with 2 days with information and at $t+3$ with 3 and 2 days of information. During influenza epidemics in 2012, the first day of excess mortality was observed for February 4th, with 386 deaths. The VDM system detected excess mortality for this day 5 days later, with 410 deaths estimated (r.e.%=5.85). During the heat wave in 2013, the first day of excess mortality was observed for June 28th with 318 deaths. The VDM system detected excess mortality for this day 5 days later, with 410 deaths estimated (r.e.%=5.85). During the heat wave in 2013, the first day of excess mortality was observed for June 28th with 318 deaths. The VDM system detected excess mortality for this day 5 days later, with 410 deaths estimated (r.e.%=5.85).

DISCUSSION
The main limitation of this estimator is not allowing predictions to be made without information (e.g. $\hat{p}_j=\theta$) or when data transmission is irregular which does not allow daily estimates. The developed method was able to produce nowcasts with a median relative error ≤10% when it had access to at least one day of information. The most frequent scenario during a year is the production of estimates with at least one day with information for all moments of prediction. This method also allowed the early detection of excess mortality during the two health-related events in study.

FUTURE DEVELOPMENTS
Development of an alternative method for the days without information using the observed and estimated mortality (auto-regressive models). Nowcast mortality per region, age group and sex in order to reduce the heterogeneity in data. Implementation of the developed method to the VDM system.