RESEARCH ARTICLE

Higher number of hospital admissions for bronchiolitis with lower mean ambient temperature

Dr Frank C CASHA, Dr Justine FARRUGIA PRECA, Dr Rebecca PISANI

ABSTRACT

Background

During our work as general practitioners (GPs) in Malta and during attachments in the Paediatric Department of the main hospital in Malta, we encountered children with bronchiolitis. Bronchiolitis has been described as a seasonal viral illness characterised by breathing difficulties, cough, poor feeding, irritability and lethargy and, in the very young, apnoea (SIGN, 2006). We speculated that there were more bronchiolitis-related admissions to hospital during colder temperatures, but could not find any literature on the local patterns of this illness. International literature described a specific seasonality of bronchiolitis in the northern hemisphere, with more admissions being recorded in the winter months (Centers for Disease Control and Prevention (CDC), 2010; Chen et al., 2014; Coffin, 2005; Grimprel, 2001; Grimwood et al., 2008; Hervás et al., 2012), specifically with colder temperatures (Chen et al., 2014). In a concurrent study, we established seasonality and recorded other epidemiological features of the condition (Casha et al., 2015).

Objectives

The aim of this retrospective study was to identify the temperature range in which most hospitalizations for bronchiolitis occur, and to determine if there is a significant difference between the number of admissions and the set mean ambient temperature categories (arbitrarily set as below 10°C, between 10.1 and 15°C, between 15.1 and 20°C, between 20.1 and 25°C and between 25.1 and 30°C). The null hypothesis is that there is no significant difference in number of hospital admissions between each mean ambient temperature group and the alternative hypothesis is that there is a difference. This was done with a view to providing a better understanding of the condition to guide both clinical and policy decisions.

Method

The four-year period January 2008 to December 2011 was chosen. Statistical data was obtained from the Department of Health Information and Research to define the dates of admission for all recorded episodes of hospital admission for bronchiolitis among infants or children under two years at Mater Dei Hospital, the main Maltese hospital, for this period. Temperature records for the same period were obtained from the Maltese Meteorological Office. Appropriate statistical tools were used to assess the relation between admission rate and temperature. The diagnosis leading to the classification of the admission as one for bronchiolitis was validated by examining a significant sample of doctors' notes in the relevant patient files and matching these against clinical criteria for diagnosis (SIGN, 2006).

Results

Our findings show that the majority of admissions occur between 10.91°C and 18.61°C. The nonparametric Kruskal-Wallis equality-of-populations rank test proved that there is a statistically different admission frequency between different mean ambient temperature categories.

Conclusions

In Malta, a higher number of hospital admissions for bronchiolitis among infants or children under two years occurs when mean ambient temperature is lower. This is in keeping with international literature.

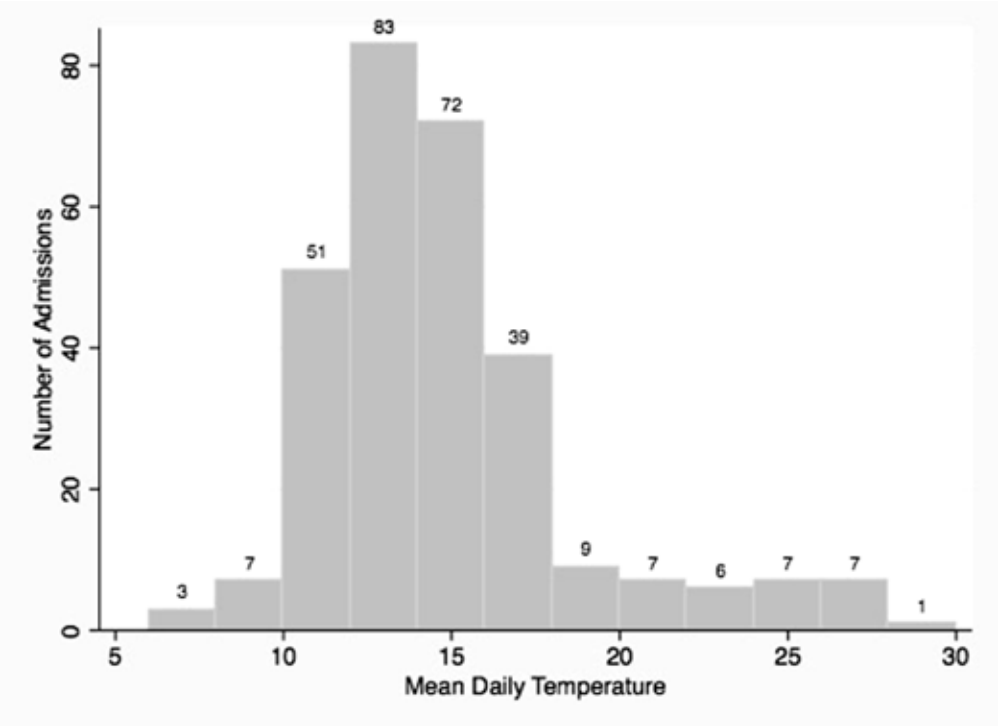
Key Words

Bronchiolitis, Malta, temperature.

BACKGROUND

Bronchiolitis is a respiratory infection which is very common in the very young (Coffin, 2005). It is characterised by breathing difficulties, cough, poor

Figure 1: Histogram showing the number of admissions per mean daily temperature



feeding, irritability and lethargy and, in some cases, apnoea (SIGN, 2006). The pathogen is usually a virus, most notably the respiratory syncytial virus, and is transmitted through direct contact with respiratory secretions and indirect inoculation from surfaces. It generally presents as a one to two-day history of upper respiratory tract infection (URTI) followed by moist cough, respiratory distress and feeding problems once the lower airways are involved. Treatment is mainly supportive and varies from treatment at local clinics intermittently to continuous inpatient treatment and at times intensive therapy unit (ITU) care (Centers for Disease Control and Prevention (CDC), 2010; Coffin, 2005; Fitzgerald and Kilham, 2004).

Bronchiolitis shows a seasonal variation, being most common during the winter months (Coffin, 2005; Fitzgerald and Kilham, 2004; Grimprel, 2001; Hervás et al., 2012; Marlais et al., 2011; Tang and Loh, 2014). This has been described in a number of international studies (Marcone et al., 2013; Munywoki et al., 2014; Riese et al., 2014; Salomão Junior et al., 2011; Vidaurreta et al., 2011), and recently, by the authors in Malta (Casha et al., 2015). However the authors could not find any local literature relating mean ambient temperature with the number of admissions for bronchiolitis among infants, and hence proceeded to try to establish whether there was any such correlation.

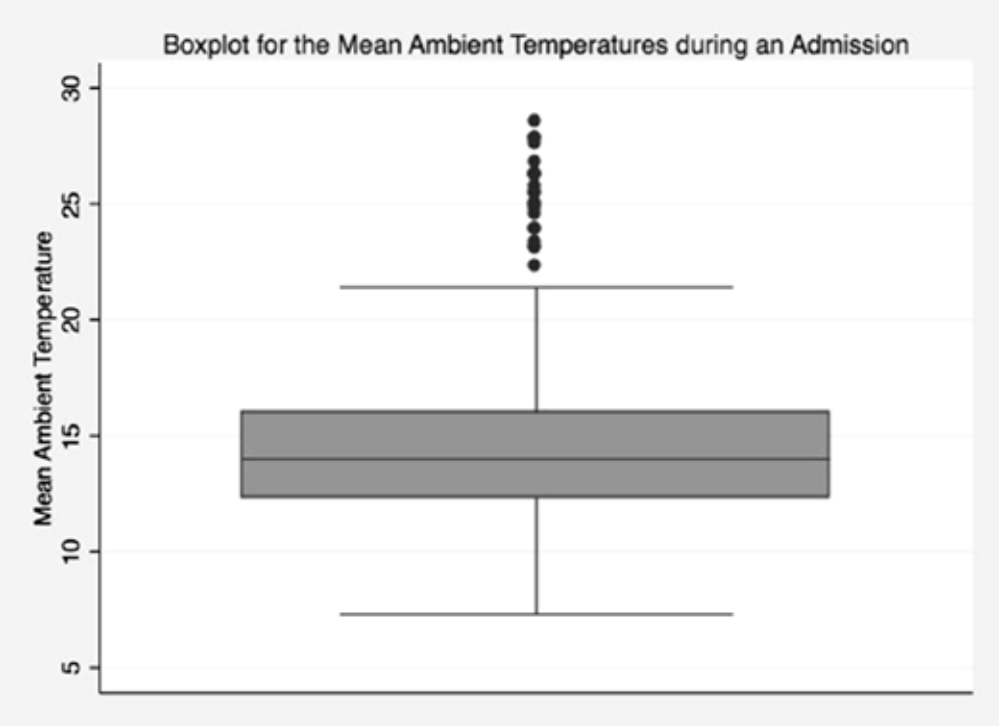
OBJECTIVES

The objectives of this study were to identify the temperature range in which most of the hospital admissions due to bronchiolitis takes place and to determine whether there is any significant difference in the number of hospital admissions due to bronchiolitis vis-a-vis the mean ambient temperature. For convenience, the mean ambient temperature was categorised into five groups: group 1 (mean ambient temperature less than 10°C); group 2 (mean ambient temperature between 10.1 and 15°C); group 3 (mean ambient temperature between 15.1 and 20°C); group 4 (mean ambient temperature between 20.1 and 25°C) and group 5 (mean ambient temperature between 25.1 and 30°C). The null hypothesis is that there is no significant difference between the number of admissions to hospital due to bronchiolitis and the mean ambient temperature groups. The alternative hypothesis is that there is a significant difference between the number of admissions to hospital due bronchiolitis and the mean ambient temperature groups.

METHOD

A list of all episodes of admission of children under two years of age to the paediatric medical wards at Mater Dei Hospital for bronchiolitis with International Classification of Disease (ICD) 10 classification

Figure 2: Boxplot for the mean ambient temperature during an admission



J21.0-J21.9 between January 2008 and December 2011 was obtained from the Department of Health Information and Research (DHIR). For each of these episodes, the date of admission was noted. The mean ambient temperature for each day for the four consecutive years was recorded. The mean temperature values were provided by the Meteorological Office of Malta.

For validation purposes, the identity of all admissions fitting the criteria described above was obtained from the DHIR, after obtaining ethics approval and approval from the Head of Department of Paediatrics, the Data Protection Officer and the hospital CEO at the time of the study.

'Bronchiolitis' is a clinical diagnosis, based on history and examination (SIGN, 2006). In order to determine that the criteria for the diagnosis of bronchiolitis made during each episode of admission were correct, a significant number of incidents of hospitalisation for bronchiolitis were randomly sampled and the corresponding patient records (hospital files) were examined to check if the clinical features noted during the hospital stay were compatible with a clinical diagnosis of bronchiolitis as defined in the SIGN guidelines for bronchiolitis (SIGN, 2006). Random selection of the files entailed listing all the admissions chronologically, then calling for 1 in 15 files. In the sample taken, 60% had both nasal discharge and cough, 36% had a cough without nasal discharge while less than 0.05% had nasal discharge without cough. Fine inspiratory crackles were present in about 20% of the sampled population while high pitched wheeze was present in 64% of the sampled population. Presence of these features was interpreted as correct clinical diagnosis.

During the study period, there were 292 admissions. For each of this admissions, the mean ambient temperature on the day of the admission was recorded. The mean ambient temperatures recorded on the day of admissions were then plotted, and the histogram shown in Figure 1 was obtained. The average of the mean ambient temperatures recorded on the day of admission and the corresponding standard deviations (SD) were then obtained, and a box plot was then drawn, as shown in Figure 2.

In order to better illustrate the relationship of mean ambient temperature with the number of admissions, the study period between January 2008 and December 2011 was divided into weekly intervals, with a total of 208 weeks, numbered week 1 to week 208. The number of admissions due to bronchiolitis during each week, and the mean ambient temperature during that week, were obtained. The values were plotted on a scatterplot as shown in Figure 3. Even though no easy linear relationship between the number of admission per week and the weekly mean ambient temperature was found, the number of admissions was visibly higher during the

low temperatures. To determine that low temperature results in a significant higher number of admissions then higher temperatures, five temperature categories were set, and the number of admissions per week during each temperature category listed. The temperature categories were as follows:

- Group 1: mean ambient temperature less than 10°C;
- Group 2: mean ambient temperature between 10.1 and 15°C;
- Group 3: mean ambient temperature between 15.1 and 20°C;
- Group 4: mean ambient temperature between 20.1 and 25°C;
- Group 5: mean ambient temperature between 25.1 and 30°C.

The nonparametric Kruskal-Wallis equality-of-populations rank test was then used to determine if there is a significant difference between the admission numbers in each temperature category.

RESULTS

Figure 1 illustrates a histogram showing the number of admissions due to bronchiolitis vis-a-vis the mean ambient temperature. As shown, most of the admissions occur between 10°C and 18°C. The highest mean ambient temperature recorded on the day of an admission was 28.5°C and the lowest mean ambient temperature recorded was 7.3°C. The mean was 14.76°C with a standard deviation of ±3.85°C. The boxplot shown in Figure 2 illustrates the measurements of central tendency described above.

The scatterplot shown in Figure 3 plots the number of admissions per week vis-a-vis the mean ambient temperature for that week. The scatterplot shows a nonlinear relation between the number of hospital admissions and mean ambient temperature. In view of this, the Pearson's product-moment correlation coefficient could not be obtained.

In order to determine that the number of admissions to hospital is significantly different in each mean ambient temperature category, the Kruskal-Wallis equality-of-populations rank test was used to rank the number of admissions in each of the mean ambient temperature category. The results obtained are shown in Figure 4. The figure shows the number of observations in each group with the corresponding rank sum. The Kruskal-Wallis test gave a chi-square of 87.2 with four degrees of freedom and a *p*-value of 0.0001. Setting the *p* at 0.05, the null hypothesis was rejected and the alternate hypothesis was accepted. Therefore, the results show that there is statistically significant difference between the numbers of admissions occurring in each temperature category.

Figure 3: Scatterplot of the number of admissions per week against the mean weekly ambient temperature

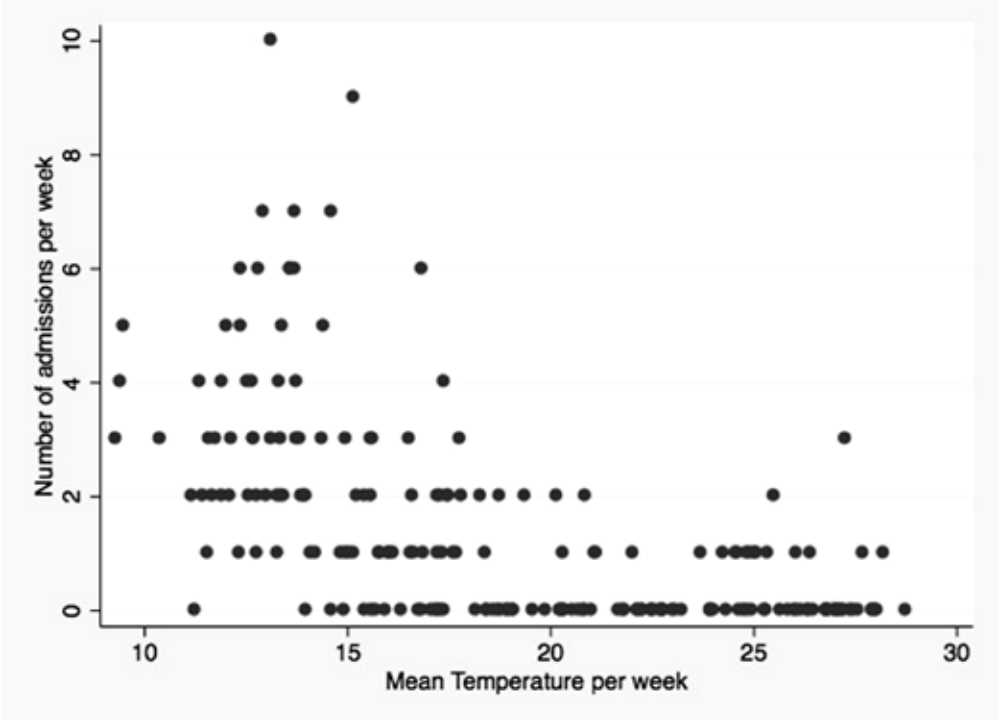


Figure 3: Kruskal-Wallis equality-of-populations rank test

Temperature Group	*Observations*	*Rank Sum*
Group 1: Below 10°C	*3*	*550.00*
Group 2: Between 10.1 and 15°C	*57*	*8941.50*
Group 3: Between 15.1 and 20°C	*58*	*5922.50*
Group 4: Between 20.1 and 25°C	*48*	*3153.00*
Group 5: Between 25.1 and 30°C	*39*	*2548.00*

chi-squared = 87.227 with 4 d.f.

probability = 0.0001

DISCUSSION

As the results show, 68% of the admissions occurred when the mean ambient temperature was between 10.91°C and 18.61°C (two standard deviations both directions from the mean of 14.76°C). This mirrors that of the countries studied in the northern hemisphere, where the number of hospital admissions is higher when the mean ambient temperature is low (Alonso et al., 2007; Deshpande and Northern, 2003; Johnson and Eccles, 2005; Panozzo et al., 2007; Reyes et al., 1997; Tang and Loh, 2014). This can be visually appreciated in the histogram of Figure 1 and the scatterplot of Figure 3, which illustrate a peak in the number of admissions in the temperature range mentioned above. The study also found that there is a significant difference in the number of admissions occurring in each mean ambient temperature category (groups defined above).

This information could be useful for a variety of purposes. Clinically, it could help general practitioners, paediatricians and emergency doctors to have a higher index of suspicion for bronchiolitis when the temperature is within the above mentioned range, and look more attentively for signs of respiratory distress needing referral to hospital or admission. From a service provision point of view, the study could help service managers to proactively prepare for higher admissions when the temperature drops, in turn avoiding bed shortages.

The study also provides information of academic interest about epidemiology of bronchiolitis in Malta. As already shown in a previous study done locally, bronchiolitis shows seasonal preference to the winter months (Casha et al., 2015). This study adds value by identifying the range of temperature in which most admissions occur and also proves that there is a significant difference in the number of admissions between the mean ambient temperature categories.

A drawback of the study is that it relied on data collected by the Department of Health Information and Research, in part gathered through the use of Electronic Case Summaries system. The system came into use in 2008 and had a usage rate of 60-70% in the first two years of use and 85% in the last two years. This raises questions about whether the undocumented cases were cases of bronchiolitis or not. The study also focussed only on the number of admissions to the main hospital, Mater Dei. Unfortunately, no data was available on the number of admissions to the Paediatric ward in the Gozo General Hospital due to bronchiolitis in the study period. It would have been interesting to determine whether a similar trends exists in Gozo. The study only included the number of cases discharged from hospital with a diagnosis of bronchiolitis; it did not take in account the number of patients presenting to the accident and emergency department and discharged with a diagnosis of bronchiolitis. It would have been interesting to know whether the rate of presentation to the accident and emergency department also varies with mean ambient temperature in a similar fashion. Further research in the area could include taking in account other environmental variables, like the level of humidity and wind direction. Also, the study did not include any reference to the viral aetiology of the cases admitted to hospital. It would have been ideal to determine whether a particular virus is causing the spike in admissions in the identified

REFERENCES

Alonso, A., Andres, J.M., Garmendia, J.R., Diez, I., Gil, J.M. and Ardura, J., 2007. Bronchiolitis due to respiratory syncytial virus in hospitalized children: a study of seasonal rhythm. *Acta Paediatr.,* 96(5) , pp. 731–735.

Casha, F., Farrugia Preca, J. and Pisani, R., 2015. Epidemiology and Seasonal Variation of state Hospital Admissions for Bronchiolitis among children in Malta. *Malta Med. J.*. 27, pp. 21–25.

Centers for Disease Control and Prevention (CDC), 2010. Respiratory syncytial virus activity - United States, July 2008-December 2009. *MMWR Morb. Mortal. Wkly. Rep.*, 59, pp. 230–233.

Chen, Z.-R., Ji, W., Wang, Y.-Q., Yan, Y.-D., Shao, X.-J., Zhang, X.-L. and Xu, J., 2014. Etiology of acute bronchiolitis and the relationship with meteorological conditions in hospitalized infants in China. *J. Formos. Med. Assoc. Taiwan Yi Zhi*, 113, pp. 463–469.

Coffin, S.E., 2005. Bronchiolitis: in-patient focus. *Pediatr. Clin. North Am.*, 52, pp. 1047–1057.

Deshpande, S.A. and Northern, V., 2003. The clinical and health economic burden of respiratory syncytial virus disease among children under 2 years of age in a defined geographical area. *Arch. Dis. Child.,* 88, pp. 1065–1069.

Fitzgerald, D.A. and Kilham, H.A., 2004. Bronchiolitis: assessment and evidence-based management. *Med. J. Aust.,* 180, pp. 399–404.

Grimprel, E., 2001. [Epidemiology of infant bronchiolitis in France]. *Arch. Pédiatrie Organe Off. Sociéte Fr. Pédiatrie,* 8 Suppl 1, pp. 83S–92S.

Grimwood, K., Cohet, C., Rich, F.J., Cheng, S., Wood, C., Redshaw, N., Cunningham, C.W., Pearce, N. and Kirman, J.R., 2008. Risk factors for respiratory syncytial virus bronchiolitis hospital admission in New Zealand. *Epidemiol. Infect.*, 136, pp. 1333–1341.

Hervás, D., Reina, J., Yañez, A., del Valle, J.M., Figuerola, J. and Hervás, J.A., 2012. Epidemiology of hospitalization for acute bronchiolitis in children: differences between RSV and non-RSV bronchiolitis. *Eur. J. Clin. Microbiol. Infect. Dis. Off. Publ. Eur. Soc. Clin. Microbiol.,* 31, pp. 1975–1981.

Johnson, C. and Eccles, R., 2005. Acute cooling of the feet and the onset of common cold symptoms. *Fam. Pract.,* 22, pp. 608–613.

Marcone, D.N., Ellis, A., Videla, C., Ekstrom, J., Ricarte, C., Carballal, G., Vidaurreta, S.M. and Echavarría, M., 2013. Viral etiology of acute respiratory infections in hospitalized and outpatient children in Buenos Aires, Argentina. *Pediatr. Infect. Dis. J.,* 32, pp. e105-110.

Marlais, M., Evans, J. and Abrahamson, E., 2011. Clinical predictors of admission in infants with acute bronchiolitis. *Arch. Dis. Child.,* 96, pp. 648–652.

Munywoki, P.K., Koech, D.C., Agoti, C.N., Kibirige, N., Kipkoech, J., Cane, P.A., Medley, G.F. and Nokes, D.J., 2014. Influence of age, severity of infection, and co-infection on the duration of respiratory syncytial virus (RSV) shedding. *Epidemiol. Infect.,* pp. 1–9.

Panozzo, C.A., Fowlkes, A.L. and Anderson, L.J., 2007. Variation in timing of respiratory syncytial virus outbreaks: lessons from national surveillance. *Pediatr. Infect. Dis. J.,* 26, pp. S41-45.

Reyes, M., Eriksson, M., Bennet, R., Hedlund, K.-O. and Ehrnst, A., 1997. Regular pattern of respiratory syncytial virus and rotavirus infections and relation to weather in Stockholm, 1984--1993. *Clin. Microbiol. Infect. Off. Publ. Eur. Soc. Clin. Microbiol. Infect. Dis.,* 3, pp. 640–646.

Riese, J., McCulloh, R.J., Koehn, K.L. and Alverson, B.K., 2014. Demographic factors associated with bronchiolitis readmission. *Hosp. Pediatr.,* 4, pp. 147–152.

Salomão Junior, J.B., Gardinassi, L.G.A., Simas, P.V.M., Bittar, C.O., Souza, F.P., Rahal, P. and Zanetta, D.M.T., 2011. Human respiratory syncytial virus in children hospitalized for acute lower respiratory infection. *J. Pediatr. (Rio J.),* 87, pp. 219–224.

SIGN, 2006. *Guideline 91: Bronchiolitis in children.* [online] Available at: http://www.sign.ac.uk/guidelines/fulltext/91/ [Accessed 9 April 2015].

Tang, J.W. and Loh, T.P., 2014. Correlations between climate factors and incidence--a contributor to RSV seasonality. *Rev. Med. Virol.,* 24, pp. 15–34.

Vidaurreta, S.M., Marcone, D.N., Ellis, A., Ekstrom, J., Cukier, D., Videla, C., Carballal, G. and Echavarría, M., 2011. [Acute viral respiratory infection in children under 5 years: Epidemiological study in two centers in Buenos Aires, Argentina]. *Arch. Argent. Pediatría,* 109, pp. 296–304.

temperature range. This study could inspire others to try and seek answers for the points discussed above, and thereby improve the local epidemiological knowledge of bronchiolitis.

CONCLUSION

The study identified the temperature range where most of the hospital admissions due to bronchiolitis occurs (i.e. between 10.91°C and 18.61°C). The study also rejected the null hypothesis and accepted the alternate hypothesis, proving that there is a significant difference in the number of admissions between the various mean ambient temperature categories. The authors can conclude that in Malta, a higher number of hospital admissions for bronchiolitis among infants or children under two years occurs when mean ambient temperature is lower. This is in keeping with international literature.

It is hoped that the insight gained from these results will be considered in everyday GP practice, with GPs being more alert during colder temperatures to the possibility of bronchiolitis needing hospital admission, and in strategic health planning for availability of resources needed for hospitalised cases of bronchiolitis during colder temperatures.

Dr Frank C CASHA
MD, MMCFD, MRCGP(INT)
Specialist in Family Medicine
Email: fcasha@gmail.com

Dr Justine FARRUGIA PRECA
MD, PG Cert ID (Lond), MMCFD, MRCGP(INT)
Specialist in Family Medicine

Dr Rebecca PISANI
MD, MMCFD, MRCGP(INT)
Specialist in Family Medicine

ACKNOWLEDGMENTS

The authors would like to thank Dr Jurgen Abela for his guidance in carrying out this research and the Meteorological Office Malta for providing the daily mean ambient temperatures for the study period.